Association between triglyceride glucose index and abdominal aortic calcification

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Abstract

Background

The triglyceride glucose (TyG) index has been regarded as a simple surrogate marker of insulin resistance. However, few studies have investigated the relationship between the TyG index and abdominal aortic calcification (AAC), an independent predictor of atherosclerotic vascular diseases and mortality.

Methods

A total of 1486 participants with comleted AAC records from the National Health and Nutrition Examination Survey (NHANES) 2013–2014 were enrolled. Baseline variables and abdominal dual-energy X-ray absorptiometry (DXA) data were collected. The TyG index was calculated as ln[triglycerides (mg/dL)×glucose (mg/dL)/2], and the presence of AAC was defined as AAC score > 0.

Results

The participants were 58.8 ± 12.2 year old and 48.6% (722/1486) were male. TyG level was positively correlated with the presence of AAC (β = 1.37, [1.15–1.63]; $p < 0.001$). The highest quartile of TyG was associated with 1.83-fold (odds ratio [OR]: 1.31–2.58; $p < 0.001$) risk of AAC compared with the lowest quantile. After adjusted for lifestyles, comorbidities and calcium metabolism factors, higher TyG level was significantly and linearly associated with higher AAC prevalence. The multivariate-adjusted OR and 95% confidence interval (CI) were 2.12 (1.05–4.35; $p = 0.038$) for participants within the highest quantile and 1.60 (1.07–2.41; $p = 0.022$) per one-unit incresement. Subgroup analysis showed that the association between TyG and AAC was still significant across groups except for age > 60.

Conclusions

Higher TyG index was significantly associated with the higher presence of AAC, which could be a marker of AAC.

Background

Cardiovascular disease (CVD) is a leading cause of death worldwide[1]. Abdominal aortic calcification (AAC), as measured by dual-energy X-ray absorptiometry (DXA)[2], has been established as an independent marker for atherosclerotic vascular diseases [3] and a predictor for all-cause mortality and cardiovascular events [4]. It is of great importance to identify factors in association with the presence of AAC.

The triglyceride glucose (TyG) index has been proposed as a reliable surrogate marker of insulin resistance (IR)[5, 6], which is a pathological condition characterized by poor insulin sensitivity in the peripheral tissues[7]. There is growing evidence to demonstrated that IR contributed to vascular remodeling and incresead vascular calcification [8, 9], thereby increasing the risk of cardiovascular diseases[10]. Many studies have identified TyG index is associated with cardiovascular diseases [11, 12]. However, few study has invesitgated the relationship between the TyG index and AAC in healthy adults.

Terefore, in the present study, we evaluated the association between the TyG index and AAC in US adults using National Health and Nutrition Examination Survey (NHANES) 2013–2014.

Methods

Study population

The National Health and Nutrition Examination Survey (NHANES) is a nationally representative survey performed by the Centers for Disease Control and Prevention. All participants provided written informed consent. A total of 10157 subjects were enrolled in the NHANES 2013–2014. After excluding those without AAC score records (n = 7035) and with missing data on glucose or triglyceride (n = 1654), 1486 participants were included in the current study. The flow chart was depicted in Fig. 1. The study protocol was approved by the review board of the Center of Disease Control and Prevention and all participants provided written informed consent.

Data collection

Information on age, sex, race/ethnicity, education level, family income-povery ratio, smoking status, physical activity, hypertension or diabetes were collected by using standardized questionnaires. Blood samples were obtained after at least 8 h of fasting and measured including glucose, triglyceride, calcium, and phosphorus. Body mass index (BMI) was calculated by weight in kilograms divided by the square of height in metres (kg/m2). BMI was caterigorized into < 25.0, 25.0-29.9, and > 30.0. Race/ethnicity was classified as non-Hispanic white, non-Hispanic black, Mexican American, or other. Education level was categorized as less than high school, high school or equivalent, or college or above. Family income-to-poverty ratio (IPR) was classified as 0–1.0, 1.0–3.0, or > 3.0. Smoking status was classified as never smoker, ever smoker, or current smoker. Physical activity was categorized into vigorous, moderate and inactive. Estimated glomerular filtration rate (eGFR) was defined based on the method of Cockcroft-Gault. High blood pressure (HBP) was defined as the average systolic blood pressure ≥ 140 mmHg, or an average diastolic blood pressure ≥ 90 mmHg or self-report history of hypertension or taking antihypertensive drugs. Diabetes mellitus (DM) was defined as fasting glucose ≥ 7.0 mmol/L or glycated hemoglobin A_{1c} (HbA_{1c} ≥ 6.5%), or self reported diabetes, or taking hypoglycemic medication. All methods were performed in accordance with the relevant guidelines and regulations.

Definition

The TyG index was determined as ln (triglycerides [mg/dL]×glucose [mg/dL]/2). The AAC score were calculated using a Kauppila score system according to lateral lumbar spine dual-energy X-ray absorptiometry (DXA) (https://wwwn.cdc.gov/Nchs/ Nhanes/2013–2014/DXXAAC_H.htm). The extent of calcification of the anterior and posterior aortic wall was graded at each vertebral level from L1 to L4 on a 0–3 scale. Trained technicians acquired and analyzed all DXA scans on the same scanner. The presence of AAC was defined as AAC score > 0.

Statistical Analysis

Continuous variables are presented as the mean ± standard deviations, and categorical variables are presented as numbers (percentages). Intergroup comparisons were performed using Chi-square test or ANOVA. Multivariable logistic regression was used to examine the association between TyG quantile and AAC while multivariable linear regression for TyG as a continuous variable. Odds ratios (ORs) were adjusted for age and sex (Model 1); further adjusted for sociademographic data and lifestyles: race, education, IPR, smoking, BMI, physical activity (Model 2); futher adjusted for the history of diseases and calcium-metabolism asscoaited biochemical data: HBP, DM, calcium, phosphorus and eGFR (Model 3). Subgroup analyses were performed to investigate whether association between TyG and AAC was modified by age, sex, hypertension, diabetes and BMI in the fully adjusted model. Data were analyzed using R sofeware version 3.6.0. P value < 0.05 was considered as statistically significant.

Results

Participants were stratified into four groups according to their TyG quantiles. The baseline clinical and laboratory characteristics of the study population were shown in **Table 1**. Significant differences were observed among the groups. The highest TyG quantile tended to have more percentage of male, non-Hispanic white, obesity and diabetes. In addition, the prevalence of AAC significantly increased with an increase in the TyG index (**Figure 2**).

The relationship between the TyG index and the presence of AAC was explored using multivariable linear regression. As shown in **Figure 3**, after adjusted for age and sex in Model 1, TyG was positive correlated with the presence of AAC (OR 1.37[1.15-1.63]; p<0.001). After further adjusted for sociademographic data and lifestyles, the OR for having AAC per one-unit increasement of TyG was 1.56 (1.10-2.23; p=0.013). Besides, after further adjusted for the history of diseases and calcium-metabolism associated biochemical data, the association was still significant (OR 1.60[1.07-2.41]; p=0.022).

Multivariable logistic regression was used to evaluate the relationship between the TyG index and ACC by categorizing the TyG index into quartiles using the first quartile as the reference (**Table 2**). In model 1, the highest TyG quantile was associated with a higher presence of AAC (1.83[1.31-2.58]; p<0.001). The OR for having AAC in the highest TyG quantile was 2.08 (1.08-4.08; p=0.031). In the fully adjusted model, the association still existed (2.12[1.05-4.35]; p=0.038).

Subgroup analysis for the associations between TyG index and the presence of AAC was shown in **Table 3**. The association was consistent in age>60, male, non-diabetes, and overweight. No significant interactions were observed except for age.

Discussion

In this cross-sectional study, we investigated the association between the TyG index and AAC in healthy U.S. adults. We found that a higher TyG index were significantly associated with the prevalence of AAC. The association was independent of sociademographic data, medical history and calcium-phosphorus metabolism factors.

The TyG index, derived from fasting glucose and triglycerides, has been proposed as an alternative surrogate marker for insulin resistance [13, 14]. Several studies demonstrated that the TyG index was positively correlated with HOMA-IR [15], even has a better predictive value that HOMA-IR[16]. The TyG index has also been proved to be useful for identifying adult population at a high risk of cardiovascular disease [17] and predicting adverse outcomes in patients with type 2 diabetes and CVD [11].In addition, some studies showed that the TyG index was significantly associated with the severity of coronary artery stenosis[18] and artery stiffness [19]. In consistent with previous results that the TyG index associated with coronary artery calcification [20] [21], we confirmed a relationship between the TyG index and abdominal artery calcification.

When investgating the association between the TyG index and artery calcification, we adjusted the cardiovascular risk factors like in most studies. Besdies, we also further adjusted the biochemical parameters including calcium, phosphorus and eGFR, excluding the confounding effect of calcium and phosphorus metabolism. Therefore, the mechanism undelying the relationship could be linked to IR. IR could lead to inflammation and atherosclerosis [22], dampening the distensibility and elasticity of abodominal aorta [23]. Vascular calcification is highly prevalent and, when present, is associated with major adverse cardiovascular events[24].

Some limitations existed in our study. Firstly, this was a cross-sectional study which could not infer causality. Thus, the causal relationship between the TyG index and AAC needs further investigation. Lastly, we could not adjust for lipid-lowering or hypoglycemic drugs, which could affect blood triglyceride and glucose levels.

Conclusions

In our study, we demonstrated that the TyG index was independently associated with the prevalence of AAC in U.S adults, which may serve as a potential predictive marker.

Abbreviations

TyG: triglyceride glucose index; AAC: abdominal aortic calcification; NHANES: National Health and Nutrition Examination Survey; DXA: dual-energy X-ray absorptiometry; CVD: cardiovascular disease; BMI: body mass index; IPR: family income-to-poverty ratio; eGFR: estimated glomerular filtration rate; HBP: high blood pressure; DM: diabetes mellitus.

Declarations

Acknowledgements

Not applicable.

Authors' contributions

B X and LN K designed the study. YH L performed the statistical analysis. MY W wrote the manuscript. All authors read and approved the final manuscript.

Competing interests

There is no conflict of interests.

Availability of data and materials

The datasets were available from NHANES 2013-2014 (https://www.cdc.gov/nchs/nhanes/index.htm).

Consent for publication

Not applicable.

Ethics approval and consent to participate

The study protocol was approved by the review board of the Center of Disease Control and Prevention and all participants provided written informed consent.

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Tables

Table 1 Baseline characteristics of the study population according to TyG index in NHANES 2013-2014.

	Q1(lowest)	Q2	Q3	Q4(highest)	P value
N	372	371	371	372	
Age (years)	57.7±12.9	59.5±12.3	59.4±11.7	59.0±11.7	<0.001
Male (%)	149 (40.1)	183 (49.3)	183 (49.3)	207 (55.6)	0.031
Race/ethnicity (%)					<0.001
Non-Hispanic white	160 (43.0)	177 (47.7)	148 (39.9)	187 (50.3)	
Non-Hispanic black	110 (29.6)	76 (20.5)	52 (14.0)	38 (10.2)	
Mexican American	32 (8.6)	35 (9.4)	64 (17.3)	38 (10.2)	
Other	70 (18.8)	83 (22.4)	107 (28.8)	87 (23.4)	
Education levels (%)					0.090
Less than high school	74 (19.9)	82 (22.1)	108 (29.1)	97 (26.1)	
High school or equivalent	82 (22.1)	77 (20.8)	75 (20.2)	82 (22.1)	
College or above	215 (58.0)	212 (57.1)	188 (50.7)	192 (51.8)	
Family income-poverty ratio (%)					0.003
≤1.0	64 (18.7)	56 (15.9)	79 (23.3)	64 (18.9)	
1.0-3.0	125 (36.4)	116 (32.9)	135 (39.8)	144 (42.5)	
>3.0	154 (44.9)	181 (51.3)	25 (36.9)	131 (38.6)	
BMI (kg/m^2)					<0.001
<25.0	163 (44.1)	126 (34.3)	85 (23.1)	45 (12.1)	
25.0-29.9	124 (33.5)	140 (38.1)	152 (41.3)	145 (39.1)	
≥30.0	83 (22.4)	101 (27.5)	131 (35.6)	181 (48.8)	
Smoking status (%)					0.213
Current smoker	50 (18.1)	60 (21.7)	65 (25.3)	66 (25.4)	
Ever smoker	6 (2.2)	11 (4.0)	9 (3.5)	11 (4.2)	
Never smoker	221 (79.8)	206 (74.4)	183 (71.2)	183 (70.4)	
Physical activity (%)					0.695
Vigorous	61 (32.6)	55 (29.7)	55 (31.2)	71 (37.0)	
Moderate	64 (34.2)	72 (38.9)	68 (38.6)	70 (36.5)	
Inactive	62 (33.2)	58 (31.4)	53 (30.1)	51 (26.6)	
Hypertension (%)	63 (17.7)	75 (20.7)	84 (23.3)	82 (22.5)	0.260
Diabetes (%)	21 (5.7)	41 (11.1)	61 (16.4)	158 (42.5)	<0.001
Glucose（mg/dL）	96.1±11.6	102.1±15.8	108.6±22.5)	138.9±59.2	<0.001
Triglyceride (mg/dL)	54.5±12.7	86.3±15.2	122.4±22.6	235.2±232.9	<0.001
TyG index	7.83±0.26	8.36±0.12	8.77±0.13	9.51±0.47	<0.001
Calcium (mmol/L)	2.34±0.09	2.35±0.09	2.36±0.08	2.36±0.09	0.004
Phosphorus (mmol/L)	1.21±0.18	1.21±0.16	1.21±0.18	1.20±0.18	0.594
eGFR (ml/min per 1.73m^2)	92.9±34.0	92.9±33.5	96.6±34.8	104.9±40.1	<0.001
AAC (%)	88 (23.7)	114 (30.7)	138 (37.2)	137 (36.8)	<0.001

Data are the mean ± SD, or number (percentage). *BMI* body mass index, *TyG* triglyceride glucose, *eGFR* estimated glomerular filtration rate, *AAC* abdominal aortic calcification.

Table 2 Odds ratios and 95% confidence intervals for AAC according to TyG index.

	OR (95% CI) *P*			
	Q1	Q2	Q3	Q4
Model 1	1.00	1.30 (0.92-1.84) *P*=0.139	1.83 (1.31-2.57) *P*<0.001	1.83 (1.31-2.58) *P*<0.001
Model 2	1.00	0.92 (0.48-1.76) *P*=792	2.05 (1.05-4.06) *P*=0.037)	2.08 (1.08-4.08) *P*=0.031
Model 3	1.00	0.92 (0.47-1.80) *P*=0.816	1.99 (0.99-4.07) *P*=0.056	2.12 (1.05-4.35) *P*=0.038)

Model 1: adjusted for age, and sex.

Model 2: further adjusted for race, edu, IPR, smoking, BMI, and physical activity.

Model 3: further adjusted for HBP, DM, calcium, phosphorus, and eGFR.

OR odds ratio, *95% CI* 95% confidence interval.

Table 3 Subgroups analysis for the associations between TyG index and the presence of AAC.

	OR (95% CI)	*P* for interaction
Age		0.008
≤60	1.04 (0.96-1.12)	
>60	**1.21 (1.03-1.41)**	
Gender		0.657
Female	1.06 (0.96-1.18)	
Male	1.10 (1.00-1.21)	
Hypertension		0.985
No	1.05 (0.97-1.13)	
Yes	1.13 (0.94-1.35)	
Diabetes		0.546
No	1.08 (1.00-1.17)	
Yes	1.08 (0.89-1.32)	
BMI		0.979
<25.0	1.10 (0.96-1.26)	
25.0-29.9	1.14 (1.02-1.27)	
≥30.0	1.01 (0.89-1.15)	

Analyses were adjusted in Model 3 except for the strata variables.

Figures

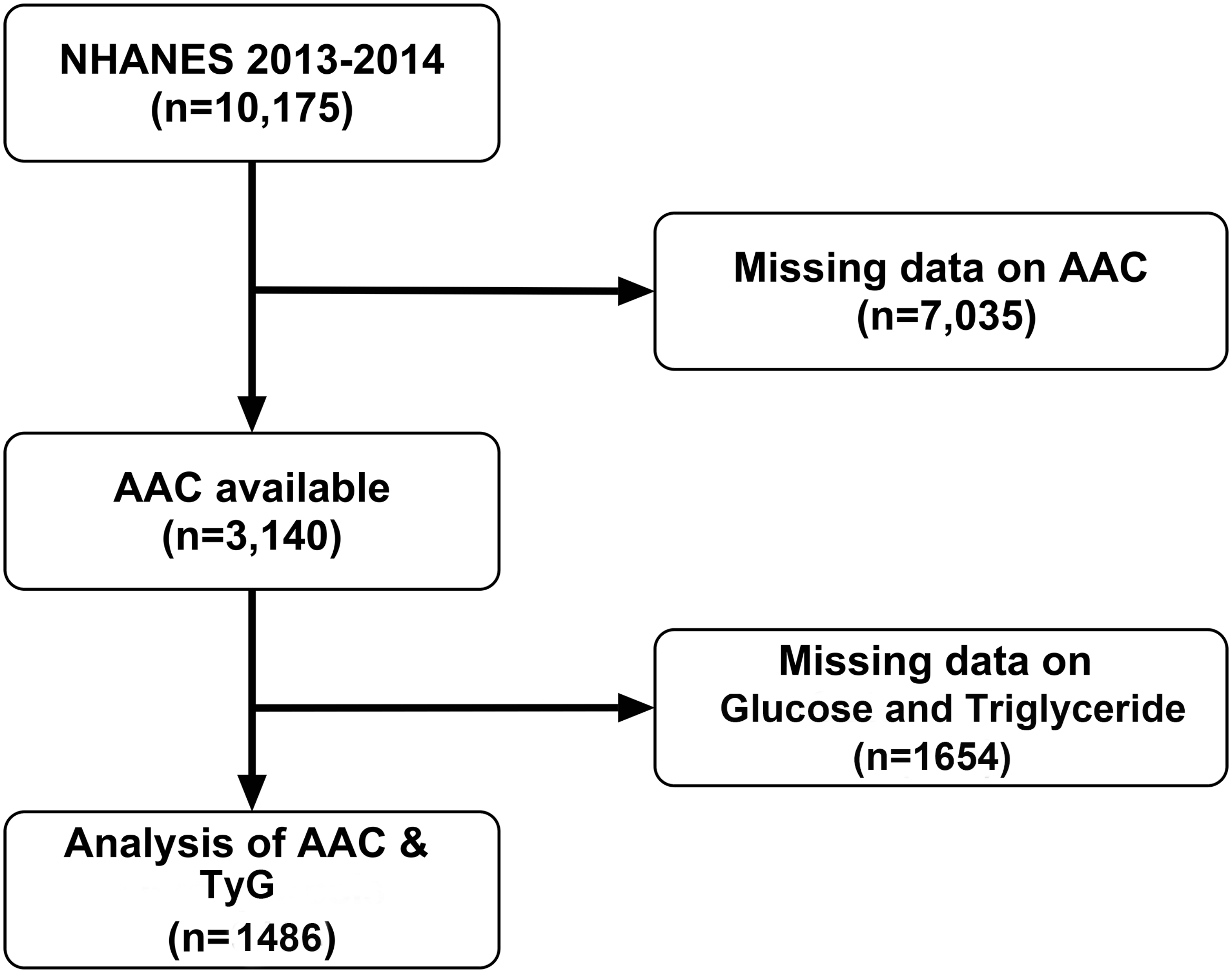

Figure 1

The flow chart of participant selection.

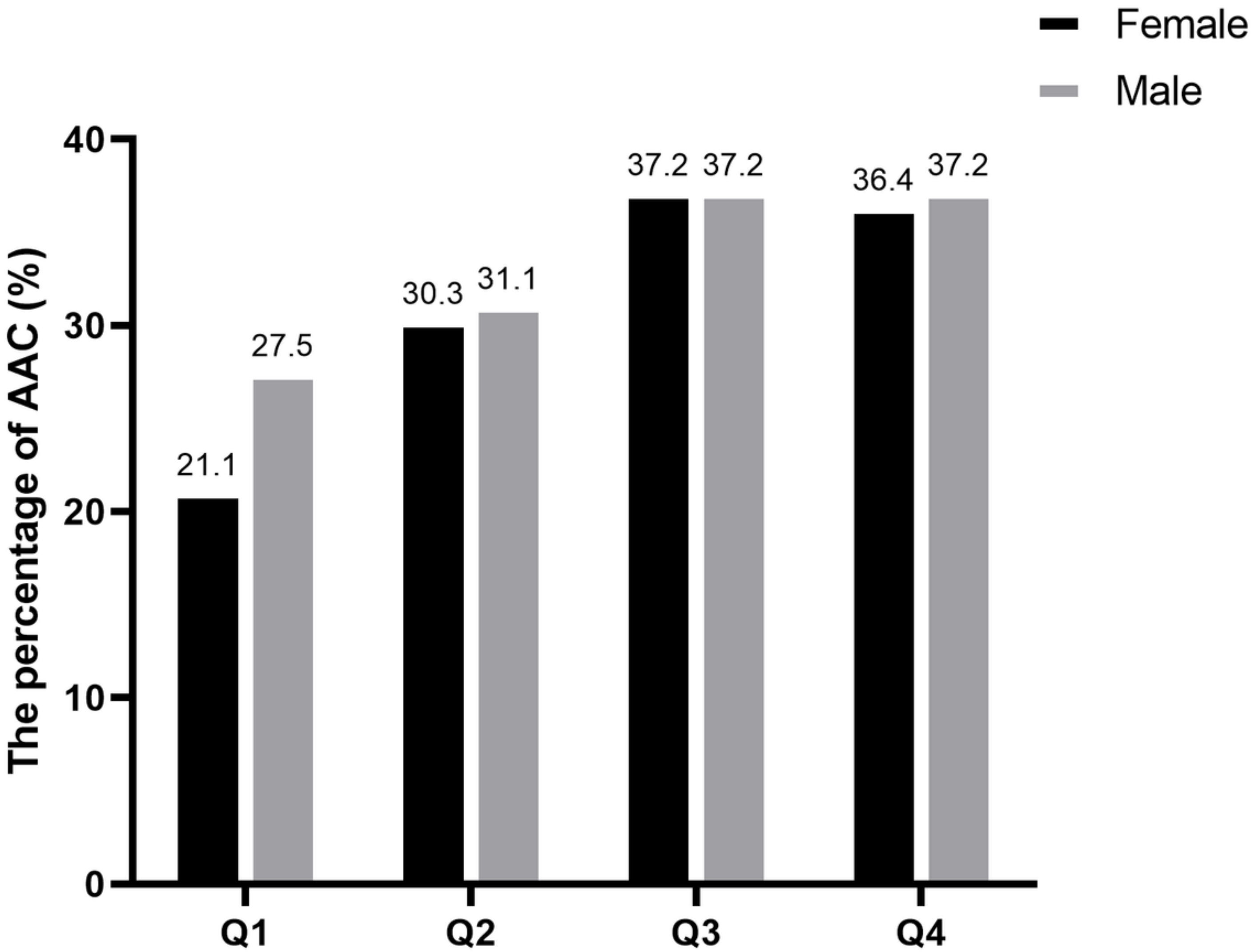

Figure 2

The percentage of AAC between gender according to TyG quantitles.

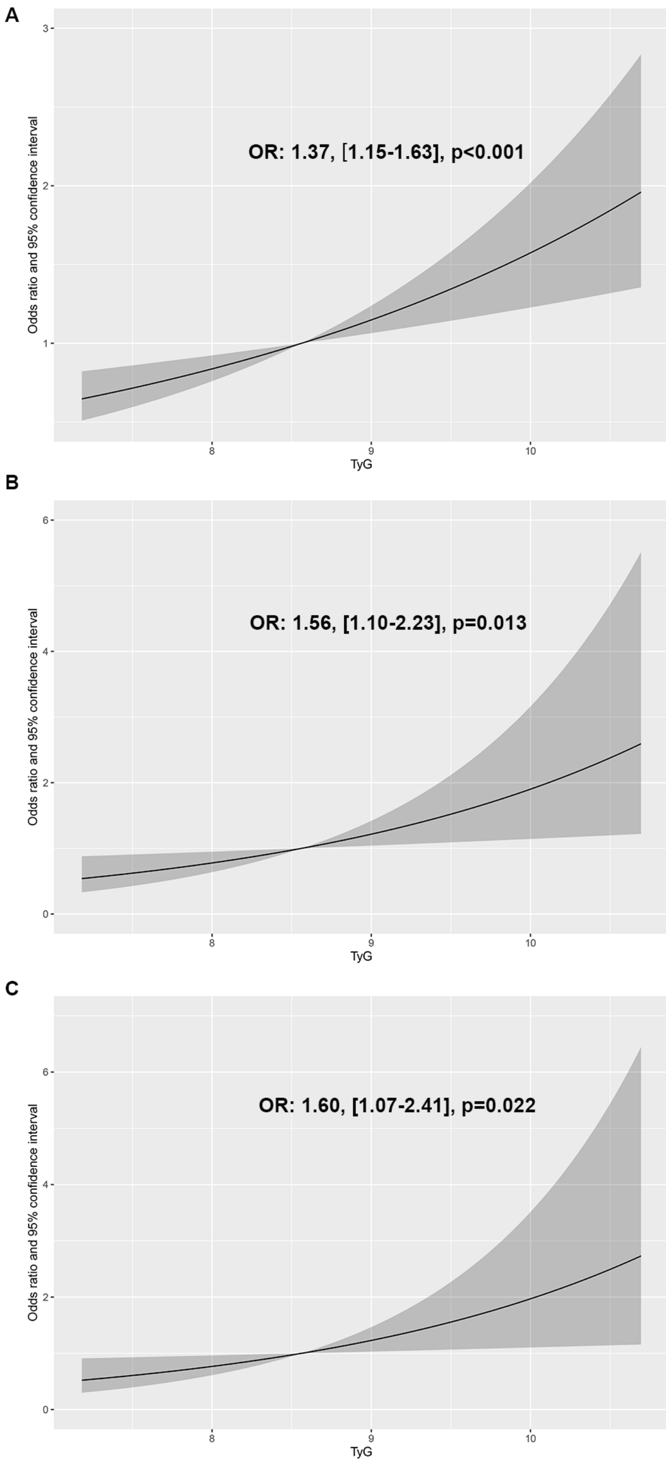

Figure 3

Multivarible linear regression between TyG (per one-unit increasement) and AAC in different models.