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ORIGINAL RESEARCH

Triglyceride-Glucose Index is Related to Carotid Artery Plaque in Railway Workers: A Cross-Sectional Study

Jia Pan[1,*], Bo Yang[1,*], Zihang Wang[2], Lei Tang[1], Peng Jia[3,4], Shujuan Yang[1,2,4], Honglian Zeng[1]

[1]Department of Clinical Medical College & Affiliated Hospital of Chengdu University, Chengdu University, Chengdu, Sichuan, People's Republic of China; [2]Department of West China School of Public Health and West China Fourth Hospital, Sichuan University, Chengdu, Sichuan, People's Republic of China; [3]Department of School of Resources and Environmental Sciences, Wuhan University, Wuhan, People's Republic of China; [4]Department of International Institute of Spatial Health Epidemiology (ISLE), Wuhan University, Wuhan, People's Republic of China

*These authors contributed equally to this work

Correspondence: Shujuan Yang; Honglian Zeng, Email rekiny@126.com; zenghonglianhl@163.com

Aim: China has the highest rail transportation density in the world. Compared to other occupational populations, railway workers in China face increased risk of chronic non-communicable diseases. This study aims to investigate the relationship between the triglyceride-glucose (TyG) index and carotid artery plaque (CAP) in a population of railway workers in southwest China.

Methods: The cross-sectional study was conducted among 3169 railway workers who were categorized into four groups based on TyG index quartiles. The presence of CAP was assessed using carotid Doppler ultrasound. Logistic regression and restricted cubic spline analyses were used to estimate the association between TyG index and CAP, and subgroup analyses were performed based on age, blood pressure, metabolic dysfunction-associated fatty liver disease (MAFLD), smoking, drinking, and physical activity.

Results: Participants with higher TyG index quartiles had a higher prevalence of CAP, with 11.63%, 14.11%, 20.20%, and 18.56% from the first to fourth quartile, respectively. The multi-adjusted logistic regression models showed a positive association between TyG index and the risk of CAP (odds ratio [OR]: 1.22, 95% confidence interval [CI]: 1.06–1.41) when treated as a continuous variable. When analyzed as a categorical variable with increasing TyG index tertiles, the risk of CAP substantially increased with ORs (95% CIs) of 1.22 (0.90–1.65) for the second quartile, 1.70 (1.27–2.28) for the third quartile, and 1.46 (1.08–1.98) for the fourth quartile compared to the lowest quartile. Restricted cubic spline revealed that the association gradually strengthened with the increase of the TyG index below 9.56.

Conclusion: TyG index was significantly associated with CAP, notably in populations with elevated quartiles of TyG index among railway workers. Monitoring the TyG index could be a useful risk management strategy for CAP in occupation population.

Keywords: TyG index, insulin resistance, carotid artery plaque, MAFLD, occupational population

Introduction

China has the highest rail transportation density in the world,[1] leading to a heavy workload for railway workers. Compared to other occupational populations, railway workers in China face increased mental stress, longer working hours, poorer sleep quality, less physical activity, and circadian rhythm disorders. These factors can increase the risk of chronic non-communicable diseases such as dysglycemia, dyslipidemia, and carotid artery plaque (CAP).[2]

CAP, measured through ultrasound, is a non-invasive and simple method for assessing the risk of early atherosclerosis and cardiovascular disease (CVD).[3] Recent evidence suggests that the presence of CAP may be linked to insulin resistance (IR), thereby increasing the risk of atherosclerotic cardiovascular disease (ASCVD).[4–6] The triglyceride glucose (TyG) index, a cost-effective and innovative surrogate for IR, is derived from fasting triglyceride (TG) and fasting blood glucose (FBG) measurements.[7,8] Several studies have linked the TyG index to chronic noncommunicable diseases, such as type 2 diabetes and metabolic syndrome, as well as early markers of ASCVD, such as intima-media

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thickness and arterial stiffness.[9–11] However, there is limited evidence on the association between CAP and the TyG index, with inconsistent results.[12,13] Additionally, few studies have examined this relationship among railway workers, who often have unhealthy lifestyles and irregular work schedules.

In this cross-sectional study based on a large sample of railway workers in southwest China, we aim to investigate the association between the TyG index and CAP and assess how specific lifestyle factors may have modified this relationship. The findings of our study may help in understanding the impact of the TyG index on the risk of CAP in occupational populations and promoting strategies for preventing ASCVD.

Materials and Methods

Study Design and Population

This cross-sectional study was conducted among 3169 railway workers in southwest China from January to December 2021.

The inclusion criteria were all on-job railway drivers. Participants with insufficient clinical information (eg, fasting blood glucose and blood lipid) and severe systemic disease (such as cardiac, renal or liver failure, and malignant) were excluded. A flowchart of the participants' recruitment is shown in Figure 1.

Data Collection

Body mass index (BMI) (kg/m^2) was calculated based on the participants' height and weight. The participants were then categorized into two groups based on their BMI: BMI < 23 kg/m^2, indicating underweight or normal weight, and BMI ≥ 23 kg/m^2, indicating overweight or obese. Blood pressure was measured using sphygmomanometers in the seated position, and the average of two readings was recorded for systolic blood pressure (SBP) and diastolic blood pressure

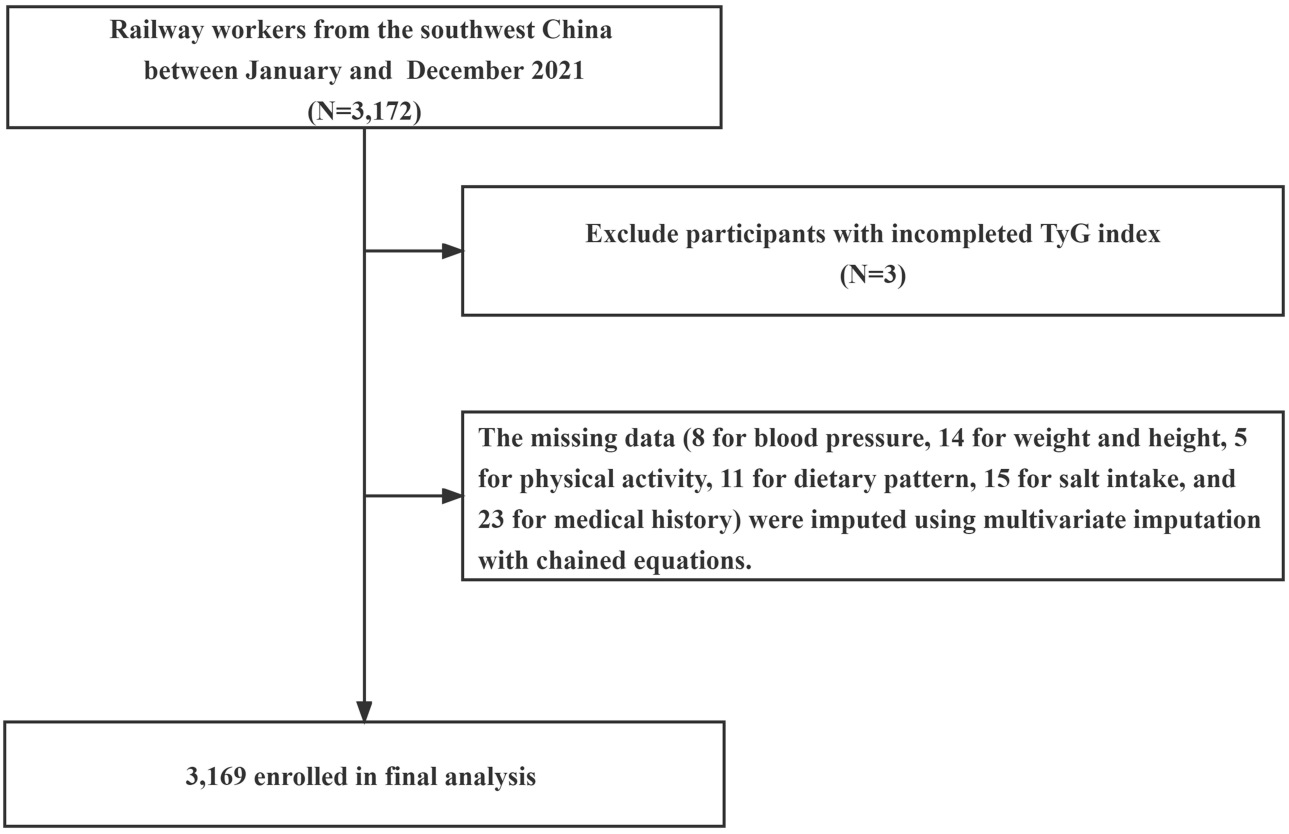

Figure 1 Flowchart of the participants' recruitment.

(DBP). Hypertension was defined as high blood pressure (SBP ≥140 mmHg or DBP ≥90 mmHg), a previous diagnosis, or the use of antihypertensive medications.

Fasting blood samples were taken after an overnight fast of 8 to 12 hr, and laboratory analysis was conducted on total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), fasting blood glucose (FBG), and high-sensitivity C-reactive protein (hs-CRP) by a laboratory physician at Clinical Medical College & Affiliated Hospital of Chengdu University. FBG levels ≥7.0 mmol/L, a previous diagnosis, or the use of hypoglycemic medications were used to determine diabetes. Dyslipidemia was defined as a self-reported history or use of lipid-lowering medications or TC levels ≥5.17 mmol/L or TG levels ≥1.69 mmol/L or LDL-C levels ≥3.62 mmol/L or HDL-C level ≤1.04 mmol/L.

The TyG index was calculated using the following formula: Ln[(fasting TG (mg/dl) × FBG (mg/dl)/2].[8]

Digital ultrasonic diagnostics were utilized to evaluate the presence or absence of CAP (EPIQ CX, Philips Ultrasound Inc., USA). The common carotid artery, the carotid artery bulb, and the near and far wall portions of the internal carotid artery were bilaterally imaged. Two physicians with over 5 years of expertise in vascular ultrasound imaging blindly examined the images. The CAP was described by the Mannheim criteria[14] as a focal zone invading the arterial lumen by at least 0.5 mm, >50% of the surrounding intima-media thickness values, or a thickness of 1.5 mm above the distance between the lumen-intima and the media–adventitia interface.

Covariates

The TyG index and CAP confounders selected by previous studies were potential factors in our analysis.[13,15,16] Our skilled physicians collected sociodemographic and personal medical history (diabetes, hypertension, hyperlipidemia, medication history) and lifestyle factors (smoking status, drinking status, dietary pattern, physical activity, etc.) using a standard questionnaire. Smoking status was defined as smoking at least one cigarette per day, and drinking status was defined as consuming at least 50g of alcohol once every week for at least 6 months. Physical activity was evaluated based on the total metabolic equivalent (MET) score and categorized into two groups (≥3000 MET min/w, <3000 MET min/w).[17] According to the standard questionnaire, dietary patterns were assessed according to the consumption of vegetables, fruits, red meat (such as pork, beef, lamb), white meat (such as poultry, fish), and preserved foods.[18] The frequency categories for these five items were recorded as follows: "never" = 0, "less than once per week" = 0.5, "2–3 times per week" = 2.5, "4–6 times per week" = 5, and "once or more daily" = 7. The participants' median scores for each item were calculated, and the individual score ≥median of the vegetable, fruit, and white meat options were assigned 1 score, and the individual score ≤median of the red meat and preserved food options were assigned 1 score. The total diet score ranged from 0 to 5, with one point assigned for each nutritional component that was deemed beneficial. Poor diet (score of 0 or 1), intermediate diet (score of 2 or 3), and ideal diet (score of 4 or 5) were categorized into three groups. The individuals' self-reported daily salt intake was categorized into three groups: low, moderate, and high intakes.

Metabolic dysfunction-associated fatty liver disease (MAFLD) was also considered a subgroup in our study. The proposed criteria for a diagnostic diagnosis of MAFLD were hepatic steatosis detected by ultrasound picture and one of the following three criteria: overweight/obesity, the presence of type 2 diabetes mellitus, or evidence of metabolic dysregulation.[19]

Statistical Analysis

According to the previous study, the prevalence of CAP in the general Chinese population was about 20.15%.[19] Assuming 80% power, a 2-sided α error of 0.05, and the allowable error was 3%; finally, we obtained a sample size of 687. Considering a dropout rate of 20%, we decided on a minimal sample size of 825. The sample size of this study has reached this standard.

The tertiles of the TyG index were used to divide participants into four categories. Continuous variables were described as the mean (SD) and analyzed by ANOVA test. Multiple regression models were employed to estimate the associations between TyG and CAP risk after adjusting age, SBP, DBP, BMI, physical activity, smoking, drinking, salt intake, and dietary pattern. ROC curves were plotted for different models in predicting CAP. When the TyG index was considered as a continuous variable, a restricted cubic spline with three knots at the 10th, 50th, and 95th percentiles of the

TyG index is used to analyze the detailed association between the TyG index and CAP. The subgroup analyses were stratified by age, MAFLD, smoking and drinking, physical activity, dietary pattern, sodium intake, and elevated blood pressure. In addition, sensitivity analyses were conducted to assess the robustness of our findings by excluding patients with hypertension, diabetes, and dyslipidemia.

All statistical analyses were conducted in R Studio (Version 4.0.5). A two-sided $P < 0.05$ was considered statistically significant.

Results

Baseline Characteristics

A total of 3169 subjects were enrolled in the study, with an average age of 49.25 years. Compared with participants in the lowest quartile of the TyG index, those with high quartiles were more likely to have a higher prevalence of diabetes, hypertension, hyperlipidemia, and higher levels of BMI, SBP, DBP, FBG, TC, TG, LDL-C, AST, ALT, SUA, hs-CRP, and a lower level of HDL-C. Among railway workers, the prevalence of hepatic steatosis, MAFLD, and CAP were 51.78%, 50.87%, and 511 16.12%, respectively. The detailed characteristics of the participants stratified by TyG index quartiles are presented in Table 1.

Table 1 General Characteristics of the Study Participants According to the TyG Index

Characteristics	Overall (N=3169)	TyG index				*P* value
		Q1 (N=791)	Q2 (N=794)	Q3 (N=792)	Q4 (N=792)	
Sociodemographics						
Sex (%)						
Male	3137 (98.99)	769 (97.22)	788 (99.24)	790 (99.75)	790 (99.75)	<0.001
Age, years, mean (SD)	49.25 (4.36)	48.90 (4.34)	49.30 (4.37)	49.45 (4.26)	49.34 (4.46)	0.064
≥45 years (%)	2704 (85.33)	666 (84.20)	681 (85.77)	686 (86.62)	671 (84.72)	0.529
Medical history						
Diabetes (%)	407 (12.84)	40 (5.06)	77 (9.70)	93 (11.74)	197 (24.87)	<0.001
Hypertension (%)	946 (29.85)	149 (18.84)	221 (27.83)	255 (32.20)	321 (40.53)	<0.001
Hyperlipidemia (%)	1323 (41.75)	131 (16.56)	268 (33.75)	389 (49.12)	535 (67.55)	<0.001
Hypoglycemic agents (%)	233 (7.35)	18 (2.28)	40 (5.04)	46 (5.81)	129 (16.29)	<0.001
Antihypertensive agents (%)	485 (15.30)	73 (9.23)	108 (13.60)	120 (15.15)	184 (23.23)	<0.001
Lipid-lowering drugs (%)	243 (7.67)	26 (3.29)	37 (4.66)	52 (6.57)	128 (16.16)	<0.001
Lifestyle behaviors						
Smoking (%)	2106 (66.46)	488 (61.69)	480 (60.45)	554 (69.95)	584 (73.74)	<0.001
Drinking (%)	2093 (66.05)	483 (61.06)	499 (62.85)	528 (66.67)	583 (73.61)	<0.001
Physical activity ≥3000 MET-min/w (%)	1110 (35.03)	301 (38.05)	257 (32.37)	293 (36.99)	259 (32.70)	0.031
Dietary pattern (%)						0.307
Poor diet	49 (1.55)	13 (1.64)	12 (1.51)	8 (1.01)	16 (2.02)	
Intermediate diet	1476 (46.58)	350 (44.25)	367 (46.22)	369 (46.59)	390 (49.24)	
Ideal diet	1644 (51.88)	428 (54.11)	415 (52.27)	415 (52.40)	386 (48.74)	
Salt intake (%)						0.001
Low intakes	570 (17.99)	172 (21.74)	152 (19.14)	117 (14.77)	129 (16.29)	
Moderate intakes	2152 (67.91)	523 (66.12)	514 (64.74)	573 (72.35)	542 (68.43)	
High intakes	447 (14.11)	96 (12.14)	128 (16.12)	102 (12.88)	121 (15.28)	
Clinical variables						
BMI, kg/m2, mean (SD)	24.99 (3.05)	23.45 (2.87)	24.75 (2.82)	25.64 (2.97)	26.12 (2.83)	<0.001
SBP, mmHg, mean (SD)	82.71 (11.08)	79.03 (11.04)	81.48 (10.87)	84.24 (10.60)	86.09 (10.50)	<0.001
DBP, mmHg, mean (SD)	124.59 (14.70)	120.11 (14.37)	123.53 (14.75)	125.98 (14.33)	128.71 (13.96)	<0.001
FBG, mmol/L, mean (SD)	5.80 (1.73)	5.10 (0.65)	5.40 (0.83)	5.69 (1.11)	7.01 (2.75)	<0.001
TC, mmol/L, mean (SD)	4.90 (0.92)	4.53 (0.75)	4.82 (0.91)	5.03 (0.87)	5.23 (0.99)	<0.001

(*Continued*)

Table 1 (Continued).

Characteristics	Overall (N=3169)	TyG index				*P* value
		Q1 (N=791)	Q2 (N=794)	Q3 (N=792)	Q4 (N=792)	
TG, mmol/L, mean (SD)	2.37 (2.16)	1.00 (0.22)	1.57 (0.25)	2.24 (0.42)	4.68 (3.24)	<0.001
HDL-C, mmol/L, mean (SD)	1.35 (0.31)	1.54 (0.31)	1.39 (0.27)	1.31 (0.25)	1.14 (0.26)	<0.001
LDL-C, mmol/L, mean (SD)	2.89 (0.66)	2.55 (0.56)	2.86 (0.64)	3.07 (0.64)	3.07 (0.68)	<0.001
hs-CRP, mg/L, mean (SD)	2.15 (4.41)	1.72 (3.17)	2.03 (3.96)	2.51 (6.39)	2.33 (3.33)	0.002
ALT, U/L, mean (SD)	28.74 (22.11)	23.11 (27.62)	27.03 (18.78)	30.70 (19.46)	34.14 (19.89)	<0.001
AST, U/L, mean (SD)	23.68 (12.28)	22.24 (15.32)	22.91 (11.17)	24.02 (10.71)	25.54 (11.10)	<0.001
SUA, mean (SD)	392.58 (82.84)	365.30 (75.28)	384.33 (75.83)	407.12 (81.49)	413.54 (89.19)	<0.001
TyG Index, mean (SD)	9.06 (0.69)	8.28 (0.24)	8.80 (0.12)	9.19 (0.13)	9.97 (0.52)	<0.001
Outcome variables						
Hepatic steatosis detected by ultrasound (%)	1641 (51.78)	161 (20.35)	346 (43.58)	506 (63.89)	628 (79.29)	<0.001
MAFLD (%)	1612 (50.87)	148 (18.71)	332 (41.81)	506 (63.89)	626 (79.04)	<0.001
CAP (%)	511 (16.12)	92 (11.63)	112 (14.11)	160 (20.20)	147 (18.56)	<0.001

Notes: Q1: TyG index <8.32, Q2: 8.32≤TyG index<9.19, Q3: 9.19≤TyG index<9.83, Q4 >9.83.
Abbreviations: TyG, triglyceride glucose; BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; FBG, fasting blood glucose; TC, total cholesterol; TG, triglyceride; HDL-C, high-density-lipoprotein cholesterol; LDL-C, low-density-lipoprotein cholesterol; hs-CRP, high-sensitivity C-reactive protein; ALT, Alanine aminotransferase; AST, aspartate aminotransferase; SUA, Serum uric acid; MAFLD, metabolic dysfunction-associated fatty liver disease; CAP, carotid artery plaque; Q1-Q4, quartile of TyG index.

The rate of hepatic steatosis detected by hepatic steatosis index (HSI) is shown in Supplementary Table 1.

Association Between the TyG Index and CAP

When the TyG index was treated as a continuous variable, the multivariate adjusted logistic regression models showed that TyG index was associated with the increased risk of CAP (OR: 1.22, 95% CI: 1.06, 1.41) after adjustment for age, SBP, DBP, BMI, physical activity, smoking, drinking, salt intake, and dietary pattern (Table 2). When using the quartiles of the TyG index, the risk of CAP increased with higher ORs in quartile 2 (OR: 1.22, 95% CI: 0.90, 1.65), quartile 3 (OR: 1.70, 95% CI: 1.27, 2.28), and quartile 4 (OR: 1.46, 95% CI: 1.08, 1.98).

In addition, restricted cubic spline was also used to examine the association between the TyG index and CAP (Figure 2), which revealed that the association was gradually strengthened with the increase of the TyG index below 9.56.

For our study population, we constructed a ROC curve for different models to predict CAP (Figure 3). Model 1 was adjusted age, SBP, DBP, model 2 added BMI based on model 1, and model 3 added physical activity, smoking, drinking, salt intake, dietary pattern based on model 2. Compared with other models, model 3 with added lifestyle increased AUC in CAP detection (AUC = 0.642, 95%Cl 0.617, 0.667).

Table 2 Association Between the TyG Index and CAP

	OR (95% CI)			
	Crude Model	Model 1[a]	Model 2[b]	Model 3[c]
TyG index	1.35 (1.18, 1.54)	1.25 (1.09, 1.43)	1.26 (1.10, 1.46)	1.22 (1.06, 1.41)
Q1	Ref.	Ref.	Ref.	Ref.
Q2	1.25 (0.93, 1.68)	1.17 (0.87, 1.58)	1.20 (0.89, 1.62)	1.22 (0.90, 1.65)
Q3	1.92 (1.46, 2.55)	1.70 (1.28, 2.26)	1.75 (1.31, 2.35)	1.70 (1.27, 2.28)
Q4	1.73 (1.31, 2.30)	1.48 (1.11, 1.98)	1.54 (1.14, 2.08)	1.46 (1.08, 1.98)
P-trend	<0.001	<0.05	<0.05	<0.05

Notes: [a]Model 1: adjusted for age, SBP, DBP. [b]Model 2: adjusted for age, SBP, DBP, BMI. [c]Model 3: adjusted for age, SBP, DBP, BMI, physical activity, smoking, drinking, salt intake, dietary pattern.
Abbreviations: CAP, Carotid artery plaque; BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; TyG, Triglyceride glucose; Q1-Q4, quartile of TyG index; Ref, reference.

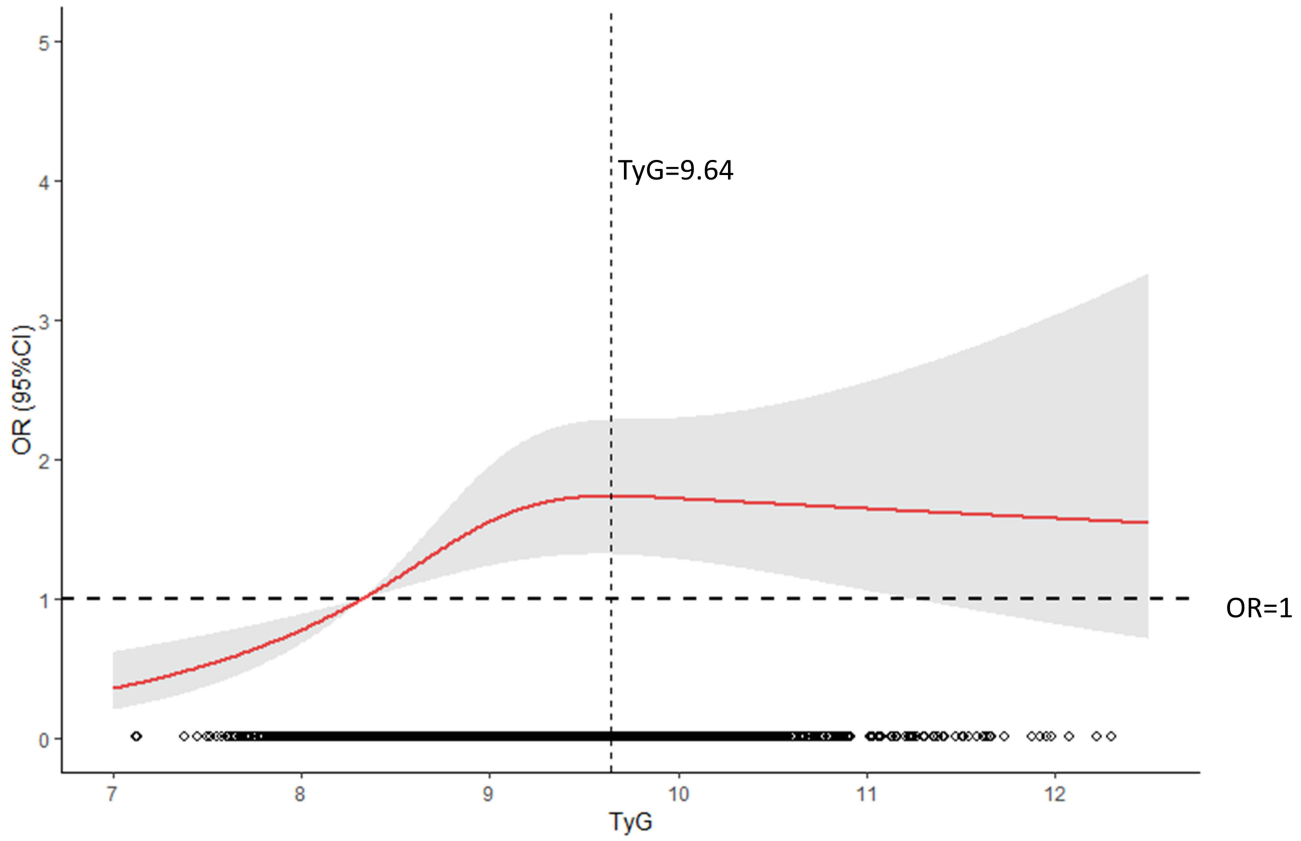

Figure 2 Multivariate-adjusted association of the TyG index and CAP based on restricted cubic splines. The OR was decreased at the TyG of 9.64; ORs were adjusted for age, SBP, DBP, MAFLD, physical activity, smoking, drinking, salt intake, dietary pattern; the Grey shadow represents 95% CI confidence interval.
Abbreviation: TyG, triglyceride glucose index.

Subgroup Analysis

The subgroup analysis was stratified by age, SBP, DBP, BMI, smoking, drinking, and physical activity. We found a significant positive association between the TyG index and CAP in different subgroups after adjustment for age, SBP, DBP, BMI, physical activity, smoking, drinking, salt intake, and dietary pattern. Since blood pressure and BMI were included in the assessment of MAFLD, we only made adjustments for age and lifestyle for the MAFLD subgroup in order to prevent collinearity in the statistical analysis. The results showed that TyG index was still correlated with carotid plaque. However, we did not find a modification effect by age, MAFLD, blood pressure, smoking, drinking, and physical activity (P for interaction >0.05). When considering the TyG index in quartiles, we observed that TyG at quartile 3 was strongest associated with risk of CAP, compared with other quartiles among different subgroups (Table 3).

The results of MAFLD subgroups as determined by HSI are shown in Supplementary Table 2.

Sensitivity Analysis

Sensitivity analyses were performed to assess the association between the TyG index and CAP by excluding participants with hypertension, diabetes, and dyslipidemia. After adjusting for age, SBP, DBP, BMI, physical activity, smoking, drinking, salt intake, and dietary pattern, the sensitivity analysis results were still robust (Table 4).

Discussion

This study contributes novel findings on the association of the TyG index with CAP among railway workers in southwest China. The primary finding of the present study is that TyG index was significantly associated with CAP, a notable feature in populations with elevated quartiles of TyG index. Furthermore, this relationship was confirmed in various subgroups based on age, smoking, drinking, physical activity, blood pressure, and MAFLD.

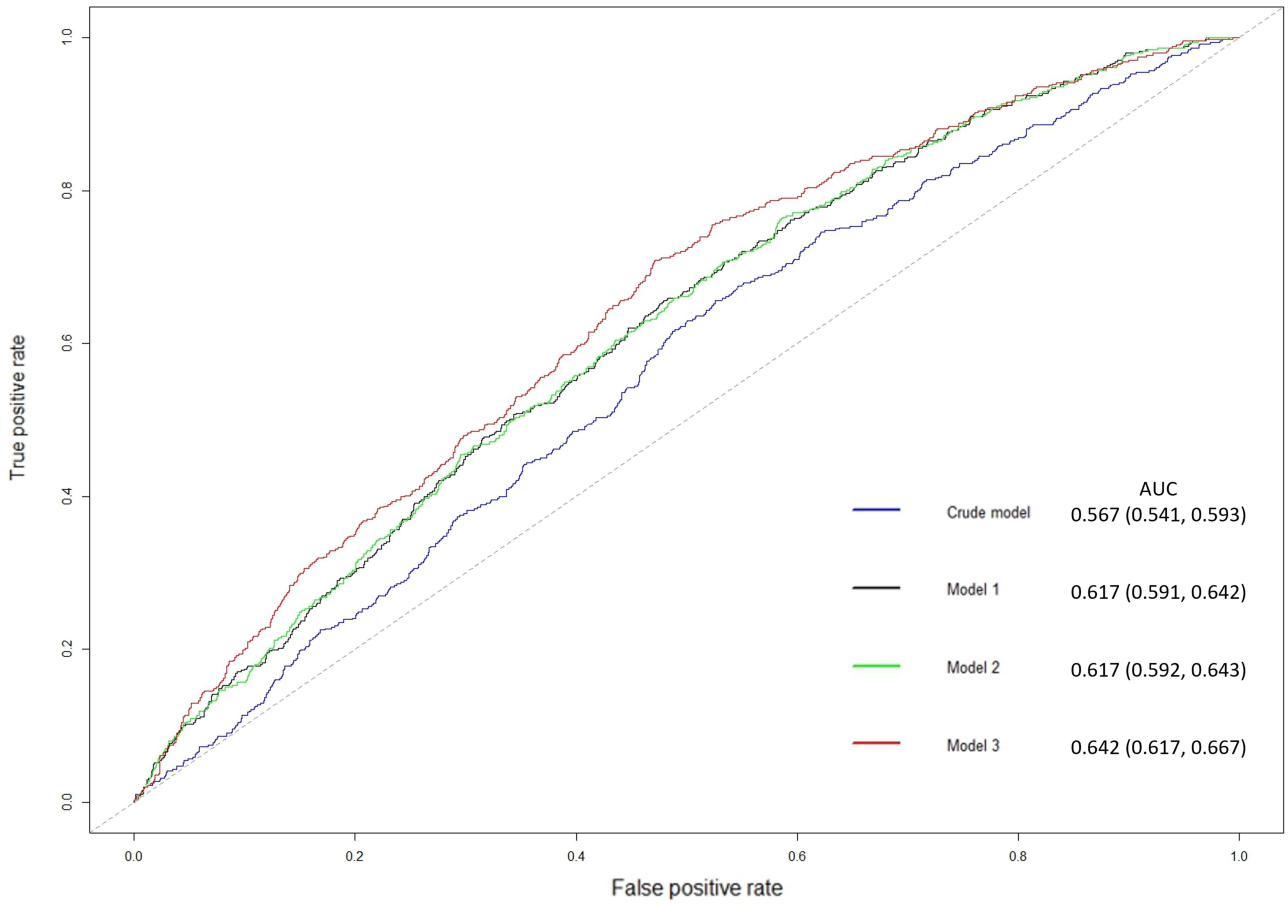

Figure 3 ROC curves for different models in predicting CAP detection. Model 1: adjusted for age, SBP, DBP. Model 2: adjusted for age, SBP, DBP, BMI. Model 3: adjusted for age, SBP, DBP, BMI, physical activity, smoking, drinking, salt intake, dietary pattern.

The finding that the TyG index is a predictor of atherosclerosis is significant because it suggests that the TyG index could be a useful tool for identifying individuals at higher risk for developing CVD. A case–control study from Taipei revealed that the TyG index could predict the intima-media thicknesses of common carotid arteries.[20] This association between the TyG index and atherosclerosis has been demonstrated in multiple populations, including those with hypertension and diabetes.[12,13,21] To the best of our knowledge, this is the first study to demonstrate this relationship between the TyG index and CAP in occupational population. Atherosclerosis can be evaluated in many ways, and previous studies have been performed using ankle-brachial pulse wave velocity, carotid-femoral pulse wave velocity, ankle-brachial index, and arterial stiffness.[22,23] Although CAP is regarded as an early lesion of atherosclerosis, few studies have examined the relationship between the TyG index and CAP, and the results have been contradictory.[12,13,16,24] A study indicated that the TyG index was associated with a high risk of arterial stiffness in elderly adults, but not CAP.[24] Our results are in line with some other studies.[13,16] There are many factors affecting the relationship between TyG and CAP. However, the prior study's regression models did not take into account the risk factors like dietary pattern and physical activity. Moreover, scientific evidence demonstrates that lifestyle factors, such as good physical activity and dietary pattern, can successfully improve CVD.[25,26] In this study, after adjusting for a number of potential confounders and performing additional sensitivity analysis excluding patients with diabetes, hypertension, and dyslipidemia, the results of this study remained stable.

In addition, our optimal cutoff point for the TyG index in the case of CAP was 9.56, which was higher than the cutoff point determined by other studies (7.9).[13] This may be due to differences in the study populations. As one of the most prevalent metabolic diseases, MAFLD, a novel concept presented by an international consensus in 2020, was mostly

Table 3 Subgroup Analysis for Association Between the TyG Index and CAP

Subgroup	TyG Index	OR (95% CI)[a]	*P-Interaction*	Subgroup	TyG Index	OR (95% CI)[a]	*P-Interaction*
Age, years				***Smoking***			
<45		1.64 (1.00, 2.66)*	Ref.	No		1.17 (0.80, 1.68)	Ref.
	Q1	Ref.			Q1	Ref.	
	Q2	1.93 (0.55, 7.70)			Q2	1.50 (0.77, 2.98)	
	Q3	3.63 (1.14, 13.94)*			Q3	2.05 (1.04, 4.15)*	
	Q4	3.15 (0.97, 12.35)			Q4	1.10 (0.49, 2.44)	
≥45		1.20 (1.03, 1.39)*	0.23	Yes		1.22 (1.04, 1.43)*	0.82
	Q1	Ref.			Q1	Ref.	
	Q2	1.19 (0.87, 1.63)			Q2	1.13 (0.80, 1.59)	
	Q3	1.62 (1.20, 2.21)*			Q3	1.62 (1.17, 2.24)*	
	Q4	1.39 (1.02, 1.91)*			Q4	1.49 (1.07, 2.07)*	
Elevated blood pressure				***Drinking***			
No		1.38 (1.13, 1.69)*	Ref.	No		1.17 (0.84, 1.61)	Ref.
	Q1	Ref.			Q1	Reference	
	Q2	1.17 (0.79, 1.73)			Q2	1.43 (0.81, 2.59)	
	Q3	1.63 (1.12, 2.39)*			Q3	1.96 (1.10, 3.57)*	
	Q4	1.62 (1.09, 2.41)*			Q4	1.40 (0.73, 2.71)	
Yes		1.15 (0.95, 1.39)	0.33	Yes		1.23 (1.05, 1.45)*	0.77
	Q1	Ref.			Q1	Reference	
	Q2	1.24 (0.77, 1.20)			Q2	1.16 (0.81, 1.66)	
	Q3	1.87 (1.21, 2.93)*			Q3	1.67 (1.19, 2.35)*	
	Q4	1.44 (0.94, 2.26)			Q4	1.46 (1.04, 2.06)*	
MAFLD				***Physical activity***			
No		1.50 (1.18, 1.92)*	Ref.	<3000 MET-min/w		1.26 (1.05, 1.51)*	Ref.
	Q1	Ref.			Q1	Ref.	
	Q2	1.32 (0.93, 1.89)			Q2	1.34 (0.91, 2.00)	
	Q3	1.88 (1.29, 2.74)*			Q3	1.95 (1.33, 2.88)*	
	Q4	1.46 (0.90, 2.32)			Q4	1.64 (1.11, 2.44)*	
Yes		1.26 (1.04, 1.52)*	0.27	≥3000 MET-min/w		1.17 (0.92, 1.48)	0.63
	Q1	Ref.			Q1	Ref.	
	Q2	1.32 (0.72, 2.55)			Q2	1.05 (0.65, 1.71)	
	Q3	2.24 (1.29, 4.15)*			Q3	1.45 (0.92, 2.29)	
	Q4	2.05 (1.19, 3.78)*			Q4	1.24 (0.77, 2.01)	

Notes: [a]Adjusted for age, SBP, DBP, BMI, physical activity, smoking, drinking, salt intake, dietary pattern (except for the one used for stratification, and subgroup of MAFLD was adjusted for age, physical activity, smoking, drinking, salt intake, dietary pattern). *$P<0.05$.

Abbreviations: CAP, Carotid artery plaque; TyG, Triglyceride glucose; BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; MALFD, Metabolic dysfunction-associated fatty liver disease; MET, metabolic equivalent; Q1-Q4, quartile of TyG index; Ref, reference.

associated with IR and as a risk factor for CVD; additionally, the TyG index was a potential risk factor for MAFLD.[27–31] Subgroup analysis of MAFLD was not performed in prior studies. Results from this study showed that the TyG index was associated with an increased risk of CAP in individuals with MAFLD, suggesting that MAFLD may amplify the influence of the TyG index on the risk of CAP. A recent study revealed that people with MAFLD had an elevated risk of ASCVD relative to those without MAFLD.[30] Thus, our findings might provide clinical implications for subjects with MAFLD. Two considerations may explain the likely mechanism of association between the TyG index and CAP. Firstly, IR as measured by the TyG index is related to a reduction in atherosclerosis-promoting shear stress in the carotid artery.[32] Secondly, IR can promote inflammation, oxidative stress, lipohyaline deposition, and metabolic alterations, resulting in inflammation-related damage to the endothelium.[33,34]

Table 4 Sensitivity Analysis for Association Between the TyG Index and CAP After Excluding Participants with Hypertension, Diabetes, Dyslipidemia

	OR (95% CI)[a]		
	Without Hypertension (N=2223)	**Without Diabetes (N=2762)**	**Without Dyslipidemia (N=1864)**
TyG index	1.30 (1.08, 1.57)	1.21 (1.01, 1.44)	1.42 (1.12, 1.78)
Q1	Ref.	Ref.	Ref.
Q2	1.18 (0.81, 1.70)	1.17 (0.84, 1.62)	1.30 (0.90, 1.90)
Q3	1.68 (1.18, 2.41)	1.75 (1.28, 2.40)	1.92 (1.32, 2.82)
Q4	1.49 (1.02, 2.19)	1.33 (0.94, 1.87)	1.66 (1.06, 2.57)
P-trend	<0.05	<0.05	<0.05

Note: [a]Adjusted for age, SBP, DBP, BMI, physical activity, smoking, drinking, salt consumptions, dietary pattern.
Abbreviations: CAP, Carotid artery plaque; TyG, Triglyceride glucose; BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; Q1-Q4, quartile of TyG index; Ref, Reference.

There were some limitations in the study. Firstly, this study was a cross-sectional study. Therefore, caution should be taken in making causal interpretations between the TyG index and CAP. Additional prospective research was required to determine the association in the occupational population. Secondly, due to the occupational features of railway workers, the vast majority of male participants limited the applicability of our findings to females. Thirdly, even though the results have been adjusted for a number of significant confounding variables, there are still a number of other uncollected variables, such as more clinical parameters (eg, waist circumference, apolipoprotein B, etc.) and detailed information about the disease (eg, different hypoglycemic medications, the progression of hypertension, diabetes, hyperlipidemia, etc.). Therefore, additional research on this population is absolutely necessary to gather these confounding factors.

Conclusion

TyG index was significantly associated with CAP, notably in populations with elevated quartiles of TyG index among railway workers. Monitoring the TyG index could be a useful risk management strategy for CAP in occupation population.

Abbreviations

ASCVD, Atherosclerotic cardiovascular disease; BMI, Body mass index; CAP, Carotid artery plaque; CVD, Cardiovascular disease; DBP, Diastolic blood pressure; FBG, Fasting blood glucose; HDL-C, High-density-lipoprotein cholesterol; hs-CRP, High-sensitivity C-reactive protein; IR, Insulin resistance; LDL-C, Low-density-lipoprotein cholesterol; MAFLD, Metabolic dysfunction-associated fatty liver disease; MET, Metabolic equivalent; SBP, Systolic blood pressure; TC, Total cholesterol; TG, Triglyceride; TyG, Triglyceride-glucose.

Data Sharing Statement

The datasets used and/or analyzed in this study are available from the corresponding author upon reasonable request.

Ethics Approval and Consent to Participate

All individuals participated in the survey voluntarily and their informed consent was obtained. This study was in accordance with the principles of the Declaration of Helsinki and approved by the Ethics Committee of Clinical Medical College & Affiliated Hospital of Chengdu University (Grant number: No. PJ 2019-015-02).

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis, and interpretation, or in all these areas; took part in drafting, revising, or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare no conflicts of interest in this work.

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