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Association between triglyceride glycemic index and gout in US adults

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Abstract

Background Insulin resistance (IR) has been linked to the development of gout. The triglyceride glycemic (TyG) index is a useful biomarker of IR, and the evidences between TyG and gout are limited. Therefore, this study aimed to examine the association between the TyG index and gout in the United States (U.S).

Methods The cross-sectional study was conducted among adults with complete TyG index and gout data in the 2007–2017 National Health and Nutrition Examination Survey (NHANES). The TyG index was calculated as fasting triglycerides (mg/dl) * fasting glucose (mg/dl)/2. Gout was assessed by self-report questionnaire (MCQ160n). Weighted chi-squared and weighted Student's t-test were used to assess group differences. Weighted multivariable logistic regression analysis, subgroup analysis, and interaction tests were used to examine the TyG index and gout association.

Results The final participants were 11,768; 5910 (50.32%) were female, 7784 (73.26%) were 18–60 years old, 5232 (69.63%) were white, and 573 (5.12%) had gout. After adjusting for all covariates, the TyG index was positively associated with gout; each unit increase in TyG index was associated with 40% higher odds of gout (odds ratio (OR), 1.40; 95% CI: 1.82–2.66; $p < 0.0001$). Participants in the highest TyG index tertile group were at high risk of gout (odds ratio (OR), 1.64; 95% CI: 1.06–2.54, $p = 0.03$) versus those in the lowest tertile group. Interaction tests showed no significant effect of age, race, marital status, PIR level, education, BMI, smoking status, drinking status, hypertension, and DM on this association between TyG index and gout (p for interaction > 0.05).

Conclusions In this large cross-sectional study, our results suggested that a higher TyG index was associated with an increased likelihood of gout in U.S. adults. Our findings highlight that the TyG index is a reliable biomarker of IR; management of IR among adults may prevent or alleviate the development of gout; meanwhile, the TyG index may be a simple and cost-effective method to detect gout.

Keywords Gout, Triglyceride glycemic index, Insulin resistance, National Health and Nutrition Examination Survey, Cross-sectional study

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Introduction

Gout is a chronic metabolic disease clinically characterized by joint deformity, chronic pain, bone erosion, and functional impairment caused by the deposition of monosodium urate crystals in the inflammatory reaction of joints and other tissues [1]. Patients with gout are more likely to suffer from gout arthritis, gouty nephropathy, hypertension, and diabetes [2, 3]. Nearly 53.87 million adults worldwide suffered from gout in 2019 [4]. The prevalence of gout ranged from 1 to 6.8%, and the prevalence of gout in the US was 3.9% and was highest among adults in the non-Hispanic black population [5, 6]. Given its high prevalence and a negative impact on unfavorable physical health [5], gout has become a major public health concern.

The TyG index was considered a good and novel index that could reflect insulin resistance (IR) [7]. It integrates triglycerides and fasting glucose, and was calculated by fasting triglycerides(mg/dl)*fasting glucose (mg/dl)/2, which was developed by Mendía et al. in 2008 and has been investigated widely [7]. Several studies have shown that the TyG index is associated with metabolic diseases such as diabetes [8], acute coronary syndrome [9], heart failure [10], and non-alcoholic fatty liver disease [11]. As it is more convenient and easily accessible in clinical settings compared to the complex technique of the plasma insulin in the homeostasis model assessment of IR, the TyG index may be a useful tool or reliable biomarker for assessing IR and its implication in metabolic diseases.

Accumulating evidence has shown that IR plays a role in the pathological process of gout. Han-Gyul Yoo et al. reported that the hyperuricemia in gout seemed to originate in the background of IR and increased adiposity [12]. Li et al. found that IR could increase Na (+) reabsorption at the level of the renal proximal tubule, inhabit the urate excretion, and induce hyperuricemia leading to acute gouty arthritis [13, 14]. Krishnan et al. reported that IR-induced hyperinsulinemia could also directly inhibit renal uric acid excretion and lead to hyperuricemia [15]. A cross-sectional study evaluating the role of uric acid in type 2 diabetes and metabolic syndrome found that excessive production of uric acid and active oxygen anion free radicals may be an important cause of IR [16]. Inflammatory reaction and IR have been proven to be related to gout; however, the association between the TyG index and gout has not been clearly defined.

Given that the TyG index may be a useful tool or reliable biomarker for assessing IR, which is related to the mechanism of gout, this study aimed to examine the association between the TyG index and gout in a large, nationally representative sample of U.S. adults using the NHANES dataset from 2007 to 2017. Therefore, this research has good generalizability. We hypothesized that a higher TyG index was associated with an increased likelihood of gout. The findings of this study will help us elucidate the association between the TyG index and gout among U.S. adults.

Methods

Study population

Our study combined six years of NHANES cycles (2007–2008, 2009–2010,2011–2012, 2013–2014, 2015–2016, and 2017–2018) with a total of 11,768 participants older than 18 years old. Our analysis included demographic information, lifestyle factors, disease history, and laboratory information (http://www.cdc.gov/nchs/nhanes/about nhanes.htm). Exclusion criteria for participants in our study were (1) missing data for Fglu, Ftrig, and TyG index [7], (2) missing data for gout, (3) missing data for covariates, (4) age < 18 years of age. Participants with missing data were discarded by listwise deletion. A total of 57,414 participants were initially recruited; after excluding missing TyG index (n = 19,407), missing gout (n = 1783), and missing covariates (n = 2204), 11,768 eligible participants aged > 18 years of age were included in our final analysis (Fig. 1).

Ethical considerations

The use of the dataset from the NHANES was approved by the National Center for Health Statistics (NCHS) Institutional Review Board, and written informed consent was obtained from all participants.

Definition of TyG index

The definition of the TyG index is as follows: TyG index = fasting triglycerides(mg/dl)*fasting glucose(mg/dl)/2 [7]. In our study, the TyG index was designed as an exposure variable. According to previous studies, participants were equally divided into three groups according to the TyG index distribution: tertile 1(5.65,8.30), tertile 2(8.30,8.85), and tertile 3(8.85,12.84).

Definition of gout

In the health questionnaire MCQ160n (https://wwwn.cdc.gov/Nchs/Nhanes/2007-2008/MCQ_E.htm#MCQ160N), participants were asked, "doctor or other health professional ever told you that you had gout?" and if the answer was "yes," they subsequently considered to have gout in further analysis.

Assessment of covariates

To account for potential confounding factors between the TyG index and gout, we controlled the following covariates in this study. Demographic data included age (18–60, ≥60), gender (female, male), race (non-Hispanic Black, Mexican American, other races, non-Hispanic White), PIR level (≤1.3,1.3–3.5,>3.5), education (less than 9th grade, 9th to 11th grade, high school grad/GED

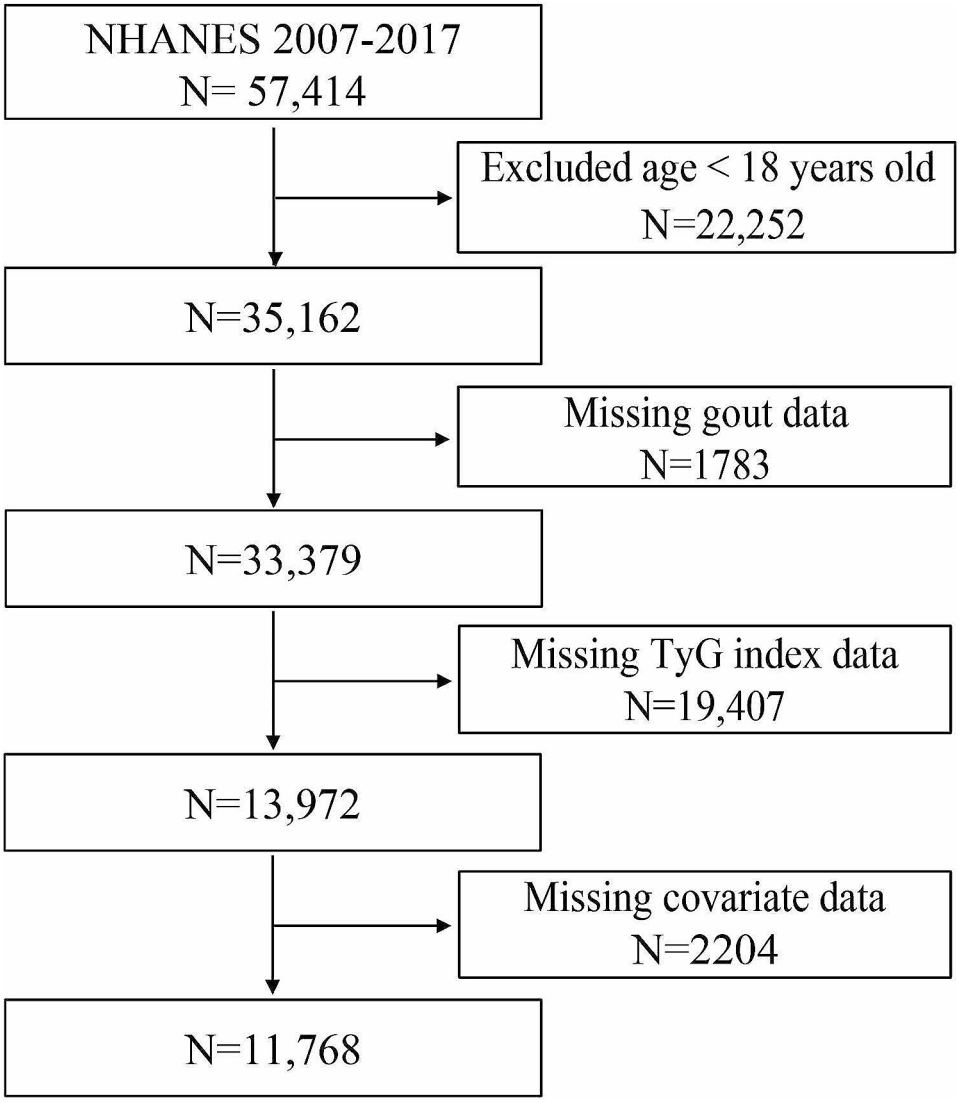

Fig. 1 Flowchart of the study participants selection from NHANES 2007–2017 **Supplementary Information**

or equivalent, some college or associate degree). Lifestyle factors included BMI (<25,25-29.99,>30), smoking status (never, former, now), and drinking status (never, former, mild, moderate, heavy). Disease history included hypertension (no, yes) and diabetes (no, IFG, IGT, DM).

Statistical analysis

Sampling weights(wtmec2 year) provided by the NHANES were applied in R 4.3.1 to account for the complex multistage cluster survey [17, 18]. Participants were divided into three groups (t1-3) according to the tertile of the TyG index and two groups according to heart failure and non-heart failure group. A weighted chi-square and Student's t-test were used to evaluate group differences. Weighted multivariable logistic regression was used to test the association between TyG index and gout in four different models. No covariates were adjusted in the unadjusted model. Model 1 was adjusted for age, gender, race, PIR level, and education. Model 2 was adjusted for age, gender, race, PIR level, education, BMI, smoking status, and drinking status. Model 3 was adjusted for age, gender, race, PIR level, education, BMI, smoking status, drinking status, hypertension, and DM. A weighted subgroup analysis on the association between TyG index and gout was performed with stratified factors including age (18–60, ≥60), gender (female, male), race (non-Hispanic Black, Mexican American, other races, non-Hispanic White), PIR level (≤1.3,1.3–3.5,>3.5), education(less than 9th grade,9th to 11th grade, high school grad / GED or equivalent, some college or associate degree), BMI (<25,25-29.99,>30), smoking status (never, former, now), drinking status (never, former, mild, moderate, heavy), hypertension (no, yes), and diabetes (no, IFG, IGT, DM). We further categorized the TyG index into three tertiles

as categorical variables (t1 to t3, setting t1 as reference) to evaluate potential trends in the association. A weighted interaction analysis was added to test the heterogeneity of associations between different groups as well. All analyses were performed using R version 4.3.1 (https://www.r-project.org/), and the significance level was set at a p-value of <0.05.

Results

Baseline characteristics of participants

Table 1 showed the weighted baseline characteristics stratified by the TyG index. A total of 11,768 participants were identified from the 2007 to 2017 cycles of NHANES, including 5910 women and 5858 men. Among the participants, 73.26% were <60 years old, while 26.74% were ≥60 years. Regarding gender, 50.32% were women, and 49.68% were men. Regarding race, 69.63% were non-Hispanic White, 14.34% were non-Hispanic Black, 12.47% were other race groups, and 8.15% were Mexican American. The range concentrations of Ftrig, Fglu, and TyG index were 124.21(1.53), 106.99(0.42), and 8.59(0.01). Participants were divided into three groups according to the tertiles of the TyG index, with T1 ranging from 5.65 to 8.30, T2 ranging from 8.30,8.85, T3 ranging from 8.85 to 12.84. A significant progressive gain in the prevalence of gout was observed as the participants' TyG index increased (T1: 2.07, T2: 3.39, T3: 6.98, $p<0.0001$).

The baseline characteristics of the participants by TyG index tertiles are shown in Table 2, Figure S1, and S2, from which we can find statistically significant differences in age, gender, race, marital status, PIR level, education, BMI, smoking status, drinking status, hypertension, DM, gout, Ftrig, and Fglu (all $p<0.05$). The results of the univariate and multivariate analysis of gout were shown in Table S1 and S2.

Association between TyG index and gout

Table 3 showed the weighted multivariate logistic regression results for the TyG index and gout association. A higher TyG index was associated with an increased likelihood of increased gout. This association was significant both in the unadjusted model (OR=2.15; 95% CI, 1.78,2.58, $p<0.0001$), model 1(OR=2.20; 95% CI, 1.82,2.66, $p<0.0001$), and model 2 (OR=1.83; 95% CI, 1.50,2.24, $p<0.0001$). In the model 4, the positive association between TyG index and gout still remained stable (OR=1.40; 95% CI, 1.14,1.71, $p=0.001$). We further converted the TyG index from a continuous variable to a categorical variable (tertiles). Compared with the lowest TyG index (T1), participants in the highest TyG index tertile (T3) had a significantly 64% increased risk of gout than those in the lowest TyG index tertile with statistical significance (OR=1.64; 95% CI, 1.06,2.54, $p=0.03$).

Subgroup analysis

Table 4 showed the weighted subgroup analysis of the TyG index and gout association across various demographic characteristics, lifestyle factors, and disease history. For the subgroup stratified by age, gender, race, marital status, PIR level, education, BMI, smoking status, and hypertension, a significant association of the TyG index with gout was detected in each group (all $p<0.05$). As for subgroup stratified by DM, association with statistical significance was only observed in those with no-diabetes, IGT, diabetes (all $p<0.05$). For participants with IFG, a positive relationship between the TyG index and gout was also observed, while this relationship did not meet the statistical significance (OR=1.427; 95% CI, 0.928,2.196, $p=0.104$). The interaction test revealed no significant differences among age, race, marital status, PIR level, education, BMI, smoking status, drinking status, hypertension, and DM (all p for interaction >0.05). On the contrary, gender may influence the positive relationship between TyG index and gout (p for interaction <0.05).

Discussion

In this national representative cross-sectional study with 11,768 participants enrolled, the relationship between the TyG index and gout was evaluated. The main finding of this study was that a higher level of TyG index increased the likelihood of having gout. The result remained consistent after adjusting for relevant confounding variables in Model 3(fully adjusted model). Subgroup analysis and interaction test showed that this relationship was similar across population settings.

A limited number of studies have evaluated the relationship between TyG index and gout. Most studies evaluated the association between gout and IR using the homeostatic model assessment index (HOMA-B) for beta cell function, HOMA-IR for peripheral tissue IR, and glucose clamp technique [19, 20]. In one early study of 46 gout male patients aged 41.96±5.77 years using HOMA-IR and HOMA-B to evaluate the association between IR and gout, a statistically significant association was found between IR and gout [19]. However, these traditional techniques are complex and time-consuming, and the impairment in the oxidation and utilization of fatty acids in IR and several important covariates were not considered, including BMI, hypertension, and diabetes. In our study, we included 11,768 participants from six NHANES cycles (2007 to 2017), evaluated IR and gout using the TyG index, and comprehensively adjusted for potential covariates, which added more robust evidence regarding the positive association between the TyG index and gout.

The possible biological mechanisms that account for the relationship between TyG index and gout are indeed complex. The observed relationship reveals potential

Table 1 Baseline characteristics of the study population according to the TyG index

Variable	Total	Tertile 1	Tertile 2	Tertile 3	*P*-value
Age					< 0.0001
18–60	7784(73.26)	2940(79.63)	2488(71.73)	2356(67.90)	
≥ 60	3984(26.74)	983(20.37)	1432(28.27)	1569(32.10)	
Gender					< 0.0001
Female	5910(50.32)	2303(58.38)	1900(49.25)	1707(42.63)	
Male	5858(49.68)	1620(41.62)	2020(50.75)	2218(57.37)	
Race					< 0.0001
Non-Hispanic Black	2289(9.75)	1105(14.34)	706(8.66)	478(5.88)	
Mexican American	1749(8.15)	390(5.99)	605(8.64)	754(10.01)	
Other races	2498(12.47)	798(12.17)	836(12.41)	864(12.85)	
Non-Hispanic White	5232(69.63)	1630(67.50)	1773(70.29)	1829(71.26)	
Marital status					0.01
Living alone	4728(36.04)	1718(37.70)	1546(37.04)	1464(33.18)	
Married or living with a partner	7040(63.96)	2205(62.30)	2374(62.96)	2461(66.82)	
PIR level					0.02
≤ 1.3	3667(21.02)	1113(19.73)	1215(20.89)	1339(22.57)	
1.3–3.5	4497(35.96)	1525(35.54)	1463(35.21)	1509(37.21)	
> 3.5	3604(43.02)	1285(44.73)	1242(43.90)	1077(40.21)	
Education					< 0.0001
Less than 9th grade	1091(4.77)	226(3.26)	362(4.79)	503(6.40)	
9th to 11th grade	1637(10.29)	471(8.53)	532(10.12)	634(12.40)	
High school grad and GED or equivalent	2684(22.76)	792(19.61)	952(23.37)	940(25.56)	
Some College or associate degree	6356(62.18)	2434(68.60)	2074(61.71)	1848(55.65)	
BMI					< 0.0001
< 25	3403(29.58)	1760(47.14)	1079(26.92)	564(13.15)	
25-29.99	3909(33.17)	1161(29.82)	1412(36.34)	1336(33.52)	
> 30	4456(37.25)	1002(23.04)	1429(36.74)	2025(53.33)	
Smoking status					< 0.0001
Never	6459(55.07)	2434(61.84)	2119(54.32)	1906(48.46)	
Former	2921(25.75)	809(21.85)	971(25.93)	1141(29.84)	
Now	2388(19.17)	680(16.31)	830(19.75)	878(21.71)	
Drinking status					< 0.0001
Never	1592(10.37)	538(10.80)	525(10.36)	529(9.92)	
Former	1839(12.82)	478(10.02)	595(12.17)	766(16.57)	
Mild	4103(38.02)	1426(38.02)	1383(38.14)	1294(37.90)	
Moderate	1816(17.55)	741(21.26)	568(16.27)	507(14.84)	
Heavy	2418(21.23)	740(19.89)	849(23.07)	829(20.78)	
Hypertension					< 0.0001
No	6711(61.42)	2709(74.52)	2226(61.24)	1776(47.27)	
Yes	5057(38.58)	1214(25.48)	1694(38.76)	2149(52.73)	
DM					< 0.0001
No	7092(65.90)	3195(85.25)	2465(68.52)	1432(42.01)	
IFG	1181(10.43)	219(5.54)	418(10.50)	544(15.70)	
IGT	955(7.20)	230(4.51)	384(9.05)	341(8.21)	
DM	2540(16.47)	279(4.69)	653(11.93)	1608(34.07)	
Gout					< 0.0001
No	11,195(95.92)	3825(97.93)	3743(96.61)	3627(93.02)	
Yes	573(4.08)	98(2.07)	177(3.39)	298(6.98)	
Ftrig	124.21(1.53)	59.88(0.42)	105.68(0.42)	213.90(3.30)	< 0.0001
Fglu	106.99(0.42)	95.81(0.29)	102.80(0.32)	123.58(1.02)	< 0.0001

Table 2 Baseline characteristics of the gout group versus the non-grout group

Variable	Total	Non-grout	Gout group	*P*-value
Age				< 0.0001
18–60	7784(73.26)	7598(74.59)	186(41.97)	
≥ 60	3984(26.74)	3597(25.41)	387(58.03)	
Gender				< 0.0001
Female	5910(50.32)	5742(51.02)	168(33.91)	
Male	5858(49.68)	5453(48.98)	405(66.09)	
Race				0.02
Non-Hispanic Black	2289(9.75)	2158(9.71)	131(10.73)	
Mexican American	1749(8.15)	1703(8.31)	46(4.33)	
Other races	2498(12.47)	2392(12.49)	106(11.98)	
Non-Hispanic White	5232(69.63)	4942(69.49)	290(72.95)	
Marital				0.02
Living alone	4728(36.04)	4535(36.33)	193(29.37)	
Married or living with a partner	7040(63.96)	6660(63.67)	380(70.63)	
PIRlevel				0.56
≤ 1.3	3667(21.02)	3486(20.97)	181(22.14)	
1.3–3.5	4497(35.96)	4279(36.09)	218(32.93)	
> 3.5	3604(43.02)	3430(42.93)	174(44.93)	
Education				0.65
Less than 9th grade	1091(4.77)	1029(4.72)	62(6.01)	
9th to 11th grade	1637(10.29)	1558(10.31)	79(9.82)	
High school grad and GED or equivalent	2684(22.76)	2533(22.76)	151(22.79)	
Some College or associate degree	6356(62.18)	6075(62.22)	281(61.37)	
BMI				< 0.0001
<25	3403(29.58)	3313(30.31)	90(12.45)	
25-29.99	3909(33.17)	3734(33.38)	175(28.23)	
>30	4456(37.25)	4148(36.31)	308(59.32)	
Smoking status				< 0.0001
Former	2921(25.75)	2692(25.16)	229(39.63)	
Never	6459(55.07)	6214(55.47)	245(45.70)	
Now	2388(19.17)	2289(19.37)	99(14.67)	
Drinking status				< 0.001
Never	1592(10.37)	1528(10.46)	64(8.36)	
Former	1839(12.82)	1705(12.45)	134(21.63)	
Mild	4103(38.02)	3892(37.96)	211(39.36)	
Moderate	1816(17.55)	1745(17.75)	71(12.99)	
Heavy	2418(21.23)	2325(21.38)	93(17.66)	
Hypertension				< 0.0001
No	6711(61.42)	6595(63.15)	116(20.66)	
Yes	5057(38.58)	4600(36.85)	457(79.34)	
DM				< 0.0001
No	7092(65.90)	6896(67.01)	196(39.84)	
DM	2540(16.47)	2288(15.54)	252(38.30)	
IFG	1181(10.43)	1101(10.19)	80(16.05)	
IGT	955(7.20)	910(7.26)	45(5.80)	
TyG	8.59(0.01)	8.57(0.01)	8.96(0.05)	< 0.0001
Ftrig	124.21(1.53)	122.61(1.52)	161.91(7.91)	< 0.0001
Fglu	106.99(0.42)	106.34(0.40)	122.18(3.36)	< 0.0001

mechanisms linking IR, oxidative stress, and inflammation to the pathogenesis of gout [21–24]. On the one hand, gout is known to be a chronic low-level inflammation disease; it induces dysfunction of vascular endothelial cells and reduces the production of nitric oxide (NO), which is an important molecule that assists insulin in promoting glucose uptake by cells [25, 26]. The decrease of NO reduces insulin-induced glucose uptake

Table 3 Association between TyG index and gout

	OR (95%CI), *p*-value			
	Unadjusted model	**Model 1**	**Model 2**	**Model 3**
Continuous				
	2.15(1.78,2.58)	2.20(1.82,2.66)	1.83(1.50,2.24)	1.40(1.14,1.71)
	< 0.0001	< 0.0001	< 0.0001	0.001
Categories				
Tertile1	ref	ref	ref	ref
Tertile2	1.66(1.15,2.40)	1.72(1.19,2.50)	1.41(0.95,2.09)	1.15(0.79,1.68)
	0.01	0.005	0.09	0.47
Tertile3	3.56(2.38,5.31)	3.72(2.47,5.61)	2.57(1.65,4.02)	1.64(1.06,2.54)
	< 0.0001	< 0.0001	< 0.0001	0.03
p for trend	< 0.0001	< 0.0001	< 0.0001	0.019

by muscle and adipose tissues [27]. On the other hand, gout is a metabolic arthropathy associated with hyperuricemia. Uric acid as a byproduct of purine metabolism, and excessive uric acid results in a pro-inflammatory response [1]. Meanwhile, urate crystals deposited in the joints and periarticular tissues stimulate the production of interleukins (IL)-1β, which leads to inflammatory responses [28]. In addition, animal models demonstrated hyperuricemia related to oxidative stress, inhibiting ATK phosphorylation and increasing insulin receptor substrate phosphorylation in the liver, muscle, and adipose tissue [29]. This impedes insulin signaling pathways, ultimately leading to IR and impaired glucose tolerance. Last but not least, metabolic diseases, including DM, are associated with the development of gout, and IR is the common pathophysiological mechanism of DM and gout [30]. DM may affect gout through hyperinsulinemia, which affects the expression of uric acid transporters and reduces renal excretion of uric acid, resulting in the occurrence of gout [31, 32]. Future studies are expected to clarify the underlying mechanism.

To the best of our knowledge, this is the first study on the association between the TyG index and gout based on the large sample size of the NHANES database. Therefore, this study contributes to the literature. Continuous and categorical variables were employed as various forms of independent variables to construct robust multiple regression models; it adds strong evidence regarding the positive association between the TyG index and gout. Last, we adjusted for confounding factors, such as a wide range of sociodemographic, lifestyle, and diseases, to produce more reliable results.

The limitation of this study is mainly the cross-sectional design, which prevents us from establishing the causal relationship between the TyG index and gout, and longitudinal studies are needed to demonstrate the causality between the TyG index and gout. Additionally, the diagnosis of gout in this study was based on the patients' self-reporting, which is prone to bias and cannot identify the specific forms of gout, such as visceral or articular gout. Medications that might influence gout and TyG index were not included in this study.

Conclusion

This study demonstrated that the TyG index was positively associated with gout; each unit increase in the TyG index was associated with 40% higher odds of gout (odds ratio (OR), 1.40; 95% CI: 1.82–2.66; $p<0.0001$). Participants in the highest TyG index tertile group were at high risk of gout (odds ratio (OR), 1.64; 95% CI: 1.06–2.54, $p=0.03$) versus those in the lowest tertile group, and higher TyG index levels may be associated with a higher incidence of gout. These results underscore that the treatment and management of IR may prevent or improve the occurrence and development of gout, and the TyG index may be a predictive tool for gout. Further, longitudinal studies are needed to examine the causal association between the TyG index and gout in the broader population to elucidate the potential mechanism of IR on gout.

Table 4 Subgroup analysis of the association between TyG index and gout

Character	95% CI	*p*	*p* for interaction
Age			0.36
18–60	2.225(1.718,2.880)	< 0.0001	
≥60	1.925(1.519,2.440)	< 0.0001	
Gender			0.005
Female	2.654(2.002,3.518)	< 0.0001	
Male	1.788(1.461,2.189)	< 0.0001	
Race			0.113
Mexican American	1.397(1.029,1.898)	0.033	
Other races	2.416(1.660,3.517)	< 0.0001	
Non-Hispanic White	2.347(1.793,3.072)	< 0.0001	
Non-Hispanic Black	1.729(1.403,2.129)	< 0.0001	
Marital status			0.408
Married or living with a partner	2.050(1.646,2.552)	< 0.0001	
Living alone	2.335(1.792,3.042)	< 0.0001	
PIR level			0.571
≤ 1.3	2.195(1.824,2.641)	< 0.0001	
1.3–3.5	2.347(1.822,3.025)	< 0.0001	
> 3.5	1.975(1.420,2.747)	< 0.0001	
Education			0.356
Less than 9th grade	1.492(1.041,2.137)	0.030	
9th to 11th grade	2.127(1.439,3.143)	< 0.001	
Some College or associate degree	2.301(1.814,2.920)	< 0.0001	
High school grad and GED or equivalent	2.016(1.436,2.829)	< 0.0001	
BMI			0.076
25-29.99	1.496(1.164,1.922)	0.002	
>30	1.936(1.526,2.454)	< 0.0001	
<25	2.442(1.626,3.667)	< 0.0001	
Smoking status			0.447
Never	2.148(1.612,2.861)	< 0.0001	
Now	1.697(1.228,2.345)	0.002	
Former	2.243(1.757,2.863)	< 0.0001	
Drinking status			0.163
Never	1.367(0.938,1.994)	0.103	
Former	1.725(1.189,2.503)	0.005	
Mild	2.299(1.728,3.060)	< 0.0001	
Moderate	2.230(1.518,3.276)	< 0.0001	
Heavy	2.495(1.737,3.582)	< 0.0001	
Hypertension			0.265
No	1.963(1.426,2.704)	< 0.0001	
Yes	1.636(1.339,2.000)	< 0.0001	
DM			0.055
No	2.052(1.451,2.902)	< 0.0001	
IFG	1.427(0.928,2.196)	0.104	
IGT	2.590(1.535,4.370)	< 0.001	
DM	1.340(1.030,1.742)	0.029	

Abbreviations

DM	Diabetes Mellitus
IR	Insulin Resistance
TyG	Triglyceride Glycemic Index
NHANES	National Health and Nutrition Examination Survey
BMI	Body Mass Index
Ftrig	Fasting Triglycerides
Fglu	Fasting Glucose

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s41043-024-00613-4.

Additional file: Figure S1. The change in the different gender on TyG index.

Additional file: Figure S2. The change in the different age on TyG index.

Additional file: Table S1. Weighted univariate logistic regression analyses of gout.

Additional file: Table S2. Weighted multivariate logistic regression analyses of gout.

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Author contributions
Wanqin Hu, Huilan Zhang, Qianyu Wu, and Siwei Guo participated in the conception and design of this study. Tao Li analyzed and interpreted the data, and Wanqin Hu wrote the manuscript. All authors read and approved the final manuscript.

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Data availability
Publicly available datasets were analyzed in this study. These data can be found here: https://www.cdc.gov/nchs/nhanes/.

Declarations

Ethics approval and consent to participate
The use of the dataset from the NHANES was approved by the National Center for Health Statistics (NCHS) Institutional Review Board. Informed consent forms were obtained from all participants. Our university's Institutional Review Board determined this study as exempt.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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