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Association between TyG index with obesity indicators and coronary heart disease: a cohort study

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The potential of utilizing the Triglyceride Glucose Index (TyG), along with its combination with obesity indicators, for predicting the risk of coronary heart disease (CHD) in the middle-aged and elderly population remains uncertain. This research aims to conduct a cohort study to assess the predictive capacity of the TyG and its combination with obesity indicators in forecasting the 10-year incidence of new-onset CHD among the middle-aged and elderly population in the Luzhou region. The study population was derived from the The China Cardiometabolic Disease and Cancer Cohort (4C) Study, comprising 8647 ordinary residents meeting specific criteria. The subjects were grouped based on quartiles of TyG, TyG-WC, TyG-WtHR, TyG-BMI, and TyG-WHR, and the occurrence of new-onset coronary heart disease was observed over a 10-year period. The study comprised 8647 participants, with 484 developing new-onset CHD, resulting in an incidence rate of 5.5% of the overall follow-up population. The comparison of new-onset CHD across quartiles of different indicators revealed a statistically significant difference ($P < 0.001$), with the order being the 4th quartile > 3rd quartile > 2nd quartile > 1st quartile. Cox proportional hazards regression analysis results indicated that, after adjusting for multiple influencing factors, the risk of new-onset CHD gradually increased with the quartiles of the 5 indicators. Specifically, when grouped according to TyG and TyG-WC quartiles, a statistically significant difference ($P < 0.05$) was observed between the 3rd and 4th quartiles compared to the 1st quartile. The ROC curve analysis results demonstrate that TyG-WC (area under the curve 0.608, $P < 0.001$) and TyG-WtHR (area under the curve 0.608, $P < 0.001$) exhibit superior predictive value for new-onset coronary heart disease compared to TyG (area under the curve 0.568, $P < 0.001$), TyG-BMI (area under the curve 0.576, $P < 0.001$), and TyG-WHR (area under the curve 0.595, $P < 0.001$). 1. TyG, TyG-WC, TyG-WtHR, TyG-BMI, and TyG-WHR demonstrate varying degrees of correlation with the incidence of new-onset coronary heart disease in the middle-aged and elderly population. 2. Specifically, TyG-WC may serve as a significant predictive factor for the occurrence of coronary heart disease in the elderly population.

Keywords Triglyceride glucose index, Coronary heart disease, TyG-WC, Insulin resistance, Obesity

Cardiovascular diseases stand out as a primary cause of non-communicable disease-related deaths worldwide, leading to over 17.7 million deaths annually[1]. In 2014, cardiovascular diseases emerged as a predominant cause of death in China, constituting over 40% of the total deaths in both rural and urban regions[1].The prevalence of cardiovascular diseases is on the rise among the Chinese population due to changes in lifestyle, urbanization, and the aging process.The incidence of cardiovascular diseases is consistently increasing, and it is anticipated to further rise in the next 10 years[2]. Coronary heart disease (CHD) ranks among the most prevalent cardiovascular diseases, posing a serious threat to human life and health.

Over the past half-century, the association between overweight/obesity and cardiovascular diseases, particularly CHD, has become more apparent. Overweight/obesity is closely linked to both traditional and non-traditional (novel) risk factors for cardiovascular diseases[3]. Traditional risk factors for cardiovascular diseases

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linked to overweight and obesity encompass type 2 diabetes, hypertension, and various lipid abnormalities. Additionally, non-traditional or novel risk factors comprise insulin resistance, hyperinsulinemia, endothelial dysfunction, various inflammatory markers, and various prothrombotic factors[3]. Metabolic diseases, featuring insulin resistance prominently, pose a significant public health challenge requiring intervention. However, direct methods to measure insulin resistance, like high-insulin euglycemic clamp experiments and insulin suppression tests, are invasive, involve complex procedures, and are costly. These factors impede their broad clinical adoption and rapid testing. Recently, some researchers have suggested employing the Triglyceride Glucose Index (TyG) as a simplified indicator for assessing insulin resistance. TyG combined with obesity indices is closely associated with insulin resistance[4,5], metabolic syndrome[6], uric acid[7], diabetes mellitus[8], and fatty liver[9]. Some studies have shown that TyG combined with adiposity indices is better than the TyG index for assessing. However, there is currently no reported cohort study in China among the middle-aged and elderly population investigating the correlation between TyG, combined with obesity indicators, and the incidence of coronary heart disease.

To achieve this objective, we conducted a cohort study to analyze the predictive abilities of TyG and its combination with different obesity indicators in forecasting the occurrence of new-onset CHD during a 10-year non-interventional follow-up among the middle-aged and elderly population (aged 40 and above) in the Luzhou region. The study aims to establish a theoretical foundation for the individual stratified management of the middle-aged and elderly population, with the ultimate goal of lowering the incidence of CHD in this age group.

Methods

Study population

The study population was derived from the The China Cardiometabolic Disease and Cancer Cohort (4C) Study, predominantly comprising participants from Luzhou City in Sichuan Province. From April to November 2011, we recruited 10,150 individuals, all aged 40 or older. Inclusion criteria: (1) Residing in the local area for ≥ 5 years; (2) Voluntary participation in follow-up; (3) Age ≥ 40 years. Exclusion criteria: (1) History of CHD; (2) History of myocardial infarction; (3) Age < 40 years; (4) Limited mobility; (5) Unwillingness to participate in follow-up; (6) Incomplete data. After meticulous screening, 8,647 individuals met the set criteria and became part of our study cohort.

Ethics statement

The present study was approved by the Research Ethics Committees of the Rui-Jin Hospital afliated to the Jiao-Tong University School of Medicine and also by the Afliated Hospital of Southwest Medical University. All methods were performed in accordance with the relevant guidelines.

Baseline survey

A baseline survey was conducted in 2011, which consisted of the following components: (1) Trained researchers performed face-to-face interviews to gather information on participants' gender, age, medical history (including hypertension, diabetes, and stroke), family history of diabetes, and smoking history. (2) Before breakfast, participants' weight, height, waist circumference, and hip circumference were measured, followed by the calculation of body mass index (BMI) and waist-to-height ratio (WtHR). Seated systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured every 5 min for each participant, with three readings taken. The average of these readings was then calculated. (3) Participants fasted for at least 10 h before undergoing a 75-gram oral glucose tolerance test. Blood samples were collected at baseline (0 h) and 2 h after the test, and stored at − 80 °C. Blood glucose measurements included glycated hemoglobin A1c (HbA1c), fasting blood glucose (FBG), and 2-h postprandial blood glucose (PBG), all measured using the glucose oxidase method. The lipid profile was assessed by measuring low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), total cholesterol (TC), and triglycerides (TG). Biochemical tests included alanine aminotransferase (ALT), aspartate aminotransferase (AST), gamma-glutamyl transferase (GGT), and creatinine (Crea) levels. All tests were conducted in accordance with the International Organization for Standardization (ISO) 15,189 guidelines in a certified central laboratory.

Follow-up survey

In 2021, follow-up evaluations were conducted, focusing on the endpoint of CHD. These evaluations primarily relied on chronic disease data provided by the Health Commission and the Disease Control and Prevention Center of Luzhou City.

Definitions

TyG, TyG-WC, TyG-WtHR, and TyG-BMI were calculated according to the following formulas: (1) TyG = ln [triglycerides (mg/dl) × glucose (mg/dl)/2][10]; (2) BMI = body mass (kg)/height^2(m^2); (3) WtHR = waist circumference/height; (4) TyG-WC = TyG × waist circumference; (5) TyG-WtHR = TyG × WtHR; (6) TyG-BMI = TyG × BMI. The study participants were divided into four groups (Q1, Q2, Q3, Q4) based on the baseline quartiles of TyG, TyG-WC, TyG-WtHR, TyG-BMI, and TyG-WHR for comparison.

Coronary heart disease

Coronary heart disease (CHD) was defined as having at least one coronary artery with a diameter stenosis ≥ 50%, as determined by coronary angiography. Participants were categorized into the CHD group and the non-CHD group based on the occurrence of new-onset CHD by the end of the follow-up period.

Statistical analysis

The sample's primary characteristics were presented using descriptive statistics. Continuous variables, based on their distribution, are detailed as mean ± standard deviation (SD) or median (interquartile range, IQR). Categorical variables are depicted as counts (percentages). Continuous variable comparisons utilized the Student's t-test, Mann–Whitney U test, Kruskal–Wallis H test, or one-way ANOVA, contingent on data normality. Chi-square tests were employed for inter-group categorical variable comparisons. The influencing factors were analyzed using Cox proportional hazards regression analysis. To compare the predictive capabilities of different indicators for the 10-year incidence of new-onset CHD in the middle-aged and elderly population, the area under the ROC curve was employed. In all statistical evaluations, p-values were two-tailed, with significance set at $p < 0.05$. SPSS software (version 26.0) facilitated all analyses, and Forest plots were generated using GraphPad Prism (version 9.0.0).

Results

Baseline characteristics

In this study, we initiated a baseline assessment involving 8,647 participants, comprising 2,887 males and 6,760 females. Throughout a 10-year non-interventional follow-up, 433 participants (5%) experienced mortality due to various causes. Additionally, 484 participants developed new-onset CHD, resulting in an incidence rate of 5.5%. Table 1 provides an overview of the baseline demographic and clinical characteristics of these participants. When stratified based on the occurrence of new-onset CHD, significant differences were observed in terms of gender, age, glucose status, hypertension, BMI, WC, WtHR, WHR, TG, HDL-C, Crea, TyG, TyG-WC, TyG-WtHR, TyG-BMI, TyG-WHR, and history of stroke ($p < 0.05$).

CHD incidence rates among different grouped subjects

Analyzing the occurrence of new-onset CHD among individuals in different quartile groups (refer to Table 2), the study involved 8647 participants. Among them, 484 developed CHD, constituting 5.5% of the total follow-up population. The comparison of new-onset CHD among quartile groups, defined by various indicators, reveals a clear hierarchy: Quartile 4 > Quartile 3 > Quartile 2 > Quartile 1, and all observed differences are statistically significant ($P < 0.001$).

Variables	All	CHD	Non CHD	Test Statistic Values	P
Gender				12.336	< 0.001
Male	2887(33.40%)	197(40.70%)	2690(33.00%)		
Female	5760(66.60%)	287(59.30%)	5473(67.00%)		
Age (years)	58.00(51.00,65.00)	64.00(58.25/72.00)	58.00(51.00/65.00)	− 13.801	< 0.001
Glycemic status				112.136	< 0.001
Normal	4734(54.70%)	183(37.80%)	4551(55.80%)		
Prediabetes	2391(27.70%)	133(27.50%)	2258(27.70%)		
Diabetes	1522(17.60%)	168(34.70%)	1354(16.60%)		
Hypertension (%)	1353(15.6%)	113(23.8%)	1238(15.2%)	25.556	< 0.001
BMI (kg/m^2)	23.70(21.50,26.00)	24.25(22.10/26.60)	23.70(21.50/25.90)	− 4.559	< 0.001
WC (cm)	83.00(76.10,89.20)	87.00(79.35/93.00)	82.90(76.00/89.00)	− 7.800	< 0.001
WtHR	0.53(0.48,0.57)	0.55(0.51/0.59)	0.52(0.48/0.57)	− 7.861	< 0.001
WHR	0.88(0.84,0.93)	0.90(0.86/0.94)	0.88(0.84/0.93)	− 6.460	< 0.001
TC (mmol/l)	4.54(3.79,5.29)	4.55(3.72/5.28)	4.54(3.80/5.29)	− 0.314	0.753
TG (mmol/l)	1.27(0.90,1.83)	1.36(0.98/1.94)	1.26(0.90/1.82)	− 2.703	0.007
HDL-C (mmol/l)	1.22(1.00,1.46)	1.14(0.93/1.37)	1.22(1.01/1.46)	− 5.084	< 0.001
LDL-C (mmol/l)	2.51(1.99,3.10)	2.53(2.00/3.15)	2.51(1.99/3.10)	0.857	0.391
ALT (U/L)	13.00(9.00,18.00)	13.00(9.00/18.00)	13.00(9.00/18.00)	-0.708	0.479
AST (U/L)	19.00(15.75,24.00)	19.00(15.00/24.00)	19.00(16.00/24.00)	-0.568	0.570
Crea (umol/l)	62.10(55.20,70.30)	64.30(57.03/73.40)	62.00(55.20/70.10)	-4.402	< 0.001
TyG	8.65(8.27,9.08)	8.79(8.38/9.20)	8.64(8.27/9.08)	− 5.025	< 0.001
TyG-WC	719.30(642.70,798.22)	767.07(680.03/835.78)	716.83(614.13/795.96)	− 7.985	< 0.001
TyG-WtHR	4.57(4.08,5.08)	4.87(4.32/5.37)	4.55(4.07/5.06)	− 8.010	< 0.001
TyG-BMI	206.02(182.13,231.35)	216.05(191.35/240.59)	205.36(181.81/230.56)	− 5.622	< 0.001
TyG-WHR	7.66(7.07,8.28)	7.99(7.39/8.52)	7.64(7.06/8.27)	− 7.010	< 0.001
History of stroke (%)	43(0.5%)	6(1.2%)	37(0.5%)	5.736	0.017
Family history of diabetes (%)	835(9.7%)	51(10.5%)	748(9.6%)	0.456	0.500
Smokingn (%)	1233(15.3%)	81(17.6%)	1152(15.1%)	2.094	0.148

Table 1. Comparison of baseline characteristics among subjects with different outcomes.

Indicators	CHD	Q1	Q2	Q3	Q4	*P*
TyG	Yes (%)	89(4.1%)	109(5.0%)	135(6.2%)	151(7.0%)	< 0.001
	No(%)	2072(95.9%)	2053(95.0%)	2027(93.8%)	2011(93.0%)	
TyG-WC	Yes(%)	64(3.0%)	104(4.8%)	132(6.1%)	184(8.5%)	< 0.001
	No(%)	2098(97.0%)	2058(95.2%)	2029(93.9%)	1978(91.5%)	
TyG-WtHR	Yes(%)	76(3.5%)	95(4.4%)	123(5.7%)	190(8.8%)	< 0.001
	No(%)	2085(96.5%)	2067(95.6%)	2039(94.3%)	1972(91.2%)	
TyG-BMI	Yes(%)	91(4.2%)	92(4.3%)	134(6.2%)	167(7.7%)	< 0.001
	No(%)	2071(95.8%)	2069(95.7%)	2028(93.8%)	1995(92.3%)	
TyG-WHR	Yes(%)	79(3.7%)	98(4.5%)	140(6.5%)	167(7.7%)	< 0.001
	No(%)	2083(96.3%)	2064(95.5%)	2021(93.5%)	1995(92.3%)	

Table 2. Comparison of the occurrence of CHD among different quartile groups based on TyG and its combination with obesity indicators. 'Q1' for the first quartile, 'Q2' for the second quartile, 'Q3' for the third quartile, and 'Q4' for the fourth quartile.

Indicators		Model1		Model2		Model3	
		HR (95% CI)	*P*	HR (95% CI)	P	HR (95% CI)	*P*
TyG	Q1	Reference		Reference		Reference	
	Q2	1.239(0.936,1.639)	0.134	1.124(0.849,1.488)	0.413	1.147(0.862,1.526)	0.347
	Q3	1.541(1.179,2.014)	0.002	1.381(1.056,1.807)	0.018	1.365(1.021,1.824)	0.036
	Q4	1.740(1.339,2.261)	< 0.001	1.478(1.136,1.923)	0.004	1.443(1.002,2.077)	0.049
TyG-WC	Q1	Reference		Reference		Reference	
	Q2	1.640(1.202,2.240)	0.002	1.352(0.988,1.848)	0.059	1.344(0.980,1.844)	0.067
	Q3	2.106(1.562,2.838)	< 0.001	1.637(1.212,2.211)	0.001	1.620(1.186,2.212)	0.002
	Q4	3.030(2.280,4.027)	< 0.001	2.186(1.639,2.915)	< 0.001	2.184(1.574,3.031)	< 0.001
TyG-WtHR	Q1	Reference		Reference		Reference	
	Q2	1.262(0.934,1.707)	0.130	1.053(0.778,1.426)	0.738	1.036(0.763,1.408)	0.821
	Q3	1.649(1.239,2.195)	0.001	1.286(0.963,1.716)	0.088	1.261(0.934,1.702)	0.130
	Q4	2.619(2.007,3.417)	< 0.001	1.849(1.407,2.429)	< 0.001	1.813(1.324,2.483)	< 0.001
TyG-BMI	Q1	Reference		Reference		Reference	
	Q2	1.013(0.758,1.353)	0.932	0.934(0.699,1.249)	0.646	0.915(0.683,1.225)	0.550
	Q3	1.478(1.133,1.929)	0.004	1.341(1.027,1.750)	0.031	1.283(0.972,1.693)	0.079
	Q4	1.880(1.456,2.427)	< 0.001	1.692(1.311,2.185)	< 0.001	1.586(1.185,2.123)	0.002
TyG-WHR	Q1	Reference		Reference		Reference	
	Q2	1.256(0.934,1.689)	0.132	1.027(0.763,1.383)	0.861	1.000(0.740,1.351)	0.999
	Q3	1.831(1.389,2.412)	< 0.001	1.365(1.033,1.804)	0.029	1.315(0.983,1.760)	0.065
	Q4	2.219(1.698,2.900)	< 0.001	1.591(1.213,2.087)	0.001	1.514(1.099,2.086)	0.011

Table 3. Cox proportional hazard regression analysis: predictive models for CHD based on TyG, alone and in combination with obesity indicators. Model1 was not adjusted for any variables. In Model2, adjustments were made for gender and age. Subsequently, Model3 underwent further adjustments, incorporating factors such as glucose metabolism, hypertension, TG, HDL-C, Crea, and a history of stroke. The quartile arrays are denoted as follows: 'Q1' for the first quartile, 'Q2' for the second quartile, 'Q3' for the third quartile, and 'Q4' for the fourth quartile.

Cox proportional hazards regression analysis

Table 3; Fig. 1 presents the outcomes of Cox proportional hazards regression analysis on TyG and its combination with obesity indicators in forecasting the 10-year incidence of new-onset CHD. The results indicate that, without adjusting any variables (refer to Table 3, Model 1), the risk of new-onset CHD increases over 10 years as subjects are grouped based on quartiles of TyG, TyG-WC, TyG-WtHR, TyG-BMI, and TyG-WHR. Specifically, among subjects grouped by TyG-WC quartiles, statistically significant differences exist between the 2nd, 3rd, and 4th quartiles compared to the 1st quartile ($P < 0.05$). For subjects grouped by TyG, TyG-WtHR, TyG-BMI, TyG-WHR quartiles, the differences between the 3rd and 4th quartiles compared to the 1st quartile are statistically significant ($P < 0.05$).

After adjusting for age and gender (refer to Table 3, Model 2), When comparing subjects grouped by TyG, TyG-WC, TyG-BMI, TyG-WHR quartiles, the differences between the 3rd and 4th quartiles and the 1st quartile

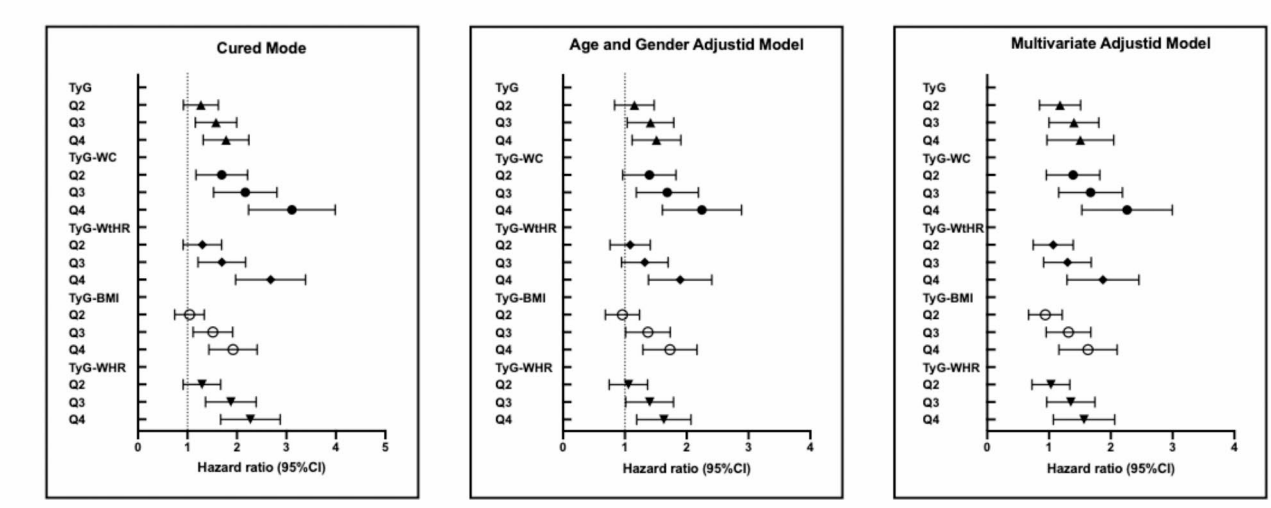

Fig. 1. Cox proportional—hazards regression models for regression predefined stratification subpopulations.

were statistically significant ($P<0.05$). Moreover, when comparing subjects grouped by TyG-WtHR quartiles, the differences between the 4th quartile and the 1st quartile were statistically significant ($P<0.05$).

After further adjusting for glucose metabolism, hypertension, TG, HDL-C, Crea, and a history of stroke (refer to Table 3, Model 3), the analysis revealed that, among subjects grouped by TyG and TyG-WC quartiles, the risk of new-onset CHD increased over a 10-year period with the rise in quartiles, and the differences between the 3rd and 4th quartiles and the 1st quartile were statistically significant ($P<0.05$). When comparing subjects grouped by TyG-WtHR, TyG-BMI and TyG-WHR quartiles, the risk of new-onset CHD increased with the rise in quartiles, and the differences between the 4th quartile and the 1st quartile were statistically significant ($P<0.05$).

ROC curve area

Different indicators predicting the occurrence of CHD in the elderly are assessed using the ROC curve area (Fig. 2). The ROC curve area analysis for TyG, TyG-WC, TyG-WtHR, TyG-BMI, and TyG-WHR is performed in the elderly population during a 10-year follow-up to evaluate the risk of new-onset CHD. Results indicate that the ROC curve areas for all five indicators exceed 0.5, with $P<0.001$, indicating statistically significant differences.

For predicting CHD, the optimal cutoff values for TyG, TyG-WC, TyG-WtHR, TyG-BMI, and TyG-WHR were as follows: (1) TyG: cutoff value = 8.7186, sensitivity = 56.4%, specificity = 55.8%, and AUC = 0.568; (2) TyG-WC: cutoff value = 759.2003, sensitivity = 53.4%, specificity = 64.3%, and AUC = 0.608; (3) TyG-WtHR: cutoff value = 7.6085, sensitivity = 67.4%, specificity = 48.6%, and AUC = 0.608; (4) TyG-BMI: cutoff value = 205.9191, sensitivity = 62.4%, specificity = 50.7%, and AUC = 0.576; (5) TyG-WHR: cutoff value = 4.8517, sensitivity = 52.3%, specificity = 66.0%, and AUC = 0.595.

Discussion

This study is based on epidemiological research, establishing a non-interventional prospective cohort study. Through a decade-long follow-up, we observed and studied the incidence of coronary heart disease in the subjects. We investigated the predictive value of TyG, combined with obesity indicators, in forecasting the occurrence of new cases of coronary heart disease over a decade in the elderly population of Luzhou. Non-interventional follow-up cohort studies have distinct advantages over cross-sectional studies in exploring the factors influencing disease. Through both univariate and multivariate analyses, we observed a correlation between TyG combined with obesity indicators and the risk of new-onset coronary heart disease in the elderly population of Luzhou over a decade. Specifically, the correlation between TyG and TyG-WC is notably strong. ROC curve analysis demonstrates that TyG-WC predicts the onset of coronary heart disease more accurately than TyG, TyG-WtHR, TyG-BMI, and TyG-WHR.

An accumulating body of evidence suggests that the significant features of metabolic syndrome and type 2 diabetes, particularly insulin resistance, may contribute to the pathogenesis of coronary artery disease[11,12]. The TyG index has been recognized as a reliable surrogate marker for insulin resistance[13]. Insulin resistance leads to endothelial dysfunction, lipotoxicity, glucotoxicity, chronic inflammation, and endoplasmic reticulum stress, all of which are closely associated with atherosclerosis-based CHD. Cohort studies from the United States, Europe, and China indicate that the TyG index is independently associated with the incidence of cardiovascular diseases[14–17]. In particular, the Tehran Lipid and Glucose Study highlights that TyG is independently linked to the occurrence of cardiovascular diseases[18]. A prospective cohort study also shows that the TyG index is positively correlated with increased all-cause mortality in hospitalized heart failure patients[19]. Data from the 2001–2012 NHANES indicate that the TyG index is associated with a higher incidence of chest pain. Furthermore, the

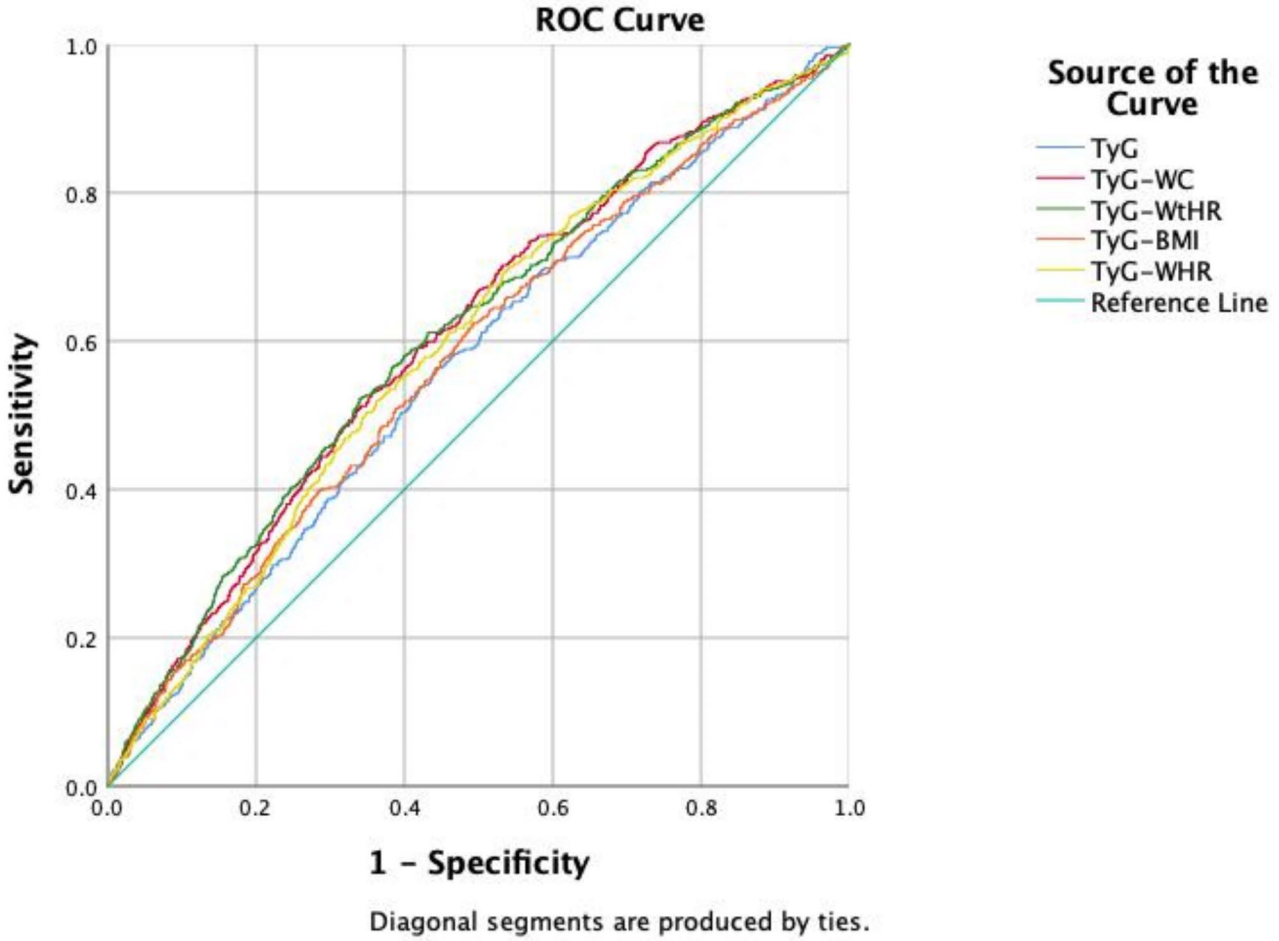

Fig. 2. The ROC curve area for predicting the occurrence of CHD using TyG and its combination with different obesity indicators.

TyG index is linked to all-cause mortality not only in participants with chest pain but also in those without chest pain[20]. The TyG index is also associated with adverse cardiac outcomes, with elevated levels significantly correlated to higher mortality risk following heart surgery[21]. In the non-diabetic young population, individuals with higher TyG index values are more likely to encounter impaired cardiovascular fitness[22]. A retrospective study indicates that consistently higher TyG index levels with poor control are associated with an increased risk of stroke[23]. A 5-year longitudinal cohort study of prediabetic individuals in China suggests that the TyG index could be a promising marker for predicting normoglycemic conversion. This study demonstrates a negative and non-linear association between TyG and the conversion from prediabetes to normoglycemia[24]. Another retrospective longitudinal cohort study shows that elevated TyG index levels at baseline, along with long-term increases in TyG trajectories, are linked to an increased risk of hypertension. Early identification of rising TyG levels could provide valuable insights into preventing hypertension later in life[25]. Additionally, a study by Yan Xue et al. demonstrates that TyG-WC, TyG-WHtR, and TyG-BMI can be used for the early screening of NAFLD and MAFLD, as they are key factors in the development of fatty liver disease[9].

Obesity is a complex metabolic disorder caused by the interaction of multiple factors. Adipokines, bioactive substances produced by adipose tissue with endocrine functions, play an essential role in regulating various physiological processes such as appetite, fat distribution, glucose-lipid metabolism, insulin sensitivity, endothelial cell function, and inflammatory chemotaxis[26–30]. In obesity, the synthesis and secretion of adipokines are dysregulated. This includes adiponectin, which reduces insulin resistance[26], omentin, which enhances glucose uptake by muscle tissue, zinc-α2-glycoprotein (ZAG), which increases insulin sensitivity through glucose metabolic signaling pathways[27], and secreted frizzled-related protein 5 (SFRP5), which inhibits inflammatory cell infiltration and the production of pro-inflammatory factors[28]. Moreover, obesity leads to an increase in pro-inflammatory factors, resulting in a systemic inflammatory response. Inflammatory cytokines can induce insulin resistance through various molecular mechanisms[30]. Additionally, individuals with obesity have higher levels of free fatty acids (FFAs)[29]. Incomplete fatty acid metabolism can cause endoplasmic reticulum stress, excessive ROS production, and consequently affect mitochondrial function. This reduces oxidative capacity and leads to an accumulation of fatty acid metabolites. Different types of obesity lead to distinct metabolic disorders, with

the metabolic abnormalities resulting from central obesity and increased visceral fat deposition being the most significant.

Numerous studies have shown that the correlation between the TyG index and diseases becomes stronger when combined with obesity indicators. Our research revealed that TyG-WC demonstrated the highest predictive ability for CHD in the Chinese middle-aged and elderly population. These findings align with previous studies, such as a cross-sectional study involving 11,937 adults from the 2003–2018 National Health and Nutrition Examination Survey (NHANES), which indicated significant and positive associations between TyG, TyG-WC, TyG-WtHR, and TyG-BMI with cardiovascular disease. Notably, the TyG index exhibited a stronger correlation with the risk of coronary heart disease, while TyG-WC showed the highest correlation with total cardiovascular disease, congestive heart failure, and angina pectoris. TyG demonstrated the highest correlation with coronary heart disease, while TyG-WtHR correlated best with myocardial infarction. Additionally, ROC curves illustrated that TyG-WtHR and TyG-WC possessed more robust diagnostic efficacy than TyG[31]. In a study involving 1145 participants from Korea, the results similarly indicated that TyG-WC exhibited superior diagnostic efficacy for the progression of coronary artery calcification compared to TyG and TyG-BMI. Obesity, a potential contributor to cardiovascular risk factors, including dyslipidemia, type 2 diabetes, hypertension, and sleep disorders, may independently lead to cardiovascular disease and death, particularly based on body fat distribution[32,33]. Unlike previous studies, ours is a 10-year follow-up investigation, providing complementary insights and significant evidence supporting TyG and TyG-WC as predictors of CHD risk in the literature. Moreover, our study found that for 10-year incident CHD, the optimal cutoff value for TyG-WC was 759.2003, suggesting that when TyG-WC exceeds this threshold, clinicians should be vigilant about the individual's future risk of CHD and consider interventions to mitigate this risk.

The mechanism underlying the increased risk of CHD associated with TyG, TyG-WC, TyG-WtHR, TyG-BMI, and TyG-WHR may be attributed to elevated levels of these indices, which are linked to insulin resistance[34,35]. Insulin resistance has the potential to induce disorders in glucose metabolism and lipotoxicity[36]. This can trigger the release of inflammatory factors by macrophages and adipocytes[37], inactivate nitric oxide[31], activate the sympathetic nervous system and renin–angiotensin–aldosterone system[38], cause hemorrhagic disorders, and activate platelets. These processes collectively contribute to cardiac dysfunction and myocardial injury, ultimately resulting in a spectrum of CHD[39]. However, specific mechanisms require confirmation through experimental research.

Advantages and limitations

This study has several strengths. It explores the relationship between TyG and the combination of various obesity indicators with the incidence of new-onset CHD in the middle-aged and elderly population through a prospective cohort study, a topic not covered in current domestic literature. However, the study also has some limitations, such as relying on the chronic disease management system of the Health Commission and the Center for Disease Control for the collection of CHD events, which may result in a small number of underreported cases. In future research, we will conduct on-site follow-ups under feasible conditions to address this limitation.

Conclusions

1. TyG, TyG-WC, TyG-WtHR, TyG-BMI, and TyG-WHR demonstrate varying degrees of correlation with the incidence of new-onset coronary heart disease in the middle-aged and elderly population. 2. Specifically, TyG-WC may serve as a significant predictive factor for the occurrence of coronary heart disease in the elderly population.

Data availability

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

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Author contributions

YM: Conceived the study, conducted data collection, performed data analysis, and drafted the manuscript. YW: Conceived the study, conducted data collection, performed data analysis and manuscript drafting. QW: Oversaw the study design, data analysis, and manuscript drafting. Provided final approval for the submitted version.

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Declarations

Competing interests
The authors declare no competing interests.

Ethics statement
The present study was approved by the Afliated Hospital of Southwest Medical University. The participants provided their written informed consent to participate in this study. Clinical trial number: not applicable.

Additional information
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