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Association between the triglyceride glucose body mass index and asthma: evidence from NHANES 2011–2018

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Abstract

Background Asthma is a common chronic respiratory disease whose increasing prevalence poses a significant burden to human health and the economy. Several studies indicate that insulin resistance (IR) is associated with asthma development. The triglyceride-glucose body mass index (TyG-BMI) is a novel biomarker used to evaluate insulin resistance; however, limited research exists on the relationship between TyG-BMI and asthma. This study aimed to investigate the relationship between TyG-BMI and asthma in U.S. adults.

Method This cross-sectional study utilized data from the National Health and Nutrition Examination Survey (NHANES) database for the 2011–2018 cycles. The exposure variable was the TyG-BMI of participants at baseline, which was calculated based on triglycerides (TG), fasting blood glucose (FBG), and body mass index (BMI). The primary outcome variable was asthma status, determined via questionnaire. We analyzed participants' baseline characteristics and employed weighted multivariate logistic regression models to assess the correlation between TyG-BMI and asthma. A subgroup analysis was conducted to assess whether the relationship between TyG-BMI and asthma was influenced by other factors.

Results In total, 8,553 participants were analyzed, revealing a positive association between TyG-BMI and asthma. In the analysis of TyG-BMI as a continuous variable, after adjusting for confounding variables, the Odds ratio (OR)(95% CI) for the association between TyG-BMI and asthma was 1.003. After further dividing TyG-BMI into quartiles and adjusting for potential confounders in Model 3, the prevalence of asthma was 0.561 times higher in those with the highest TyG-BMI than in those in the lowest quartile (OR: 1.561, 95% CI: 1.181, 2.065). There was a significant interaction between asthma and TyG-BMI among subgroups defined by gender, coronary heart disease, and stroke (interaction $P < 0.05$).

Conclusions This cross-sectional study found a positive association between TyG-BMI and asthma. These results suggest that TyG-BMI has the potential to be used as an indicator to monitor the prevalence of asthma, but further longitudinal studies are needed to confirm causality and to assess its utility in the management of long-term comorbidities.

Clinical trial number Not applicable.

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Keywords TyG-BMI, Asthma, NHANES, Insulin resistance

Introduction

Asthma is one of the most common chronic respiratory diseases characterized by intermittent bronchospasm leading to symptoms such as wheezing and shortness of breath, with airway inflammation, hyperresponsiveness and hypersecretion of mucus [1]. According to the Global Initiative for Asthma (GINA), more than 262 million people worldwide suffer from asthma, and approximately 461,000 people die annually as a result [2]. The rising prevalence of asthma worldwide is a serious burden on global health and economic resources. The development of asthma is associated with a number of factors, including genetic susceptibility, immune dysfunction and environmental factors. The study of asthma-related markers is crucial for advancing asthma prevention and treatment strategies.

Insulin resistance (IR) is a condition in which adipocytes, muscle cells, and hepatocytes exhibit impaired responsiveness to normal insulin concentrations despite a healthy pancreas [3]. IR plays a key role in the pathogenesis of many metabolism-related diseases. Multiple studies have established a link between obesity and the development of asthma in adults [4, 5]. Additionally, lipid metabolism influences asthma development and symptoms, as total cholesterol(TC), TG, and low-density lipoprotein (LDL) cholesterol are positively correlated with asthma, whereas high-density lipoprotein (HDL) cholesterol is inversely correlated [6]. An NHANES-based study of 3,902 asthma patients identified a positive linear correlation between the triglyceride-glucose index (TyG) and blood eosinophil counts in asthma patients [7]. It has been shown that TyG is a good indicator of metabolic function and is associated with respiratory symptoms and impaired lung function [8].Yang et al. explored the relationship between TyG and pulmonary function indices in the general population undergoing a health screening.The study found that subjects in the high TyG group were typically older, had a higher BMI, and had a higher proportion of males, smokers, and alcohol drinkers, as well as higher FVC, FEV1, FET, and PEF, as compared to those in the low TyG group. The study found that compared with the low TyG group, subjects in the high TyG group were usually older, had a higher BMI, a higher proportion of male smokers and alcohol drinkers, and also had higher lung function indices such as FVC, FEV1, FET and PEF. The researchers concluded that although the exact mechanism by which the TyG index affects lung function is not yet clear, it may be related to IR [9]. TyG-BMI combines fasting blood glucose(FBG), BMI, and TG levels as an index for evaluating insulin resistance. Recent evidence shows that the TyG BMI index is strongly associated with chronic diseases, including diabetes, hypertension, coronary heart disease, and stroke [10–13]. The hyperinsulinemic-euglycemic clamp (HEC) technique is the current gold standard for diagnosing IR. Compared to the HEC technique, the TyG-BMI index is more accessible and efficient, and it enhances the validity of IR assessment when compared to the TyG index alone [14]. Thus, investigating the association between the TyG-BMI index and asthma may offer valuable insights for future research.

Methods

Study population and data source

This study utilized U.S. demographic data from the NHANES between 2011 and 2018. NHANES is jointly administered by the Centers for Disease Control and Prevention (CDC) and the National Center for Health Statistics (NCHS). Ethical clearance for the NHANES protocol was granted by the Institutional Review Board of NCHS, and written informed consent was obtained from all participants. The data used in this study are publicly accessible and available for download from the NHANES website.

Study population and methods

In this study, we analyzed data from the NHANES database for the 2011–2018 cycle, including comprehensive asthma-related questionnaire responses and relevant covariate information. The exclusion criteria for study participants were: (1) missing data on TyG-BMI, (2) missing data on asthma, (3) missing data on covariates, and (4) participants under 20 years of age. Participants with incomplete data were excluded through listwise deletion. A total of 39,156 participants were initially recruited; after excluding those under 20 years of age ($n = 16{,}539$), those missing TyG-BMI data ($n = 13{,}098$), asthma status ($n = 8$), and covariates ($n = 958$), missing LDL and alcohol consumption data were interpolated using the random forest approach. Ultimately, 8,553 eligible participants aged ≥ 20 years were included in the final analysis (Fig. 1).

Definition of asthma

In this study, participants who answered affirmatively to a questionnaire item regarding a diagnosis of asthma were categorized as having asthma.

Definition of triglyceride glucose-body mass index

$$TyG\ index = \mathrm{Ln}\left[TG\,(mg/dL) \times\ FPG\,(mg/dL)\,/2\right]$$

$$BMI = weight\,(kg)\,/height\,(m)^2$$

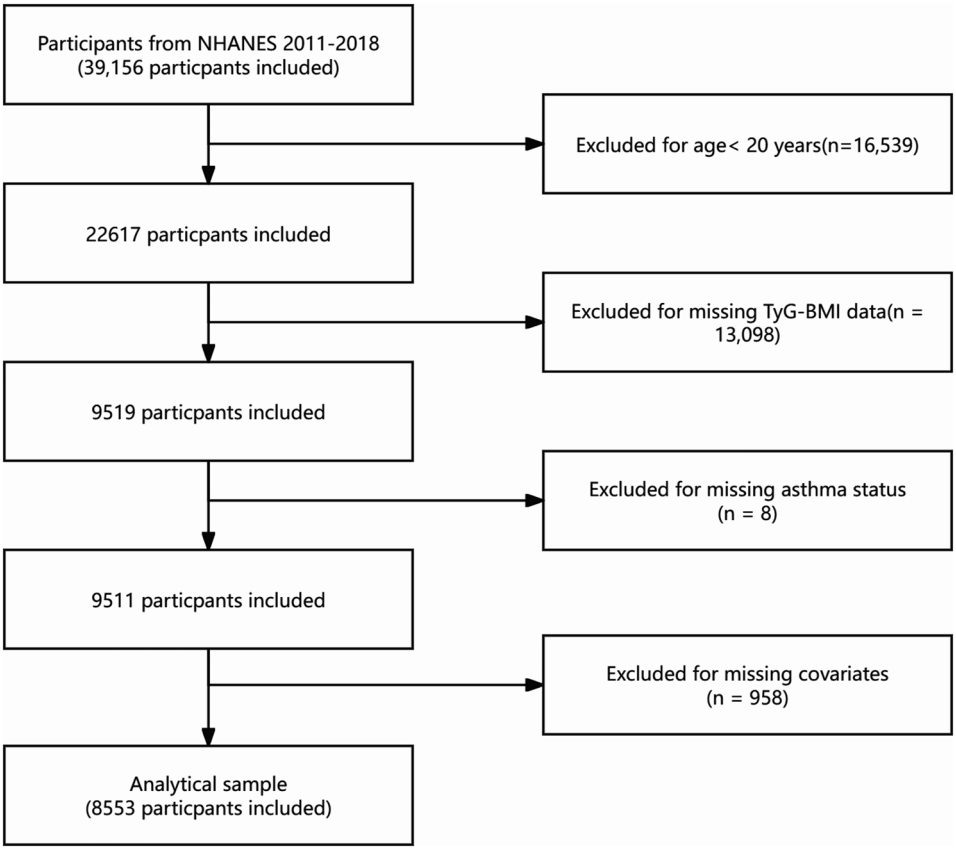

Fig. 1 From chart of sample selection from the NHANES 2011–2018

$$TyG - BMI = TyG\,index \times BMI$$

The purpose of TyG-BMI in our study was to be an exposure variable [15].

Using an autoanalyzer, TG and FPG were measured enzymatically in blood samples from individuals who had fasted for at least 8 h but less than 24 h.

Covariates

Potential covariates that could confound the association between asthma and TyG-BMI were controlled for in this study. These covariates included sex, age, race, education level, poverty-to-income ratio (PIR), coronary heart disease, stroke, hypertension, LDL, physical activity, diabetes mellitus, smoking, alcohol consumption, and TC. Age was stratified into three groups (20–39, 40–59, and ≥ 60 years), and race was classified as non-Hispanic white, non-Hispanic black, Mexican American, and other. Educational level was categorized into five levels: less than 9th grade, 9th–11th grade (including 12th grade without a diploma), high school graduate/GED or equivalent, some college or associate degree, and college graduate or higher. PIR were calculated based on poverty guidelines adjusted for family size and subsequently categorized into three groups representing socioeconomic status: ≤1.3, 1.3–3.5, and > 3.5 [16]. Hypertension, coronary heart disease, and stroke were determined by a self-reported "yes" response to the question "ever told you had" the corresponding condition. Participants with a lifetime history of smoking over 100 cigarettes were categorized as smokers, and alcohol consumption status was self-reported via questionnaire. Physical activity intensity was classified based on metabolic equivalent of task (MET) minutes per week: MET ≤ 500 was considered insufficient, 500 < MET ≤ 1000 was considered moderate, and MET > 1000 was considered high [17]. The diagnosis of diabetes mellitus was established based on the following criteria: (1) physician's diagnosis of diabetes mellitus; (2) current use of hypoglycemic medication; (3) glycated hemoglobin (HbA1c) level of ≥ 6.5%; and (4) FBG level of ≥ 7.0 mmol/L. LDL and TC data were extracted from laboratory data on the NHANES website, ranked in ascending order, and subsequently divided into tertiles.

Statistical analysis

All continuous data were presented as medians and interquartile ranges, and categorical variables were expressed as proportions with 95% confidence intervals (CIs), reported as counts (n) and percentages (%). Because NHANES is designed to generate data representative of

the noninstitutionalized civilian population within the United States, we considered sample weights in accordance with NCHS analytical guidelines.Participants were stratified into quartiles according to their TyG-BMI for baseline characterization, and chi-square tests were used to compare categorical variables. Subsequently, to assess the correlation between TyG-BMI and asthma, we created three models and employed weighted multivariate logistic regression. The unadjusted (crude) model was followed by Model 1, which adjusted for age, gender, and race. Building on Model 1, Model 2 further adjusted for additional covariates, including education level, PIR, coronary heart disease, stroke, hypertension, LDL, physical activity, diabetes mellitus, smoking, alcohol consumption, and TC. Subgroup analyses were conducted to explore potential heterogeneity among subgroups. Finally, sensitivity analyses were performed to verify whether the different ways of interpolating missing values had a significant impact on the results.All analyses were performed using R software (version 4.3.1) and EmpowerStats (version 4.2). A P-value of < 0.05 was considered statistically significant.

Results

Baseline characteristics of participants

Excluding ineligible participants, a total of 8,553 people participated in the survey.The median age of participants was 41 years, with 48.49% males and 51.51% females. The racial composition was as follows: 13.12% Mexican American, 10.23% Other Hispanic, 39.51% Non-Hispanic White, 20.83% Non-Hispanic Black, and 16.31% identifying as other races.

The clinical characteristics of the participants by TyG-BMI quartiles are shown in Table 1. The distribution of age, gender, race, education level, PIR, coronary heart disease, hypertension, LDL, physical activity, diabetes, smoking, and TC across TyG-BMI quartiles was statistically significant ($P < 0.05$). Compared with the lowest TyG-BMI quartile, participants in the highest quartile were more likely to be older, female, non-Hispanic white, have lower education levels, lower PIR, engage in smoking, exhibit lower physical activity, and have a higher prevalence of coronary heart disease, hypertension, diabetes, and asthma. Additionally, those in the highest TyG-BMI quartile exhibited higher levels of LDL and TC.

Association between TyG-BMI and asthma

Table 2 displays the relationship between TyG-BMI and Asthma。Weighted multivariate logistic regression models were employed to evaluate the association between TyG-BMI and asthma. After adjusting for potential confounders in analyses with TyG-BMI as a continuous variable (Model 3), a positive association was observed between TyG-BMI and the prevalence of asthma attacks (OR = 1.003, 95% CI: 1.001, 1.004). When TyG-BMI was categorized into quartiles and adjusted for confounders in Model 3, the odds of developing asthma in the highest quartile of the TyG-BMI index was 1.638 times that of the lowest quartile(OR: 1.561, 95% CI: 1.181, 2.065). Additionally, a trend test across all three models yielded a p-value of < 0.005, indicating statistical significance.

Subgroup analysis

To assess whether different factors affect the stability of the association between asthma and TyG-BMI, subgroup analyses were performed based on Model 3 (Fig. 2). The results showed a significant interaction between asthma and TyG-BMI among subgroups stratified by gender, coronary heart disease, and stroke (interaction $P < 0.05$). Conversely, in subgroups defined by age, hypertension, diabetes, LDL levels, TC levels, smoking, and alcohol consumption, the association between asthma and TyG-BMI remained stable ($P > 0.05$ for interaction), highlighting the robustness and prevalence of the association across these populations.

Sensitivity analysis

We used two different methods to interpolate missing values and found that the different interpolation methods had no significant effect on the relationship between TyG-BMI and asthma prevalence(Table 3).

Discussion

To the best of our knowledge, this is the first study to examine the association between asthma and TyG-BMI based on the NHANES database. The findings showed that the prevalence of asthma increased with increasing TyG-BMI, and this association remained significant after adjusting for confounders. The association between TyG-BMI and asthma prevalence showed significant interactions in subgroups stratified by gender, coronary heart disease, and stroke. These findings suggest that greater emphasis should be placed on metabolic health in asthma management, particularly among women and individuals with cardiovascular risk.

Asthma is a common chronic inflammatory respiratory disease characterized primarily by recurrent wheezing, dyspnea, chest tightness, and cough. Asthma is a systemic inflammatory disease caused by the interaction of multiple factors. The pathogenesis is mainly related to the environment, immunity, genetics and other aspects, such as air pollution, allergen exposure, infection, and smoking [18–21]. Despite advancements in medical technology, the incidence of asthma continues to increase annually [22]. Studies have shown that there is a complex two-way relationship between obesity and asthma, and that obese patients are often accompanied by IR [23].Some studies have suggested that obese individuals accumulate

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

TYG.BMI	Q1, *N* = 2137	Q2, *N* = 2139	Q3, *N* = 2138	Q4, *N* = 2139	*P*-value
Age (years)	41.00 (28.00, 59.00)	53.00 (37.00, 66.00)	51.00 (37.00, 65.00)	51.00 (38.00, 63.00)	< 0.001
LDL (mmol/L)	101.00 (81.00, 122.00)	111.00 (88.00, 137.00)	115.00 (91.00, 139.00)	110.00 (90.00, 134.00)	< 0.001
TC (mmol/L)	178.00 (155.00, 204.00)	188.00 (161.00, 215.00)	191.00 (165.00, 219.00)	189.00 (162.00, 216.00)	< 0.001
Gender (%)					< 0.001
Male	930 (43.52%)	1156 (54.04%)	1122 (52.48%)	939 (43.90%)	
Female	1207 (56.48%)	983 (45.96%)	1016 (47.52%)	1200 (56.10%)	
Race (%)					< 0.001
Mexican American	144 (6.74%)	269 (12.58%)	355 (16.60%)	354 (16.55%)	
Other Hispanic	166 (7.77%)	206 (9.63%)	267 (12.49%)	236 (11.03%)	
Non-Hispanic White	828 (38.75%)	846 (39.55%)	802 (37.51%)	903 (42.22%)	
Non-Hispanic Black	414 (19.37%)	444 (20.76%)	426 (19.93%)	498 (23.28%)	
Other Races	585 (27.37%)	374 (17.48%)	288 (13.47%)	148 (6.92%)	
Education level (%)					< 0.001
Less than 9th grade	135 (6.32%)	189 (8.84%)	213 (9.96%)	201 (9.40%)	
9-11th grade	245 (11.46%)	257 (12.01%)	287 (13.42%)	288 (13.46%)	
high school graduate	424 (19.84%)	455 (21.27%)	490 (22.92%)	506 (23.66%)	
AA degree	608 (28.45%)	629 (29.41%)	665 (31.10%)	751 (35.11%)	
College graduate or above	725 (33.93%)	609 (28.47%)	483 (22.59%)	393 (18.37%)	
PIR (%)					< 0.001
<=1.3	662 (30.98%)	641 (29.97%)	687 (32.13%)	802 (37.49%)	
> 1.3, <=3.5	771 (36.08%)	788 (36.84%)	831 (38.87%)	819 (38.29%)	
> 3.5	704 (32.94%)	710 (33.19%)	620 (29.00%)	518 (24.22%)	
Coronary heart disease (%)					0.001
Yes	62 (2.90%)	98 (4.58%)	80 (3.74%)	111 (5.19%)	
No	2075 (97.10%)	2041 (95.42%)	2058 (96.26%)	2028 (94.81%)	
Stroke (%)					0.128
Yes	68 (3.18%)	84 (3.93%)	81 (3.79%)	98 (4.58%)	
No	2069 (96.82%)	2055 (96.07%)	2057 (96.21%)	2041 (95.42%)	
Hypertension (%)					< 0.001
Yes	424 (19.84%)	735 (34.36%)	900 (42.10%)	1120 (52.36%)	
No	1713 (80.16%)	1404 (65.64%)	1238 (57.90%)	1019 (47.64%)	
Physical Activity level (%)					< 0.001
<=500	827 (38.70%)	937 (43.81%)	1040 (48.64%)	1193 (55.77%)	
> 500, <=1000	270 (12.63%)	268 (12.53%)	244 (11.41%)	240 (11.22%)	
> 1000	1040 (48.67%)	934 (43.67%)	854 (39.94%)	706 (33.01%)	
Diabetes (%)					< 0.001
Yes	130 (6.08%)	297 (13.88%)	493 (23.06%)	821 (38.38%)	
No	2007 (93.92%)	1842 (86.12%)	1645 (76.94%)	1318 (61.62%)	
Smoking status (%)					< 0.001
Yes	821 (38.42%)	931 (43.53%)	975 (45.60%)	987 (46.14%)	
No	1316 (61.58%)	1208 (56.47%)	1163 (54.40%)	1152 (53.86%)	
Drinking status (%)					0.657
Yes	1866 (87.32%)	1887 (88.22%)	1877 (87.79%)	1893 (88.50%)	
No	271 (12.68%)	252 (11.78%)	252 (11.78%)	246 (11.50%)	
Asthma (%)					< 0.001
Yes	273 (12.77%)	290 (13.56%)	292 (13.66%)	453 (21.18%)	
No	1864 (87.23%)	1849 (86.44%)	1846 (86.34%)	1686 (78.82%)	

The median and interquartile range for continuous variables: *P* value was calculated by linear regression model. % for categorical variables: *P* value was calculated by chi-square test

NHANES: National Health and Nutrition Examination Survey; TyG-BMI: Triglyceride glucose body mass index; TC: Total cholesterol; LDL: low-density lipoprotein; PIR: Poverty-to-income ratio

Table 2 Association between TyG-BMI and asthma

Exposure	Model 1 OR(95% CI), *P* value	Model 2 OR (95% CI), *P* value	Model 3 OR (95% CI), *P* value
TYG-BMI (continuous)	1.003 (1.002, 1.004) < 0.0001	1.003 (1.002, 1.005) < 0.0001	1.003 (1.001, 1.004) 0.0007
TyG-BMI (quartile)			
Q1	1(Reference)	1(Reference)	1(Reference)
Q2	1.076 (0.878, 1.317) 0.4830	1.205 (0.970, 1.498) 0.0981	1.179 (0.940, 1.478) 0.1631
Q3	1.061 (0.832, 1.353) 0.6362	1.202 (0.942, 1.533) 0.1453	1.129 (0.870, 1.465) 0.3677
Q4	1.624 (1.282, 2.057) 0.0002	1.779 (1.396, 2.267) < 0.0001	1.561 (1.181, 2.065) 0.0034
P for trend	0.0003	< 0.0001	0.0059

Table 3 Sensitivity analysis after interpolating missing values in different ways

Exposure	Model 1 OR (95% CI), *P* value	Model 2 OR (95% CI), *P* value	Model 3 OR (95% CI), *P* value
Method 1			
TYG-BMI (continuous)	1.003 (1.002, 1.004) < 0.0001	1.003 (1.002, 1.005) < 0.0001	1.003 (1.001, 1.004) 0.0008
Method 2			
TYG-BMI (continuous)	1.003 (1.002, 1.004) < 0.0001	1.003 (1.002, 1.005) < 0.0001	1.003 (1.001, 1.004) 0.0007

Method 1: missing LDL data were imputed using the median, and missing alcohol consumption data were imputed using the Random Forest method

Method 2: missing LDL and alcohol consumption data were interpolated using the random forest approach

chest and abdominal fat, affecting lung capacity, and that a higher BMI is associated with reduced forced expiratory volume in 1 s (FEV1) and forced vital capacity (FVC) [24], however, other studies suggest this causal relationship is minimal [25]. In insulin resistance, inflammatory markers such as tumor necrosis factor-α (TNF-α), interleukin-6 (IL-6), and vascular endothelial growth factor are elevated, activating inflammatory pathways in the airways and contributing to the worsening of asthma symptoms and exacerbations [26]. Hypertriglyceridemia and circulating free fatty acids induce inflammation in macrophages and other immune cells [27]. In hyperinsulinized states, presynaptic inhibitory M2 muscarinic receptors on parasympathetic nerves are disrupted, resulting in increased release of neuronal acetylcholine and enhanced bronchoconstrictio [28]. Additionally, IR is associated with impaired glucose tolerance, and glucose-induced oxidative stress further triggers prolonged inflammation [29].The Severe Asthma Research

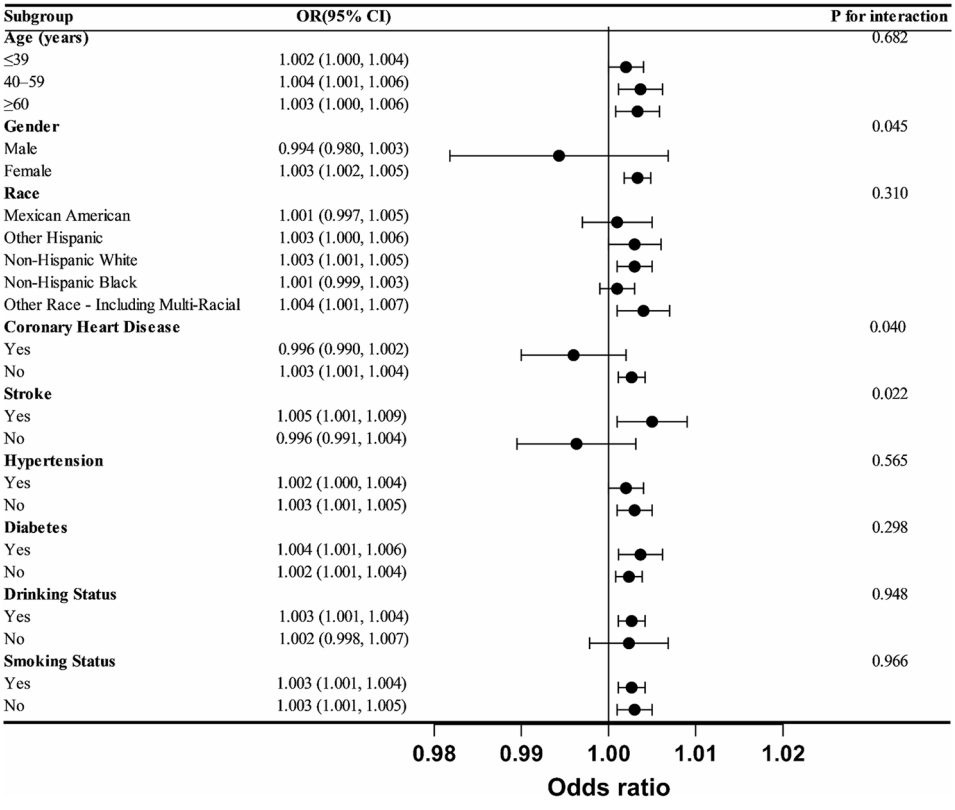

Fig. 2 Subgroup analysis for the association between TyG-BMI index and asthma legends: Subgroup analyses of the TyG-BMI index and asthma. Adjustment factors included sex, age, race, education level, poverty-to-income ratio (PIR), coronary heart disease, stroke, hypertension, LDL, physical activity, diabetes mellitus, smoking, alcohol consumption, and TC. OR, odds ratio; CI, confidence interval

Program 3 (SARP-3) is a multi-year longitudinal cohort study of asthmatics in the U.S. Among the 307 SARP-3 participants, 170 (55%) were obese, and 140 (46%) had insulin resistance. Findings from SARP-3 indicate that, compared to participants without IR, those with moderate or severe IR experienced more rapid declines in lung function, suggesting that IR leads to impaired lung function in asthma [30]. Currently, many studies have also demonstrated the association between blood lipids, related metabolic indicators, and asthma. R.V. Fenger and others used data from the Ibermutuamur Cardiovascular Risk Assessment Plan (ICARIA) to study 85,555 Spanish workers and found that high s-TG and low s-HDL were significantly associated with the risk of asthma [31]. The research shows a linear negative correlation between HDL-C and eosinophil count in adults with ACOS [32]. For every unit increase in LDL-C (mmol/L), the risk of death decreases by 17% for adult asthma patients [33]. Nitric oxide (NO) is widely regarded as a short half-life cellular messenger that induces airway hyperreactivity through inflammatory mediation, and there is a positive linear relationship between TGI (triglyceride-glucose index) and FeNO (fractional exhaled nitric oxide) in asthma patients [34]. Additionally, a TyG index greater than 4.8 has been shown to increase mortality in critically ill COPD and asthma patients [35]. Therefore, the use of BMI or TyG alone to evaluate the relationship between IR and asthma remains controversial. Several studies have shown that TyG-BMI, as a novel and robust predictor integrating BMI, blood glucose, and lipid levels, can more comprehensively predict the prognosis of various metabolism-related diseases [36–38].

Numerous studies have explored the relationship between asthma and cardiovascular disease. For example, a meta-analysis of cohort studies showed that asthma increased the risk of coronary heart disease in women [39]. A population-based cohort study including 3,697 patients confirmed that asthma was independently associated with coronary artery spasm-related angina [40]. Meanwhile, a large-scale longitudinal study from South Korea demonstrated that adults with asthma were more likely to develop ischemic heart disease, stroke, and other cardiovascular diseases [41]. A population-based cohort study using health insurance claims data showed that the HR for stroke was 1.37 times higher in asthmatics than in controls (aHR = 1.37, 95% CI = 1.27–1.48) [42]. Our study further confirmed these findings by showing a significant interaction between women, coronary heart disease, and stroke regarding the association between asthma and TyG-BMI, as demonstrated in the subgroup analysis.

It is well known that the triggers of asthma partially overlap with those of coronary heart disease and stroke, such as smoking, environmental pollution, and cold weather. These triggers tend to be more frequent in the early morning, potentially due to parasympathetic excitation. Pathophysiologically, some pro-inflammatory cytokines, such as TNF-α and IL-6, which are strongly associated with the incidence of asthma, likewise play a crucial role in the etiology of atherosclerosis [43]. Similarly, platelet-activating factors have been implicated as inflammatory mediators contributing to airway hyperresponsiveness and, in cardiovascular disease, lead to inflammation and thrombosis [44]. On the other hand, medications used for asthma, such as β-2 agonists and glucocorticoids, may also impact the occurrence of adverse cardiovascular events. A recent study demonstrated that the TyG index and its related parameters were significantly associated with atherosclerotic cardiovascular disease [45]. In the Chinese middle-aged and elderly population, elevated TyG-BMI was strongly associated with stroke risk, and reducing TyG-BMI below 174.63 significantly decreases stroke risk [46]. Overall, an in-depth exploration of TyG-BMI may contribute to improved management of comorbidities.

In conclusion, the present study was a large and successful cross-sectional analysis that revealed a positive association between TyG-BMI and asthma. The use of a nationally representative cohort enhanced the generalizability of the findings, and the large sample size allowed for subgroup analyses. Although this study deepened our understanding of the relationship between TyG-BMI and asthma, it has certain limitations. First, asthma diagnosis in the NHANES database relies heavily on self-reported questionnaires, potentially introducing recall bias that could influence the findings. Second, due to the cross-sectional design of this study, it was not possible to establish a causal relationship between TyG-BMI and asthma. Third, this study was conducted exclusively among participants from the United States. While it included individuals from various ethnic backgrounds, the findings may not be directly generalizable to populations in other countries, where dietary patterns, lifestyle habits, and healthcare systems may differ significantly. These contextual differences could influence the observed relationship between TyG-BMI and asthma. To address this limitation, future research should aim to include prospective studies across diverse populations to validate and extend these findings, ultimately providing a more robust theoretical foundation for asthma prevention and treatment strategies.

Conclusion

This cross-sectional study found a positive association between TyG-BMI and asthma. These results suggest that TyG-BMI has the potential to be used as an indicator to monitor the prevalence of asthma, but further longitudinal studies are needed to confirm causality and to assess its utility in the management of long-term comorbidities.

Abbreviations

IR	Insulin resistance
TyG-BMI	Triglyceride glucose body mass index
NHANES	National Health and Nutrition Examination Survey
TG	Triglycerides
FBG	Fasting blood glucose
BMI	Body mass index
OR	Odds ratio
GINA	the Global Initiative for Asthma
TC	Total cholesterol
LDL	low-density lipoprotein
HDL	High-density lipoprotein
TyG	Triglyceride-glucose index
HEC	Hyperinsulinemic-euglycemic clamp
CDC	The Centers for Disease Control and Prevention
NCHS	The National Center for Health Statistics
PIR	Poverty-to-income ratio
MET	Metabolic equivalent of task
CIs	Confidence intervals
FEV1	Forced expiratory volume in 1 second
FVC	Forced vital capacity
TNF-α	Tumor necrosis factor-α
IL-6	Interleukin-6
SARP-3	The Severe Asthma Research Program 3
ARIC	The Atherosclerosis Risk in Communities

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Author contributions
All authors contributed to the study's conception and design. Data collection: SY, SW. Statistical analysis: SY, SW, SW. Drafting of the manuscript: SY, SW, SW. Review and editing: SY, SW, SW. All authors read and agreed to the final version of the manuscript.

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Data availability
All data analyzed in our study were extracted from NHANES and could be found at https://www.cdc.gov/nchs/nhanes/.

Declarations

Human ethics and consent to participate
The data analyzed in this study were sourced from the NHANES. The survey protocol received approval from the Institutional Review Board of NCHS, and all participants provided written informed consent.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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