Association Between the Triglyceride-Glucose Index and High Cardiovascular Disease Risk Among Middle-Aged Obese Residents by Gender in Anhui Region: Postprint

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Abstract

Background: The triglyceride-glucose (TyG) index is an indicator for evaluating insulin resistance (IR) and obesity-related metabolic diseases, and is closely associated with high risk of cardiovascular disease (CVD). However, the relationship between the TyG index and high CVD risk may differ among middle-aged obese populations of different genders.

Objective: To investigate the relationship between the TyG index and high CVD risk in middle-aged obese populations by gender, and to evaluate its role in CVD prevention and treatment.

Methods: Study subjects were sourced from 10 early screening and comprehensive intervention projects for high-risk CVD populations conducted in Anhui Province. A total of 30,425 middle-aged obese individuals were selected. The uniformly designed preliminary screening questionnaire and basic information registration form from the National Cardiovascular Center were utilized, and surveys were conducted by uniformly trained and qualified investigators. Survey items included gender, age, hypertension, dyslipidemia, diabetes, smoking status, alcohol consumption status, etc. Subjects were divided into male and female groups. The male group was stratified by TyG index quartiles into T (7.417~8.870), T2 (8.871~9.204), T3 (9.205~9.578), and T4 (9.579~11.435) groups; the female group was divided into F1 (7.579~8.876), F2 (8.877~9.183), F3 (9.184~9.526), and F4 (9.527~11.647) groups. Binary logistic regression analysis was employed to explore the relationship between the TyG index and high CVD risk, and Z-test was used to compare effect value differences between subgroups.

Results: The proportion of high CVD risk was 28.4% in the male group and 26.0% in the female group. Binary logistic regression analysis revealed that TyG index T2 (F2), T3 (F3), and T4 (F4) were associated with high CVD risk in both male and female groups (P<0.05), with the association gradually increasing as the TyG index increased. In the male group, compared with T1, the risk of high CVD risk in the T4 group was OR (95%CI) = 1.827 (1.622, 2.058); in the female group, compared with T1, the risk in the T4 group was 1.552 (1.410, 1.708). The association between the fourth quartile TyG index and high CVD risk differed significantly between the two gender groups (P<0.05). After further adjustment for indicators such as total cholesterol (Model 2), the association between T2 (F2), T3 (F3), T4 (F4) and high CVD risk attenuated, but T2 (F2), T3 (F3), and T4 (F4) in both male and female TyG index groups remained associated with high CVD risk (P<0.05), with the association gradually increasing as TyG index levels increased. Compared with the T1 group, the risk of high CVD risk in the TyG index T4 group was OR (95%CI) = 1.804 (1.584, 2.055) in the male group, and OR (95%CI) = 1.496 (1.345, 1.665) in the female group; the association between the fourth quartile TyG index and high CVD risk differed significantly between the two gender groups (P<0.05).

Conclusion: Middle-aged obese men with high TyG index levels are more prone to high CVD risk, and attention should be focused on the TyG index levels in this population.

Full Text

Relationship between Triglyceride-Glucose Index and High-Risk Cardiovascular Disease in Middle-Aged Obese Residents of Different Genders in Anhui Province

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Abstract

Background: The triglyceride-glucose (TyG) index serves as an indicator for evaluating insulin resistance (IR) and obesity-related metabolic diseases, and is closely associated with high cardiovascular disease (CVD) risk. However, the relationship between TyG index and CVD risk may differ across genders among middle-aged obese populations.

Objective: To investigate the relationship between TyG index and high CVD risk in middle-aged obese populations of different genders, and to evaluate its role in CVD prevention and treatment.

Methods: A total of 30,425 middle-aged obese residents were selected from 10 early screening and comprehensive intervention projects for high-risk CVD populations in Anhui Province. Investigators trained and certified by the National Cardiovascular Center conducted surveys using uniformly designed preliminary screening questionnaires and basic information registration forms. The survey collected data on gender, age, hypertension, dyslipidemia, diabetes, smoking status, and alcohol consumption. Participants were divided into male and female groups. The male group was further stratified by TyG index quartiles: T1 (7.417–8.870), T2 (8.871–9.204), T3 (9.205–9.578), and T4 (9.579–11.435). The female group was stratified as F1 (7.579–8.876), F2 (8.877–9.183), F3 (9.184–9.526), and F4 (9.527–11.647). Binary logistic regression analysis was used to explore the relationship between TyG index and high CVD risk, while Z-tests were employed to compare effect values between subgroups.

Results: The proportion of participants at high risk for CVD was 28.4% in the male group and 26.0% in the female group. Binary logistic regression analysis revealed that TyG index levels T2 (F2), T3 (F3), and T4 (F4) were significantly associated with high CVD risk in both male and female groups ($P<0.05$), with the strength of association increasing progressively with higher TyG index levels. In the male group, the risk of high CVD risk in T4 compared to T1 was OR (95%CI) = 1.827 (1.622, 2.058). In the female group, the risk in F4 compared to F1 was OR (95%CI) = 1.552 (1.410, 1.708). The difference in CVD risk associated with the fourth quartile TyG index between male and female groups was statistically significant ($P<0.05$). After further adjustment for total cholesterol and other indicators (Model 2), the associations between T2 (F2), T3 (F3), T4 (F4) and high CVD risk were attenuated but remained significant in both groups ($P<0.05$), with the same dose-response relationship. In Model 2, the risk for T4 versus T1 was OR (95%CI) = 1.804 (1.584, 2.055) in males and OR (95%CI) = 1.496 (1.345, 1.665) in females. The gender difference in the fourth quartile remained statistically significant ($P<0.05$).

Conclusion: Middle-aged obese men with high TyG index levels are more susceptible to high CVD risk. Special attention should be paid to monitoring TyG index levels in this population.

Keywords: Obesity; Triglyceride-glucose index; Different genders; Cardiovas-

cular diseases; Middle aged; High risk

Introduction

As population aging accelerates, cardiovascular disease (CVD) has become an increasingly significant public health problem, with rising incidence and mortality rates affecting residents' healthy lives. In 2019, the number of CVD patients in 204 countries and regions increased by 252 million compared to 271 million in 1990, with CVD deaths increasing by 6.5 million, making it one of the leading causes of death worldwide. Unhealthy lifestyles have led to rising trends in overweight and obesity prevalence. Obesity increases the risk of high CVD risk, and middle-aged populations are more prone to obesity, which increases their high CVD risk status. Urgent prevention and control strategies are needed to address CVD risk factors and delay CVD progression.

The triglyceride-glucose (TyG) index is a marker of insulin resistance (IR), serving as an inexpensive and readily accessible surrogate variable for detecting IR and pancreatic function that better predicts type 2 diabetes risk. IR and obesity increase the risk of glucose and lipid metabolism disorders, thereby increasing high CVD risk. The relationship between TyG index and high CVD risk may differ significantly across genders. Based on this, our study investigated the relationship between TyG index and high CVD risk in middle-aged obese populations of different genders, aiming to provide evidence-based support for CVD prevention and screening in this demographic.

Methods

1.1 Study Subjects Study participants were sourced from 10 early screening and comprehensive intervention projects for high-risk CVD populations conducted in Anhui Province. A total of 30,425 middle-aged obese individuals were selected. Inclusion criteria were: (1) residence at the project site for $ $6 months within the past year; (2) voluntary participation with full survey completion; and (3) age 45–65 years with body mass index (BMI) $ $25kg/m\hat{}\{2\}$. Exclusion criteria included: (1) incomplete survey data; (2) inability to perform self-care; and (3) advanced malignant tumors, severe liver or kidney dysfunction, or acute infection. The project was approved by the Ethics Committee of Suzhou Municipal Hospital (Approval No. A2022033), and all participants provided informed consent.

1.2 Methods 1.2.1 Questionnaire Survey: Investigators trained and certified by the National Cardiovascular Center used uniformly designed preliminary screening questionnaires and basic information registration forms to collect data on gender, age, hypertension, dyslipidemia, diabetes, smoking status, and alcohol consumption.

1.2.2 Physical Examination: Trained medical staff measured height (cm) and weight (kg) for all participants.

1.2.3 Laboratory Tests: After fasting for at least 8 hours, participants provided venous blood samples between 6:30–9:00 AM. Fasting plasma glucose (FPG) was measured using a glucose meter, and triglycerides (TG) were measured using a rapid lipid analyzer.

1.2.4 Indicator Definitions: Participants were classified as high-risk CVD if they met any of four criteria: (1) history of myocardial infarction, percutaneous coronary intervention, coronary artery bypass grafting, or stroke (ischemic or hemorrhagic); (2) systolic blood pressure $ $160 mmHg or diastolic blood pressure $ $100 mmHg; (3) LDL-C $ $160 mg/dl (4.14 mmol/L) or HDL-C <30 mg/dl (0.78 mmol/L); or (4) 10-year CVD risk $ $20% according to the 2008 WHO cardiovascular risk assessment charts. The project data collection system automatically determined high-risk CVD status based on screening results. Smoking was defined as current smoking at the time of survey; alcohol consumption was defined as drinking $ $1 time per week.

1.2.5 Index Calculation and Grouping: BMI was calculated as weight/height^2. TyG index was calculated as Ln[serum triglycerides (mmol/L) $\times$ fasting plasma glucose (mmol/L)/2]. Male participants were stratified by TyG index quartiles: T1 (7.417–8.870), T2 (8.871–9.204), T3 (9.205–9.578), and T4 (9.579–11.435). Female participants were stratified as F1 (7.579–8.876), F2 (8.877–9.183), F3 (9.184–9.526), and F4 (9.527–11.647).

1.3 Statistical Analysis SPSS 25.0 software was used for statistical analysis. Non-normally distributed continuous variables were described as M(P25, P75) and compared between groups using non-parametric rank-sum tests. Categorical variables were described using relative frequencies and compared using ^{2} tests. Logistic regression analysis was used to examine the relationship between TyG index and high CVD risk in male and female groups. R software (version 4.1.1) was used for Z-tests to compare OR values between male and female groups. The significance level was set at α=0.05.

Results

2.1 Basic Characteristics of Study Subjects Among the 30,425 middle-aged obese residents, 11,566 were in the male group and 18,859 in the female group. The prevalence of high CVD risk was 28.4% (3,280/11,566) in males and 26.0% (4,909/18,859) in females. In the male group, individuals at high CVD risk showed statistically significant differences in TyG index, total cholesterol, HDL-C, LDL-C, BMI, triglycerides, and fasting glucose compared to non-high-risk individuals (P<0.05). In the female group, high CVD risk individuals differed significantly in smoking status, TyG index, total cholesterol, HDL-C, LDL-C, BMI, triglycerides, and fasting glucose (P<0.05).

2.2 Characteristics Across Gender and TyG Index Groups The median TyG index was 9.204 in the male group and 9.183 in the female group. In the male group, significant differences were observed across TyG quartiles in smoking status, alcohol consumption, hypertension prevalence, diabetes prevalence, dyslipidemia prevalence, high CVD risk status, total cholesterol, HDL-C, LDL-C, BMI, triglycerides, and fasting glucose ($P<0.05$). In the female group, significant differences were found across TyG quartiles in hypertension prevalence, diabetes prevalence, dyslipidemia prevalence, high CVD risk status, LDL-C, total cholesterol, HDL-C, BMI, triglycerides, and fasting glucose ($P<0.05$).

2.3 Univariate Logistic Regression Analysis of TyG Index with Hypertension, Diabetes, Dyslipidemia, and High CVD Risk Using TyG index grouping as the independent variable (male group: T1=1, T2=2, T3=3, T4=4; female group: F1=1, F2=2, F3=3, F4=4) and hypertension (0=no, 1=yes), diabetes (0=no, 1=yes), dyslipidemia (0=no, 1=yes), and high CVD risk (0=no, 1=yes) as dependent variables, univariate logistic regression analysis showed that TyG index was a significant factor for hypertension, diabetes, dyslipidemia, and high CVD risk in both groups ($P<0.05$). In the male group, T4 showed 1.956, 5.389, 4.633, and 1.785 times higher risk for hypertension, diabetes, dyslipidemia, and high CVD risk respectively compared to T1. In the female group, F4 showed 2.287, 11.479, 4.237, and 1.515 times higher risk respectively compared to F1. In both groups, the risks of hypertension, diabetes, dyslipidemia, and high CVD risk increased progressively with higher TyG index levels.

2.4 Multivariate Logistic Regression Analysis of TyG Index and High CVD Risk Multivariate binary logistic regression analysis was performed with TyG index grouping as the independent variable and high CVD risk status as the dependent variable. In Model 1, adjusted for smoking, alcohol consumption, hypertension, diabetes, and dyslipidemia, TyG index levels T2 (F2), T3 (F3), and T4 (F4) were significantly associated with high CVD risk in both male and female groups ($P<0.05$), with strengthening associations at higher TyG index levels. In the male group, the risk for T4 versus T1 was OR (95%CI) = 1.827 (1.622, 2.058). In the female group, the risk for F4 versus F1 was OR (95%CI) = 1.552 (1.410, 1.708). The difference between genders in the fourth quartile was statistically significant ($P<0.05$).

After further adjustment for total cholesterol, HDL-C, and LDL-C (Model 2), the associations between T2 (F2), T3 (F3), T4 (F4) and high CVD risk were attenuated but remained significant in both groups ($P<0.05$), with the same progressive increase in risk with higher TyG index levels. In Model 2, the risk for T4 versus T1 was OR (95%CI) = 1.804 (1.584, 2.055) in males and OR (95%CI) = 1.496 (1.345, 1.665) in females. The gender difference in the fourth quartile remained statistically significant ($P<0.05$).

Discussion

CVD remains the leading cause of health burden among Chinese residents. Individuals at high risk for CVD are extremely susceptible to cardiovascular events, making risk factor control and risk assessment the primary measures for CVD prevention. In China, more than half of middle-aged individuals are obese, and this middle-aged obese population is more susceptible to hypertension and diabetes, significantly increasing their high CVD risk status. Our study analyzed the prevalence of high CVD risk and related risk factors among middle-aged obese residents of different genders in Anhui Province. The high CVD risk prevalence was higher in males (28.4%) than in females (26.0%), consistent with findings from Ren et al. and Jia et al.

Our results showed that among middle-aged obese individuals at high CVD risk, the detection rate of hypertension (34.5%) was higher than that of diabetes (13.6%) and dyslipidemia (6.4%) in both gender groups, indicating that hypertension prevention and control remain the top priority for CVD prevention. Hypertensive patients have a higher risk of developing high CVD risk status, and effective intervention for this risk factor should be strengthened to reduce CVD incidence.

Smoking emerged as an important risk factor for high CVD risk in females. With societal development and changing mindsets, more women have entered the workforce and become family breadwinners, while smoking and social drinking have become common in many female groups. Smoking increases the risk of hypertension and stroke and is also a high-risk factor for CVD. Therefore, smoking cessation and lifestyle interventions should be implemented early to prevent CVD. While Cao et al. found that even moderate alcohol consumption increased the incidence of diabetes, hypertension, and dyslipidemia in high-risk CVD populations, our study did not find an association between alcohol consumption and high CVD risk, possibly because our definition of alcohol consumption did not include type or amount of alcohol. Further investigation into the relationship between alcohol type/quantity and high CVD risk is warranted.

Type 2 diabetes mellitus (T2DM) is a global chronic disease and a risk factor for CVD. Obesity in middle age increases the risk of developing T2DM in older age. The TyG index, incorporating both metabolic disorder (hypertriglyceridemia) and glycemic components (fasting glucose), serves as a diagnostic indicator for prediabetes and effectively reflects IR-induced lipid and glucose metabolism abnormalities. It is considered an efficient and simple tool for predicting diabetes. Our results showed that in the male group, the risk of diabetes in T4 was 5.389 times that of T1, while in the female group, the risk in F4 was 11.479 times that of F1. The risk of diabetes increased progressively with higher TyG index levels in both groups.

IR is closely associated with arteriosclerosis, calcification, thrombosis, oxidative stress, and inflammatory responses. Elevated TyG index may accelerate the development of arteriosclerosis, while changes in these metabolic indicators

also increase the incidence of hypertension and dyslipidemia. The 2022 American Diabetes Association (ADA) standards indicate that patients with elevated TG and glucose require early lifestyle intervention to slow the progression of cardiovascular disease caused by arteriosclerosis.

A prospective cohort study by Luan et al. found that high TyG index is an independent risk factor for hypertension. Our results similarly showed that the risk of hypertension increased progressively with higher TyG index in both male and female groups. Hypertension and dyslipidemia are mutual influencing factors. The combination of antihypertensive and lipid-lowering drugs can better control high CVD risk and reduce adverse cardiovascular events. Our study found that high TyG index increased the risk of dyslipidemia by 4.633 times in males and 4.237 times in females, with incidence increasing progressively with higher TyG index levels. Metabolic disorders caused by dyslipidemia are the pathological basis for cardiovascular and cerebrovascular diseases and are closely associated with CVD mortality. Therefore, controlling hypertension and dyslipidemia by reducing TyG index may delay the progression to high CVD risk.

Our binary logistic regression analysis showed that after controlling for various confounders, TyG index is a high-risk factor for high CVD risk, with risk increasing progressively at higher TyG index levels. In males, the high CVD risk in T4 was 1.827 times that of T1, while in females, F4 was 1.552 times that of F1. After further adjustment for total cholesterol and other indicators, the association was attenuated but remained significant, with T4 versus T1 risk at 1.804 in males and F4 versus F1 at 1.496 in females. Z-tests showed significant gender differences in the fourth quartile, indicating that males with high TyG index are more susceptible to high CVD risk than females.

This may be because in our middle-aged obese population, males had higher detection rates of smoking (48.6% vs. 1.2%), alcohol consumption (34.5% vs. 3.0%), hypertension (34.5% vs. 29.8%), and diabetes (13.6% vs. 11.3%) than females, making the association between high TyG index and high CVD risk more pronounced in males. Additionally, in obese middle-aged populations, males have higher serum aldosterone levels and higher hypertension incidence than females, making them more susceptible to CVD at high TyG index levels. However, Zhang et al. found that in populations without traditional risk factors, CVD incidence increased with TyG index without gender differences, which differs from our findings. In our middle-aged obese population, the relationship between TyG index and high CVD risk showed a progressive increase with higher TyG index, with significant gender differences at high TyG index levels. The mechanisms underlying these gender differences require further investigation.

A 25-year follow-up cohort study of 4,754 young adults found that high TyG index levels and persistently high TyG index trajectories were significantly positively associated with future CVD events, suggesting that TyG index can serve as an effective predictor of CVD development even in younger populations.

Our study has several strengths. Few previous studies have examined gender-specific associations, and our analysis of common risk factors such as age, smoking, alcohol consumption, hypertension, diabetes, and dyslipidemia provides valuable insights. Our data from the Anhui Province cardiovascular high-risk population screening project offer a large, representative sample with high-quality measurements. However, limitations include the cross-sectional design, with single measurements of triglycerides and fasting glucose that cannot capture temporal changes or their dynamic impact on our outcomes. Additionally, our study was limited to middle-aged obese residents of Anhui Province, so caution is needed when generalizing findings to other regions, age groups, or non-obese populations.

Conclusion

TyG index is closely associated with high CVD risk in middle-aged obese populations of different genders in Anhui Province. The association is more pronounced in middle-aged obese men with high TyG index levels, providing a basis for early targeted intervention for high CVD risk factors in this population. Future efforts should implement practical measures to reduce TyG index levels in middle-aged obese populations to provide scientific evidence for reducing CVD risk in Anhui Province.

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Author Contributions: Pan Yaojia and Gu Huaicong organized data; Pan Yaojia performed statistical analysis and drafted the manuscript; Wang Weiqiang planned and supervised the research, reviewed and guided the manuscript; Yi Weizhuo guided statistical analysis; Fu Fanglin, Dong Yaqin, Han Zheng, Sun Meng, and Gao Bing collected data; Fu Fanglin assisted with manuscript revision.

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Note: Figure translations are in progress. See original paper for figures.