Hyperuricemia is associated with metabolic syndrome: A cross-sectional analysis of the National Health and Nutrition Examination Survey (NHANES)

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ABSTRACT

This study aimed to understand the prevalence of hyperuricemia and MetS in the United States and evaluate the potential effect of gender and ethnicity on hyperuricemia and MetS. Data was obtained from National Health and Nutrition Examination Survey (NHANES) between 2011 and 2018. Logistic regression analysis was utilized to investigate the association between hyperuricemia and MetS. A total of 7273 participants with an average age of 47.59 ± 16.92 years old were enrolled in our analysis. Of all the people, 1833 were diagnosed with MetS, with which 547 (29.8 %) were found with hyperuricemia. As for gender, 261 (28.3 %) females were with both Mets and hyperuricemia and this number came to 286 (31.4 %) for males.For population distribution, Non-Hispanic American white, and Hispanic American making up 61.2 % of the cohort. The logistic regression analysis showed that there was a significant association between MetS and hyperuricemia (OR = 2.608, 95 %CI: 2.281–2.982). And the relationship still existed between both males (OR = 2.172, 95 %CI: 1.829–2.579) and females (OR = 3.464, 95 %CI: 2.868–4.185); in addition, participant's ethnicity was also found to play an important role. And the association was found either in Hispanic Americans Non-Hispanic Americans White and black or from other races. In conclusion, our study found a significant association between hyperuricemia and MetS. The higher the uric acid level, the greater risk of people getting MetS and this risk was not influenced by people's gender and ethnicity.

1. Introduction

Metabolic syndrome (MetS), characterized by hyperglycemia, dyslipidemia, hypertension, and visceral obesity, is frequently associated with various health issues and is a major contributor to morbidity and mortality worldwide (Kassi, et al., 2011, Lemieux and Després, 2020, McCracken, et al., 2018). As an important risk factor for multiple chronic diseases, such as atherosclerotic cardiovascular disease, type 2 diabetes, and chronic kidney diseases, MetS reported that nearly 25 % of the general population suffered from the disease, and of them around 40 % of the population over 40 years old worldwide (Rojas et al., 2021). Although multiple interrelated factors had been reported to be associated with MetS, many aspects of this clinical entity are still not completely understood.

Hyperuricemia, which has become an important public health problem, is caused by serum uric acid (SUA) accumulation due to endogenous and exogenous purine metabolism disorders (Copur, et al., 2022, Zhang, et al., 2020). Due to Dietary patterns and lifestyle changes, a general increase in mean uric acid levels in the USA and worldwide over the last several decades. Accumulating evidence demonstrated that hyperuricemia is a necessary precursor to develop gout and is also associated with chronic kidney disease, cardiovascular disease, and other non-communicable diseases such as MetS (Petreski, et al., 2020, Zhang, et al., 2019, Zhong, et al., 2022). Choi et al. reported a significant correlation between increased SUA level with metabolic syndrome (Choi and Ford, 2007). Also, Chen et al. found that there was a bidirectional relationship between MetS and hyperuricemia (Chen, et al., 2022). Nevertheless, still, some studies reported a negative correlation between MetS and hyperuricemia after body mass index and lifestyle choices were adjusted (Li, et al., 2019, Liu, et al., 2018). Thus, it is necessary to
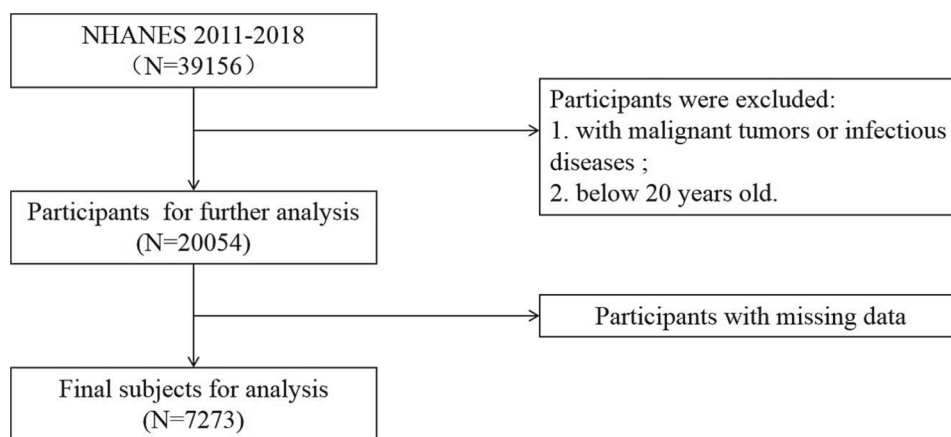
Fig. 1. Flow chart of this analysis based on NHANES from 2011 to 2018.

make further exploration of the causal factors of metabolic syndrome and hyperuricemia.

In this study, we made use of the 10 years of health data from the National Health and Nutrition Examination Survey (NHANES) data which assessed the health and nutritional status of adults and children in the USA to further explore the relationship between hyperuricemia and MetS with different gender and ethnicity.

2. Methods

2.1. Study populations

Data for this analysis were drawn from NHANES, a representative cross-sectional survey of all non-institutionalized civilian populations in the United States. All NHANES data were collected by the National Center for Health Statistics (NCHS) and Centers for Disease Control and Prevention via household survey and physical examination. This nationally representative survey engages a variety of population health in the United States which can be freely available from the NHANES website (https://www.cdc.gov/nchs/nhanes). The ethics review committee of NCHS had approved all protocols and written informed consent were obtained from all participants before enrolling in each examination.

As the NHANES data are released in 2-year cycles, to obtain large samples for analysis, we combined the NHANES data from 2011 to 2018 (covered four periods (2011–2012, 2013–2014, 2015–2016, and 2017–2018). The following selection criteria were used: (1) Participants over 20 years of age; (2) complete data on variables of age, sex, race, waist circumference, body mass index (BMI), triglyceride (TG), blood pressure (BP), blood glucose, SUA, smoking status, and drinking status. Patients with malignant tumors or infectious diseases were excluded from this study.

2.2. Assessment of metabolic syndrome and hyperuricemia

MetS were identified according to criteria established by the Adult Treatment Panel III of the National Cholesterol Education Program. People with three or more of the following five criteria were considered metabolically abnormal (Deedwania, et al., 2021, See, et al., 2011). Briefly, (1) waist circumference more than 102 cm for men or more than 88 cm for women; (2) triglyceride levels ≥150 mg/dL; (3)HDL-C less than 40 mg/dL for men or less than 50 mg/dL for women; (4) systolic blood pressure (SBP) ≥ 130 mmHg or diastolic blood pressure (DBP) ≥ 85 mmHg; (5) fasting glucose level ≥ 110 mg/dL or higher. Hyperuricemia was defined as serum uric acid ≥6.0 mg/dL in females and ≥7.0 mg/dL in males (Zhang et al., 2020).

2.3. Statistical analysis

The laboratory index was changed into binary data according to their normal range. Continuous variables were presented as mean and standard deviation (SD), whereas categorical variables were presented as cases (n) and percentages (%). Chi-squared tests and 2-tailed Student's t-tests were used to compare the characteristics of the normal and MetS groups. Logistic regression analysis was used to estimate the odds ratio (OR) and 95 % confidence interval (CI) for the association between hyperuricemia and MetS. Stratified analysis was conducted according to SUA level presented as means (SD) or medians (25th-75th percentile) and confounding factors were adjusted in different models. All statistical analyses were conducted using R software (Version 4.2.0). Two-tailed P < 0.05 was considered statistically significant.

3. Results

3.1. Clinical characteristics of patients

A total of 39,156 participants enrolled in the NHANES survey between 2011 and 2018. After further screening, 7273 participants were finally enrolled in the analysis. The participants' selection process is illustrated in Fig. 1. Of all the participants, the number of Mets and no Mets were 5440 and 1883 respectively. The average age of all the participants was 47.59 ± 16.92 years old, with the MetS group 54.15 ± 15.41 years old and the no Mets group were 45.37 ± 16.84 years old. There were 1858 (25.5 %) participants were Hispanic American, 2599 (35.7 %) were non-Hispanic American white, 1564 (21.5 %) were non-Hispanic American black and 1252 (17.2 %) were from another ethnicity. There were 1296 (17.8 %) participants who were diagnosed with hyperuricemia. Among them, 749 (13.8 %) were without MetS and 547 (29.8 %) were also with MetS. In addition, to further elucidate potential factors in the Mets development, we also made a subgroup analysis base on the gender difference. There were 3590 participants who were male and 3683 who were female. People who got MetS in male and female were 910 with an average age of 53.45 ± 15.41 and 923 with an average of 54.84 ± 15.39 respectively. Of them, 286 (31.4 %) participants from the male group and 261 (28.3 %) from the female were diagnosed with MetS and hyperuricemia. The basic characteristics of the cohort are shown in Table 1 and Table 2.

3.2. The trend of MetS and hyperuricemia in 2011–2018

In our study, we found that MetS increased dramatically from 2011 to 2018(from 23.45 % to 28.13 %). The increase rate was from 23.60 % to 28.88 and 23.66 % to 27.42 % for men and women. Of this increase,

Table 1
The demographics of the study participants (N = 7273) in NHANES from 2011 to 2018.

Characteristics	Total (N = 7273)			
	Total	No MetS N = 5440	MetS N = 1833	P-Value
Age [yrs,mean(SD)]	47.59 ± 16.92	45.37 ± 16.84	54.15 ± 15.41	<0.001
Race/ethnicity (%)				<0.001
Hispanic American	1858 (25.5)	1291 (23.7)	567 (30.9)	
Non-Hispanic American white	2599 (35.7)	1898 (34.9)	701 (38.2)	
Non-Hispanic American Black	1564(21.5)	1227 (22.6)	337 (18.4)	
Others	1252 (17.2)	1024 (18.8)	228 (12.4)	
Education (%)				<0.001
High school or less	3201 (44.0)	2268 (41.7)	933 (50.9)	
College	2213 (30.4)	1651 (30.3)	562 (30.7)	
Graduate or higher	1859 (25.6)	1521 (28.0)	338 (18.4)	
Smoking (%)				<0.001
Current	4199 (57.7)	3258 (59.9)	941 (51.3)	
Past	1635 (22.5)	1140 (21.0)	495 (27.0)	
Never	1439 (19.8)	1042 (19.2)	397 (21.7)	
Excessive alcohol consumption (%)				0.003
No	6302 (86.6)	4751 (87.3)	1551 (84.6)	
Yes	971 (13.4)	689 (12.7)	282 (15.4)	
Physical activity (%)				<0.001
No	3646 (50.1)	2519 (46.3)	1127 (61.5)	
Yes	3627 (49.9)	2921 (53.7)	706 (38.5)	
Waist circumference (%)				<0.001
Normal	3228 (44.4)	3047 (56.0)	181 (9.9)	
Abnormal (male: ≥102; female: ≥88)	4045 (55.6)	2393 (44.0)	1652 (90.1)	
Raised blood pressure (%)				<0.001
Normal	5029 (69.1)	4333 (79.7)	696 (38.0)	
Abnormal (≥130/85)	2244 (30.9)	1107 (20.3)	1137 (62.0)	
Triglyceride (%)				<0.001
Normal	5647 (77.6)	4919 (90.4)	728 (39.7)	
Abnormal (≥150)	1626 (22.4)	521 (9.6)	1105 (60.3)	
Raised FPG (%)				<0.001
Normal	5276(72.5)	4683 (86.1)	593 (32.4)	
Abnormal (≥110)	1997(27.5)	757 (13.9)	1240 (67.6)	
HDL-C (%)				<0.001
Normal	5247 (72.1)	4629 (85.1)	618 (33.7)	
Abnormal (<40 in men and < 50 in women)	2026 (27.9)	811 (14.9)	1215 (66.3)	
Hyperuricemia (%)				<0.001
Normal	5977(82.2)	4691 (86.2)	1286 (70.2)	
Abnormal	1296(17.8)	749 (13.8)	547 (29.8)	
Subgroups of SUA[#] (%)				<0.001
Quartile 1	1843 (25.3)	1545 (28.4)	298 (16.3)	
Quartile 2	1813 (24.9)	1425 (26.2)	388 (21.2)	
Quartile 3	1832 (25.2)	1352 (24.9)	480 (26.2)	
Quartile 4	1785 (24.5)	1118 (20.6)	667 (36.4)	

Note: For continuous variables, data are showed with Mean ± SD; For categorical variables, data are showed with n (%). P < 0.05 means statistically significant. [#]: The subgroup analysis was based on the SUA level of 25th-75th percentile; FPG: fasting blood-glucose; HDL-C: high-density lipoprotein cholesterol; SUA: serum uric acid.

we found that people from Hispanic American and other ethnicity had contributed the vast majority. Whereas the non-Hispanic American black population was maintained unchanged (from 21.38 % to 20.84 %). As for hyperuricemia, we had observed a slight increase these years (from 17.86 % to 18.83 %). The increase rate in males and female were not changed much. Hispanic Americans (11.35 % to 15.24 %) and other ethnicities (18.82 % to 21.59 %) showed a great increase in hyperuricemia during these years. While the morbidity remained roughly in balance among the non-Hispanic American black and non-Hispanic American white populations (Fig. 2).

3.3. Relationship study between hyperuricemia and MetS based on gender

The logistic regression analysis was performed to detect the relationship between hyperuricemia and MetS based on gender (Table 3). The crude model showed that hyperuricemia was significant associated with MetS (OR = 2.664, 95 %CI:2.348–3.023). The difference still existed after dividing all the participants into subgroup (OR = 2.172, 95 %CI:1.829–2.579) as male and female (OR = 3.464, 95 % CI:2.868–4.185). To further eliminate the influence of confounding

factors, we adjusted for age, gender, smoking, excessive alcohol consumption, physical activity, education, and ethnicity, nevertheless, significant differences were still observed in total participants (OR = 2.608, 95 %CI:2.281–2.982), male (OR = 2.298, 95 %CI:1.919–2.753) and female group (OR = 2.979, 95 %CI:2.431–3.650). In addition, to further elucidate the role of SUA in MetS development, we took the uric acid level into quartiles. After adjusting for confounding factors, the higher the uric acid level, the greater risk of MetS for people (OR = 3.775, 95 % CI:3.150–4.524), and this trend were both observed in male (OR = 2.707, 95 %CI:2.163–3.388) and female group (OR = 4.524, 95 % CI:3.513–5.825).

3.4. Relationship study between hyperuricemia and MetS based on ethnicity

To further observe the morbidity tendency of hyperuricemia and metabolic syndrome among different ethnicity, we conducted a logistic regression based on population races (Table 4). In our study, we found that there was a significant correlation between hyperuricemia and MetS eighter in Hispanic Americans (OR = 2.304, 95 % CI:1.762–3.013),

Table 2

The baseline characters of the sub-group based on gender based on NHANES from 2011 to 2018.

Characteristics	Male (N = 3590)			Female (N = 3683)		
	No Mets	MetS	P-Value	No Mets	MetS	P-Value
	N = 2680	N = 910		N = 2760	N = 923	
Age [yrs,mean(SD)]	45.88 ± 17.03	53.45 ± 15.41	<0.001	44.89 ± 16.64	54.84 ± 15.39	<0.001
Race/ethnicity (%)			<0.001			<0.001
Hispanic American	636 (23.7)	271 (29.8)		655 (23.7)	296 (32.1)	
Non-Hispanic American White	943 (35.2)	379 (41.6)		955 (34.6)	322 (34.9)	
Non-Hispanic American Black	593 (22.1)	138 (15.2)		634 (23.0)	199 (21.6)	
Others	508 (19.0)	122 (13.4)		516 (18.7)	106 (11.5)	
Education (%)			<0.001			<0.001
High school or less	1237 (46.2)	448 (49.2)		1031 (37.4)	485 (52.5)	
College	727 (27.1)	278 (30.5)		924 (33.5)	284 (30.8)	
Graduate or higher	716 (26.7)	184 (20.2)		805 (29.2)	154 (16.7)	
Smoking (%)			<0.001			<0.001
Never	1337 (49.9)	382 (42.0)		1921 (69.6)	559 (60.6)	
Past	708 (26.4)	319 (35.1)		432 (15.7)	176 (19.1)	
Current	635 (23.7)	209 (23.0)		407 (14.7)	188 (20.4)	
Excessive alcohol consumption (%)			0.004			0.325
No	2177 (81.2)	699 (76.8)		2574 (93.3)	852 (92.3)	
Yes	503 (18.8)	211 (23.2)		186 (6.7)	71 (7.7)	
Physical activity (%)			<0.001			<0.001
No	1209 (45.1)	534 (58.7)		1310 (47.5)	593 (64.2)	
Yes	1471 (54.9)	376 (41.3)		1450 (52.5)	330 (35.8)	
Waist circumference (%)			<0.001			<0.001
Normal	1920 (71.6)	155 (17.0)		1127 (40.8)	26 (2.8)	
Abnormal	760 (28.4)	755 (83.0)		1633 (59.2)	897 (97.2)	
(male: ≥102 cm; female: ≥88 cm)						
Raised blood pressure (%)			<0.001			<0.001
Normal	2043 (76.2)	302 (33.2)		2290 (83.0 %)	394 (42.7 %)	
Abnormal (≥130/85 mmHg)	637 (23.8)	608 (66.8)		470 (17.0 %)	529 (57.3 %)	
Triglyceride (%)			<0.001			<0.001
Normal	2317 (86.5)	319 (35.1)		2602 (94.3 %)	409 (44.3 %)	
Abnormal (≥150)	363 (13.5)	591 (64.9)		158 (5.7 %)	514 (55.7 %)	
Raised FPG (%)			<0.001			<0.001
Normal	2165 (80.8)	269 (29.6)		2518 (91.2 %)	324 (35.1 %)	
Abnormal (≥110)	515 (19.2)	641 (70.4)		242 (8.8 %)	599 (64.9 %)	
HDL-C (%)			<0.001			<0.001
Normal	2355 (87.9)	360 (39.6)		2274 (82.4 %)	258 (28.0 %)	
Abnormal (<40 in men and < 50 in women)	325 (12.1)	550 (60.4)		486 (17.6 %)	665 (72.0 %)	
Hyperuricemia (%)			<0.001			<0.001
Normal	2213 (82.6)	624 (68.6)		2478 (89.8 %)	662 (71.7 %)	
Abnormal	467 (17.4)	286 (31.4)		282 (10.2 %)	261(28.3 %)	
Subgroups of SUA[#] (%)			<0.001			<0.001
Quartile 1	700 (26.1)	169 (18.6)		77 5(28.1 %)	110 (11.9 %)	
Quartile 2	752 (28.1)	164 (18.0)		735 (26.6 %)	171 (18.5 %)	
Quartile 3	653 (24.4)	231(25.4)		725 (26.3 %)	260 (28.2 %)	
Quartile 4	575 (21.5)	346 (38.0)		525 (19.0 %)	382 (41.4 %)	

Note: Data are showed with Mean ± SD for continuous variables and n (%) for categorical variables. P < 0.05 means statistically significant. [#] The subgroup analysis was based on the SUA level of 25th-75th percentile. FPG: fasting blood-glucose; HDL-C: high-density lipoprotein cholesterol; SUA: serum uric acid.

non-Hispanic American white (OR = 3.147, 95 % CI:2.556–3.875), non-Hispanic American black (OR = 2.889, 95 % CI:2.213–3.771) or other ethnicities (OR = 2.808, 95 % CI:2.036–3.873). These differences were also observed even after adjusted for the confounding factors. Beyond that, by taking uric acid levels into quartiles, we found that no significant differences were observed in the first quartile in Hispanic Americans (OR = 1.345, 95 % CI:0.999–1.812) and other ethnic populations (OR = 1.025, 95 %CI:0.626–1.678). In addition, in the second quartile, there was still no significant difference observed in other ethnic populations (OR = 1.545, 95 % CI:0.944–1.672.528). For non-Hispanic American white and non-Hispanic American black ethnicity, the higher the uric acid level, the greater risk of MetS.

4. Discussion

This study performed a cross-sectional design to investigate the association between hyperuricemia and MetS by using the data from NHANES. We reported that the morbidity of MetS and hyperuricemia

had increased from 23.45 % to 28.13 % and 17.86 % to 18.83 % respectively between 2011 and 2018. The elevated SUA levels were significantly associated with MetS after adjusting for confounding factors. In addition, ethnicity and gender were found to play an important role in hyperuricemia and MetS, however, there was not significantly difference between different gender or ethnicity. These findings might help evaluate the relationship between hyperuricemia and MetS for physicians to take a differentiated prevention strategy.

As the prevalence of MetS comorbidities among U.S. adults, it is critical to identify risk factors that may influence disease management and long-term health outcomes. SUA is a long-awaited key for regulating harmful sides of metabolism. There is an abundant study to identify the relationship between hyperuricemia and MetS, such as Tu et al. reported a dose–response effect of SUA on incident MetS (Tu, et al., 2021), and Huang et al. found that hyperuricemia is associated with MetS in general very elderly (Huang, et al., 2020). Nevertheless, most of the studies were regional and none of these had reported the morbidity tendency of hyperuricemia and MetS in American. In this study, we careful extract data
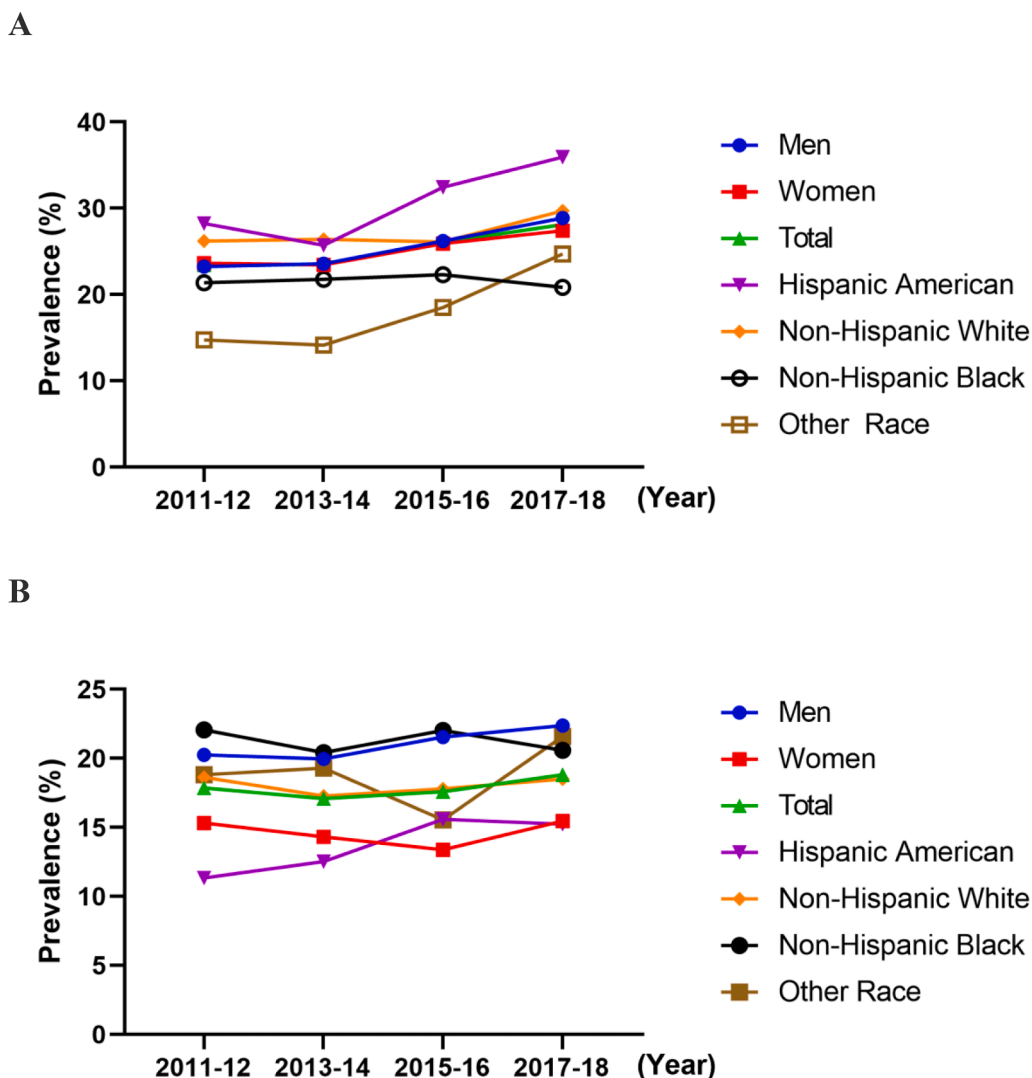
A

B

Fig. 2. The descriptive statistics for the prevalence of MetS and hyperuricemia in the United States based on NHANES from 2011 to 2018. Note:The x-axis indicates years and the y-axis show the prevalence. Figure A is the tendency of MetS and firuge B is the tendency of hyperuricemia.

from NHANES and analyzed the status of hyperuricemia and MetS over a long period. Our study reported a positive correlation between SUA and MetS,and also we found that the association between MetS and SUA concentration varies among peoples of different ethnicity in American. These results were similar with what had been reported in a Chinese cohort from CHARLS database in which they just found a bidirectional relationship between MetS and hyperuricemia (Chen, et al., 2022).

Hyperuricemia is the physiological prerequisite for gout which affect longevity and well-being. Our study was in accordance with what had been reported by Xu et al. from 2007 to 2016 (Chen-Xu et al., 2019). By using the NHANES database, they found that the prevalence of hyperuricemia in the United State was 20.2 % for men and 20.0 % for women (Chen-Xu et al., 2019). This hyperuricemia morbidity rate is much higher than the Chinese population at the same time which was reported that the hyperuricemia prevalence was 7.9 % and 4.9 % for men and women respectively (Song, et al., 2018). The increase in the prevalence of hyperuricemia was directly related to the increased incidence of obesity and MetS.

MetS is a complex disease that was associated with a huge of factors. Increased concentration of serum urate (hyperuricemia) is the most important risk factor for kind's diseases such as cardiovascular disease, CKD, goat (Danve, et al., 2021, Yanai, et al., 2021, Zhang, et al., 2019), yet its management remains suboptimal. Although, we got a positive correlation between MetS and hyperuricemia among different ethnicity and gender, large-scale clinical trials with well-designed are needed to translate preclinical UA data into patient care, early intervention, and lifestyle change.

The current study had several limitations. To begin with, we did not enroll the data from 2019 to 2020. With the influence of COVID-19, people's lifestyles had changed a lot, and this may cause bias to the whole analysis. Second, this was a cross-sectional study with all data were from the NHANES database which focused on the comprehensive information of a person, thus some pertinence information about hyperuricemia and MetS is lacking. Thirdly, although a lot of confounding factors were adjusted, we still could not exclude the causal relationship between these factors.

Table 3
Logistic analysis of the relationship between hyperuricemia and MetS according to gender based on NHANES from 2011 to 2018.

Models	Total	Male	Female
Hyperuricemia	OR (95 %CI)	OR (95 %CI)	OR (95 %CI)
Model 1	2.664 (2.348–3.023)	2.172 (1.829–2.579)	3.464 (2.868–4.185)
Model 2	2.443 (2.144–2.784)	2.160 (1.812–2.576)	2.788 (2.291–3.394)
Model 3	2.608 (2.281–2.982)	2.298 (1.919–2.753)	2.979 (2.431–3.650)
Subgroups of SUA			
Model 1:			
Q1	*Reference*	*Reference*	*Reference*
Q2	1.412 (1.194–1.669)	0.903 (0.712–1.146)	1.639 (1.264–2.126)
Q3	1.841 (1.565–2.164)	1.465 (1.170–1.835)	2.527 (1.978–3.227)
Q4	3.093 (2.644–3.618)	2.492 (2.011–3.089)	5.126 (4.035–6.512)
Model 2:			
Q1	*Reference*	*Reference*	*Reference*
Q2	1.441 (1.213–1.713)	0.934 (0.734–1.190)	1.537 (1.180–2.002)
Q3	1.970 (1.657–2.344)	1.528 (1.215–1.922)	2.195 (1.710–2.819)
Q4	3.483 (2.917–4.158)	2.498 (2.008–3.108)	4.004 (3.132–5.119)
Model 3:			
Q1	*Reference*	*Reference*	*Reference*
Q2	1.464 (1.229–1.743)	0.943 (0.738–1.205)	1.687 (1.289–2.208)
Q3	2.058 (1.726–2.454)	1.566 (1.240–1.977)	2.380 (1.844–3.073)
Q4	3.775 (3.150–4.524)	2.707 (2.163–3.388)	4.524 (3.513–5.825)

Note: Model 1 is a univariate analysis; Model 2 is adjusted for age; Model 3 is adjusted for age, smoking, excessive alcohol consumption, physical activity, education, and race. $P < 0.05$ means statistically significant.

Table 4
Logistic analysis of the relationship between hyperuricemia and MetS according to ethnicity based on NHANES from 2011 to 2018.

Models	Hispanic American	Non-Hispanic American White	Non-Hispanic American Black	Others
Hyperuricemia				
Model 1	2.304 (1.762–3.013)	3.147 (2.556–3.875)	2.889 (2.213–3.771)	2.808 (2.036–3.873)
Model 2	2.120 (1.602–2.805)	2.991 (2.416–3.703)	2.461 (1.863–3.251)	2.659 (1.904–3.713)
Model 3	2.142 (1.611–2.848)	2.993 (2.408–3.719)	2.459 (1.859–3.254)	2.757 (1.960–3.876)
Subgroups of SUA				
Model 1:				
Q1	*Reference*	*Reference*	*Reference*	*Reference*
Q2	1.418 (1.070–1.879)	1.547 (1.159–2.065)	1.625 (1.072–2.462)	1.083 (0.675–1.738)
Q3	1.587 (1.199–2.100)	1.997 (1.510–2.641)	2.767 (1.875–4.083)	1.467 (0.933–2.307)
Q4	2.382 (1.791–3.167)	4.162 (3.170–5.465)	3.796 (2.610–5.521)	2.816 (1.863–4.258)
Model 2:				
Q1	*Reference*	*Reference*	*Reference*	*Reference*
Q2	1.407 (1.048–1.888)	1.622 (1.206–2.183)	1.685 (1.101–2.577)	1.060 (0.652–1.722)
Q3	1.833 (1.348–2.492)	2.090 (1.551–2.816)	3.022 (2.006–4.554)	1.451 (0.892–2.362)
Q4	2.957 (2.119–4.126)	4.572 (3.379–6.185)	4.515 (2.970–6.862)	2.909 (1.812–4.669)
Model 3:				
Q1	*Reference*	*Reference*	*Reference*	*Reference*
Q2	1.345 (0.999–1.812)	1.629 (1.207–2.199)	1.673 (1.092–2.563)	1.025 (0.626–1.678)
Q3	1.823 (1.336–2.486)	2.069 (1.531–2.796)	3.044 (2.018–4.590)	1.545 (0.944–2.528)
Q4	2.876 (2.052–4.030)	4.585 (3.374–6.231)	4.495 (2.952–6.843)	3.020 (1.867–4.883)

Note: Model 1 is a univariate analysis; Model 2 is adjusted for age, gender; Model 3 is adjusted for age, smoking, excessive alcohol consumption, physical activity, and education. $P < 0.05$ means statistically significant.

5. Conclusion

In conclusion, our study found a significant association between hyperuricemia and MetS. The higher the uric acid level, the higher risk of people getting MetS and the risk can be affected by gender and ethnicity. However, as the cross-sectional nature of the NHANES, our conclusion should be further analyzed in future clinical studies.

Ethical approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki. The ethics review committee of National Center for Health Statistics had approved all protocols. Written informed consent was obtained from all participants before enrolling in each examination.

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CRediT authorship contribution statement

Jin Shu: Conceptualization, Formal analysis, Writing – original draft. **Rushun Zhao:** Formal analysis, Methodology. **Hanbo Xu:** Formal analysis, Resources. **Xin Liu:** Validation. **Hao Guo:** Conceptualization, Writing – review & editing. **Chao Lu:** Conceptualization, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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