Association of Serum Uric Acid and Blood Pressure: A Cross-Sectional Study in A Working Population in China

Hang Qian
Sinopharm Dongfeng General Hospital
Aihua Mei
Sinopharm Dongfeng General Hospital
Hao Xu
Sinopharm Dongfeng General Hospital
Jishun Chen
Sinopharm Dongfeng General Hospital
Xintao Zhou
Sinopharm Dongfeng General Hospital
Yunpeng Li
Sinopharm Dongfeng General Hospital
Xinwen Min
Sinopharm Dongfeng General Hospital
Handong Yang
Sinopharm Dongfeng General Hospital
Xiulou Li
Sinopharm (Shiyan) Health Management Co., LTD
Jingning Yang
Hubei University of Medicine
Jixin Zhong
Huazhong University of Science and Technology
Xueqiang Jiang
Sinopharm Dongfeng General Hospital
Dongfeng Li
Sinopharm Dongfeng General Hospital
Jun Chen (chenjun0121@126.com)
Sinopharm Dongfeng General Hospital

Research Article

Keywords: Uric Acid, hyperuricemia, blood pressure, metabolic, Hypertension

Posted Date: February 18th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1308183/v1

Abstract

Objective: The aim of this study was to evaluate the independent relationship between Serum uric acid (SUA) and blood pressure. Methods: A cross-sectional study was conducted based on a sample of 6035 employees (3605 males and 2430 females). Multivariable regression analysis was performed to identify the association between risk factors for metabolic disorders and hypertension.

Results: The SUA levels were closely and independently related to hypertension even after adjusting for age, sex, lipids and glucose.

Conclusions: We verified that uric acid was associated with hypertension independent of other metabolic risk factors and that the presence of other risk factors with uric acid had an additive effect on blood pressure.

Introduction

Hypertension is a disease with a high prevalence and low control rate in China [1, 2]. In addition to heart involvement, patients with hypertension have an increased prevalence of obesity [3], hyperuricemia [4, 5], renal impairment and stroke [6]. Uric acid, as the end-product of purine metabolism, is excreted primarily through the kidneys and is associated with the occurrence of gout. Endogenous synthesis of uric acid accounts for approximately 80% of uric acid in the body [7]. Although the prevalence of hyperuricemia in China is not as high as that in developed countries, there is an increasing trend [8, 9]. Several epidemiological studies have indicated that hyperuricemia is associated with hypertension[10, 11]. Some studies have drawn different conclusions [12]. The mechanism between uric acid and hypertension has not been thoroughly studied. The aim of this study was to investigate the association between uric acid and hypertension and explore the combined power of other factors of metabolic disorders on blood pressure in a Chinese population.

Patients And Methods

Study population

This was a cross-sectional study. In 2018, the Health Room was established to serve the on-the-job staff of Dongfeng Commercial Vehicle Company in the urban area of Shiyan, Hubei Province, China. They were trying to comprehensively reduce the incidence of cardiovascular events, and hypertension management was a part of that. Management and individual therapy were administered to patients who were screened for hypertension. We included 6035 adults (3605 males and 2430 females) who were successfully measured for blood pressure, routine blood tests, SUA, fasting glucose and lipid profiles. **This study was reviewed and approved by the ethics committee of the Sinopharm Dongfeng General Hospital (LW-2022-004)**, the Affiliated Dongfeng Hospital, Hubei University of Medicine. Informed consent was provided by all study participants.

Data Collection

Data collection was performed at the physical examination center. A standard questionnaire was designed to collect demographic, medical and medication history. Systolic and diastolic blood pressure (SBP and DBP) were measured with a standard mercury sphygmomanometer after the participant had rested for 10 min and calculated as the mean value of three measurements on a single occasion. Body mass index (BMI) was calculated by dividing the current weight in kilograms by the square of height (kg/m2). Fasting blood samples were collected from each subject after a 12-h overnight fast by trained nurses. Blood specimens were assayed for serum uric acid (SUA), fasting blood glucose (FBG), total cholesterol (TC), high-density lipoprotein (HDL) cholesterol, low-density lipoprotein (LDL) cholesterol and triglycerides (TGs) with a biochemistry analyzer.

Diagnostic Criteria

In the present study, hypertension was defined as SBP/DBP ≥ 140/90 mmHg, current intake of antihypertensive medication, or a history of hypertension [13]. Hyperuricemia was defined as an SUA concentration > 416.4 μmol/L (7.0 mg/dL) in males or > 356.9 μmol/L (6.0 mg/dL) in females [14]. We used quartile-based analysis by dividing serum uric acid levels into four quartiles. The cutoff levels for serum uric acid level quartiles were as follows: Q1 < 274 μmol/L, 274 μmol/L ≤ Q2 ≥ 333 μmol/L, 334 μmol/L ≤ Q3 ≥ 397 μmol/L and Q4 > 397 μmol/L. Diabetes mellitus was defined by a medical history report and/or fasting blood glucose (FBG) ≥ 7 mmol/L or a glycosylated hemoglobin value ≥ 6.5%. An elevated TG was defined as TG ≥ 1.7 mmol/L. Hypercholesterolemia was defined as a blood cholesterol level of ≥ 5.2 mmol/L[15]. Low HDL cholesterol (HDL-C) was defined as HDL-C ≤ 1.03 mmol/L for males and ≤ 1.29 mmol/L for females[16]. High LDL-C was identified as LDL-C ≥ 3.4 mmol/L. Obesity was identified as having a body mass index (BMI) equal to or more than 25, according to the recommendation for Asians.

Statistical analysis

All statistical analyses were performed by IBM SPSS statistics version 21. Data are expressed as the mean ± standard derivation (SD), median (interquartile range) or counts or frequencies as a percentage. Comparisons between two means were tested using Student's t-test for normally distributed variables. Multiple comparisons between groups were assessed using one-way analysis of variance. The $\chi 2$ test was performed for proportions or categorical parameters. All statistical tests were two-tailed, and analyses were considered statistically significant with p values of < 0.05.

Results

Baseline characteristics of the population

Table 1 shows the basic characteristics of all participants. Of the 6035 subjects, 59.73% were males, and 40.27% were females. The mean SBP and DBP in males were significantly higher than those in females ($p < 0.001$). A significant difference was also observed for the average levels of serum SUA ($p < 0.001$), TC ($p = 0.037$), TG ($p < 0.001$), HDL-C ($p < 0.001$), LDL-C ($p < 0.001$), FBG ($p < 0.001$), and WBC ($p < 0.001$) between the sex groups.

Table 1
Baseline characteristics of the participants.

	Male(n = 3605)	**Female(n = 2430)**	***p value***
Age (years)	47.19 ± 8.28	45.46 ± 5.27	< 0.001
SBP (mmHg)	126.47 ± 16.95	118.59 ± 16.1	< 0.001
DBP (mmHg)	79.28 ± 12.22	73.13 ± 11.34	< 0.001
Pulse	74.24 ± 18.22	77.23 ± 13.96	< 0.001
BMI (kg/m2)	24.69 ± 3.21	22.85 ± 3.07	< 0.001
SUA(μmol/L)	382.38 ± 80.42	276.91 ± 63.46	< 0.001
TC (mmol/L)	4.72 ± 0.91	4.67 ± 0.90	0.037
TG (mmol/L)	1.79 ± 1.53	1.19 ± 1.01	< 0.001
HDL (mmol/L)	1.05 ± 0.23	1.23 ± 0.26	< 0.001
LDL (mmol/L)	2.86 ± 0.80	2.73 ± 0.72	< 0.001
FBG (mmol/L)	5.59 ± 1.57	5.06 ± 0.80	< 0.001
WBC ($\times 10^9$/L)	6.13 ± 1.51	5.7 ± 1.42	< 0.001
Values are presented as the mean ± SD. P values were obtained from the independent sample t-test.			

Prevalence Of Hyperuricemia Among The Participants

In our study, SUA levels > 416.4 μmol/L for males and > 356.9 μmol/L for females were considered hyperuricemia. Based on the diagnostic criteria, there were 1314 hyperuricemic patients, including 1068 males and 246 females. The overall prevalence of hyperuricemia was 21.77%, with 29.63% in males and 10.12% in females. The average values of SUA were 478.97 ± 55.03 μmol/L (max 736 μmol/L) and 404.57 ± 41.98 μmol/L (max 596 μmol/L) in the male hyperuricemic and female hyperuricemic groups, respectively. Males had higher uric acid levels and a higher risk of hyperuricemia than females ($p < 0.001$). Additionally, the hyperuricemic group had higher SBP, DBP, BMI, lipids (HDL-C, which showed a decreasing trend), FBG and WBC than the nonhyperuricemia group. There was no significant difference in age between the two groups (Table 2).

Table 2
Comparison of baseline characteristics between nonhyperuricemic and hyperuricemic subjects.

	Nonhyperuricemia	Hyperuricemia	*p value*
Male	2537	1068	
SUA (μmol/L)	341.72 ± 48.32	478.97 ± 55.03	< 0.001
Female	2184	246	
SUA (μmol/L)	262.53 ± 47.32	404.57 ± 41.98	< 0.001
Age (years)	46.51 ± 6.97	46.42 ± 8.27	0.725
SBP (mmHg)	121.58 ± 16.5	129.46 ± 17.6	< 0.001
DBP (mmHg)	75.51 ± 11.82	81.47 ± 12.62	< 0.001
Pulse	75.6 ± 16.09	74.9 ± 18.72	0.219
BMI (kg/m^2)	23.45 ± 3.06	25.75 ± 3.43	< 0.001
TC (mmol/L)	4.64 ± 0.88	4.91 ± 0.94	< 0.001
TG (mmol/L)	1.38 ± 1.2	2.16 ± 1.75	< 0.001
HDL-C (mmol/L)	1.15 ± 0.27	1.02 ± 0.22	< 0.001
LDL-C (mmol/L)	2.77 ± 0.75	2.94 ± 0.81	< 0.001
FBG (mmol/L)	5.34 ± 1.37	5.5 ± 1.23	< 0.001
WBC ($\times 10^9/L$)	5.86 ± 1.46	6.29 ± 1.53	< 0.001

Baseline characteristics of the study subjects according to SUA quartiles

As shown in Table 3, all participants were divided into four groups according to SUA levels (Q1 < 274; Q2:274–333, Q3: 334–397 and Q4 > 397 μmol/L). With elevated serum uric acid levels, the proportion of males, SBP, DBP, BMI, TC, TG, LDL-C FBG and WBC tended to increase gradually ($p < 0.001$ for all analyses). Upon further analysis, we found that the effect of elevated uric acid on blood pressure (both SBP and DBP) was more pronounced in females (Fig. 1).

Table 3
Characteristics of the subjects according to SUA (μmol/L) quartiles.

	Q1	Q2	Q3	Q4		
	< 274	274–333	334–397	> 397	F/x2	*p value*
Number	1506	1526	1509	1494		
SUA (μmol/L)	231.97 ± 29.29	303.93 ± 17.27	364.25 ± 18.2	460.89 ± 56.16	12223.6	< 0.001
Gender(m/f)	218/1288	803/723	1210/299	1374/120	2222.43	< 0.001
Age (years)	45.91 ± 5.13	46.84 ± 7.00	46.67 ± 7.95	46.53 ± 8.53	4.68	0.003
BMI (kg/m2)	22.31 ± 2.71	23.49 ± 3.08	24.32 ± 3.08	25.69 ± 3.28	326.88	< 0.001
SBP (mmHg)	117.33 ± 15.72	122.17 ± 16.5	124.51 ± 16.33	129.24 ± 17.48	135.27	< 0.001
DBP (mmHg)	72.5 ± 10.96	75.79 ± 11.97	77.52 ± 11.85	81.47 ± 12.45	149.64	< 0.001
TC (mmol/L)	4.55 ± 0.84	4.66 ± 0.92	4.7 ± 0.88	4.89 ± 0.95	38.16	< 0.001
TG (mmol/L)	1.08 ± 0.99	1.37 ± 1.11	1.62 ± 1.32	2.14 ± 1.75	171.88	< 0.001
HDL (mmol/L)	1.25 ± 0.27	1.14 ± 0.26	1.07 ± 0.24	1.01 ± 0.22	267.42	< 0.001
LDL (mmol/L)	2.64 ± 0.72	2.79 ± 0.74	2.86 ± 0.77	2.94 ± 0.81	43.13	< 0.001
FBG (mmol/L)	5.19 ± 1.35	5.40 ± 1.48	5.41 ± 1.25	5.52 ± 1.24	16.04	< 0.001
WBC ($\times 10^9$/L)	5.55 ± 1.38	5.89 ± 1.53	6.10 ± 1.43	6.29 ± 1.51	72.11	< 0.001

Association Of Sua With The Prevalence Of Hypertension

We compared systolic and diastolic blood pressure between two groups according to the critical value of TC (5.2 mmol/L), TG (1.7 mmol/L), HDL (1.03 mmol/L for males and 1.29 mmol/L for females), LDL-C (3.4 mmol/L), FBG (7 mmol/L), BMI (25 kg/m^2), WBC(7×10^9/L). The patients had higher SBP and DBP in the group above the threshold (Fig. 2). After adjusting for the confounding variable of age, sex, BMI, FBG, TC, TG, HDL-C, LDL-C and WBC, binary logistic regression analysis implicated SUA as an independent risk factor associated with the hypertension ($P < 0.01$, Table 4). Figure 3 shows the relationship between blood

pressure and the number of factors of metabolic disorders in the population. SBP and DBP proved to be higher with more factors of metabolic disorders. Patients with five or six factors of metabolic disorders showed significantly higher SBP and DBP than those with no or one factor of metabolic disorders.

Table 4
Univariate and multivariate logistic regression analyses were used to evaluate the association between quartiles of SUA and hypertension.

	Serum uric acid, mmol l/L (in quartiles)				*p values* for trend
	Q1	Q2	Q3	Q4	
Model 1	1.0	1.68(1.38–2.06)	1.92(1.58–2.34)	3.31(2.74–3.99)	< 0.001
Model 2	1.0	1.39(1.12–1.72)	1.44(1.15–1.81)	2.41(1.92–3.03)	< 0.001
Model 3	1.0	1.18(0.95–1.47)	1.09(0.86–1.38)	1.43(1.12–1.83)	< 0.01
Model 1: unadjusted, Model 2: adjusted for age and sex, Model 3: adjusted for factors in Model 2 and BMI, FBG, TC, TG, HDL-C, LDL-C and WBC.					

Discussion

Type 2 diabetes mellitus and hypertension are two important public health challenges, and both are linked to an increased risk of cardiovascular events. There is compelling evidence that hyperuricemia has been found to be positively related to the risk of atherosclerosis, hypertension and metabolic syndrome. However, controversy remains in epidemiological population studies. In this study, we found that SUA levels were higher in males than in females, which is comparable with the findings of other authors. We also found that males had higher levels of other factors associated with metabolic disorders, such as glucose and lipids. The association between hypertension and SUA was independent of other factors. This independent association also included sex, BMI, WBC, TG and HDL, excluding TC and LDL (data not shown).

Based on prospective cohort studies involving 55607 subjects, hypertension risk was found to increase by 13% for every 1 mg/dL increase in serum SUA level[17]. Elevated blood uric acid was observed in 89% of adolescents with primary hypertension in the early stage [18]. Another later study also had a similar finding [19]. A randomized double-blind clinical study found that allopurinol (an inhibitor of uric acid synthesis in vivo) reduces blood pressure in asymptomatic hyperuricemia [20]. This indicates that hyperuricemia may increase cardiovascular risk during asymptomatic periods. Therefore, whether asymptomatic hyperuricemia needs treatment is an urgent problem to be solved in the future management of hypertension. Further studies are needed to determine whether there is a threshold for the effect of serum urate on blood pressure.

In this study, according to the quartile analysis of uric acid, it was found that the levels of TC, TG, LDL-C FBG and WBC were also higher with an increase in uric acid. The change in HDL showed an obviously

opposite trend. SBP and DBP proved to be higher with more factors of metabolic disorders. This evidence indicated that uric acid might increase the risk for metabolic syndrome. In addition, a cross-sectional study involving 4053 patients demonstrated that individuals with hyperuricemia were also accompanied by a higher risk of insulin resistance and diabetes. The risk of cardiovascular disease due to hyperuricemia may be a secondary effect of uric acid, which presents as a higher BMI, TG and fasting insulin and lower HDL-C[21]. Of course, some studies do not fully support this view. A clinical study including 3508 subjects without clinical cardiovascular disease revealed that high SUA levels were associated with increased triacylglycerol/high-density lipoprotein and hepatic steatosis, independent of metabolic syndrome and obesity [22]. Choi et al. found that uric acid promoted fat synthesis in the liver in an ER stress-induced manner [23]. Uric acids have also been suggested to play a role in hyperglycemia. Rats with oxyacid-induced hyperuricemia have an increased metabolic response to fructose and increased blood glucose, blood pressure and kidney damage [24]. Another study also reported that hyperuricemic rats exhibited increased liver fat accumulation through elevated hepatic aldose reductase expression [25].

Urate may induce the occurrence and development of hypertension through a variety of potential underlying mechanisms. Several recent studies mentioned the observation of urate crystal deposits in the joints of the majority of asymptomatic hyperuricemic patients, which may promote chronic inflammation [26]. Soluble uric acid activates the NLRP3 inflammasome and the assembly of NLRP3 and apoptosis-associated speck-like protein in macrophages, even at low concentrations of 300 μmol/L. In addition, then, the level of IL-1β increases [27]. The stimulation of urate increases the expression of c-reactive protein in human umbilical vein endothelial cells and smooth muscle cells [28]. Another study found that soluble urate induced reactive oxygen species increases in human umbilical vein endothelial cells [29]. Urate may promote endothelial dysfunction by nitric oxide inhibition and increasing oxidative stress. Meanwhile, urate stimulates proliferation, angiotensin II production and oxidative stress mediated by the MAP kinase pathway in vascular smooth muscle cells [30]. This proliferative effect may be involved in vascular remodeling. Animal model studies of hyperuricemia have revealed that hyperuricemic rats show proteinuria and reduced renal function microvascular injury and macrophage infiltration[31, 32].

We noted some limitations to our study. First, we do not seem to know for sure whether uric acid was the "cause" of hypertension because this was a cross-sectional study. Second, almost all the research subjects were employees of the Dongfeng Commercial Vehicle Company and of Han nationality. Therefore, our findings may not apply to other ethnic groups with different genetic backgrounds. More prospective cohort studies need to be performed to confirm the cause-effect relationship between SUA and hypertension. Basic research on urate and its influencing mechanism on hypertension is still a matter of debate in this field.

In conclusion, we verified that uric acid was associated with hypertension independent of other metabolic risk factors. However, the presence of other risk factors with uric acid had an additive effect on blood

pressure. Therefore, routine control of SUA is recommended in the management of hypertension to reduce long-term risk.

Declarations

Acknowledgements

We appreciated physical examination center for supporting our study.

Authors' contributions

JC conceived the project, designed the study, and revised the manuscript. HQ and AM were responsible for design and collected the clinical data, analyzed data and wrote the paper. HX, JC, XZ, YL, XM, HY, XL, JY, XJ and DL contributed to data analysis and revision. All the authors read, critically revised, and agreed to be accountable for the content of manuscript.

Funding

This work was supported by grants from National Natural Science Foundation of China (81400288, 81573244), the Foundation of Health Commission of Hubei (WJ2021M061, WJ2019F071), the Natural Science Foundation of the Bureau of Science and Technology of Shiyan City (grant no. 21Y71, 21Y84, 21Y86, 19Y89, 16Y06), the Faculty Development Grants from Hubei University of Medicine (2018QDJZR04), and Hubei Key Laboratory of Wudang Local Chinese Medicine Research (Hubei University of Medicine) (Grant No. WDCM2020010).

Availability of data and materials

The datasets generated and analyzed during the current study are not publicly available because of the restrictions by the Sinopharm Dongfeng General Hospital, but are available from the corresponding author Jun Chen on reasonable request.

Ethics approval and consent to participate

This study was reviewed and approved by the ethics committee of the Sinopharm Dongfeng General Hospital (LW-2022-004), the Affiliated Dongfeng Hospital, Hubei University of Medicine. **The written informed consent was obtained from all study participants. The study was conducted in accordance with 1964 Helsinki Declaration.**

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no conflict of interest.

References

1. Marsico F, Paolillo S, Gargiulo P, Bruzzese D, Dell'Aversana S, Esposito I *et al*. Effects of glucagon-like peptide-1 receptor agonists on major cardiovascular events in patients with Type 2 diabetes mellitus with or without established cardiovascular disease: a meta-analysis of randomized controlled trials. *EUR HEART J* (2020) 41: 3346-3358.
2. Lu J, Lu Y, Wang X, Li X, Linderman GC, Wu C *et al*. Prevalence, awareness, treatment, and control of hypertension in China: data from 1.7 million adults in a population-based screening study (China PEACE Million Persons Project). *LANCET* (2017) 390: 2549-2558.
3. Narkiewicz K. Diagnosis and management of hypertension in obesity. *OBES REV* (2006) 7: 155-162.
4. Mallat SG, Al KS, Tanios BY, Jurjus A. Hyperuricemia, Hypertension, and Chronic Kidney Disease: an Emerging Association. *CURR HYPERTENS REP* (2016) 18: 74.
5. Mortada I. Hyperuricemia, Type 2 Diabetes Mellitus, and Hypertension: an Emerging Association. *CURR HYPERTENS REP* (2017) 19: 69.
6. Pistoia F, Sacco S, Degan D, Tiseo C, Ornello R, Carolei A. Hypertension and Stroke: Epidemiological Aspects and Clinical Evaluation. *High Blood Press Cardiovasc Prev* (2016) 23: 9-18.
7. Yokose C, McCormick N, Choi HK. The role of diet in hyperuricemia and gout. *CURR OPIN RHEUMATOL* (2021) 33: 135-144.
8. Chen-Xu M, Yokose C, Rai SK, Pillinger MH, Choi HK. Contemporary Prevalence of Gout and Hyperuricemia in the United States and Decadal Trends: The National Health and Nutrition Examination Survey, 2007-2016. *ARTHRITIS RHEUMATOL* (2019) 71: 991-999.
9. Song P, Wang H, Xia W, Chang X, Wang M, An L. Prevalence and correlates of hyperuricemia in the middle-aged and older adults in China. *Sci Rep* (2018) 8: 4314.
10. Lin X, Wang X, Li X, Song L, Meng Z, Yang Q *et al*. Gender- and Age-Specific Differences in the Association of Hyperuricemia and Hypertension: A Cross-Sectional Study. *INT J ENDOCRINOL* (2019) 2019: 7545137.
11. Shen Y, Chang C, Zhang J, Jiang Y, Ni B, Wang Y. Prevalence and risk factors associated with hypertension and prehypertension in a working population at high altitude in China: a cross-sectional study. *Environ Health Prev Med* (2017) 22: 19.
12. Ouppatham S, Bancha S, Choovichian P. The relationship of hyperuricemia and blood pressure in the Thai army population. *J POSTGRAD MED* (2008) 54: 259-262.
13. Wang M, Wu T, Yu C, Gao W, Lv J, Wu Y *et al*. Association between blood pressure levels and cardiovascular deaths: a 20-year follow-up study in rural China. *BMJ OPEN* (2020) 10: e35190.
14. Dominguez-Zambrano E, Pedraza-Chaverri J, Lopez-Santos AL, Medina-Campos ON, Cruz-Rivera C, Bueno-Hernandez F *et al*. Association between Serum Uric Acid Levels, Nutritional and Antioxidant Status in Patients on Hemodialysis. *NUTRIENTS* (2020) 12.
15. Al-Zahrani J, Shubair MM, Al-Ghamdi S, Alrasheed AA, Alduraywish AA, Alreshidi FS *et al*. The prevalence of hypercholesterolemia and associated risk factors in Al-Kharj population, Saudi Arabia:

a cross-sectional survey. *BMC Cardiovasc Disord* (2021) 21: 22.

16. Goncalves JP, Oliveira A, Severo M, Santos AC, Lopes C. Cross-sectional and longitudinal associations between serum uric acid and metabolic syndrome. *ENDOCRINE* (2012) 41: 450-457.
17. Rebora P, Andreano A, Triglione N, Piccinelli E, Palazzini M, Occhi L *et al*. Association between uric acid and pulse wave velocity in hypertensive patients and in the general population: a systematic review and meta-analysis. *Blood Press* (2020) 29: 220-231.
18. Feig DI, Johnson RJ. Hyperuricemia in childhood primary hypertension. *HYPERTENSION* (2003) 42: 247-252.
19. Alper AJ, Chen W, Yau L, Srinivasan SR, Berenson GS, Hamm LL. Childhood uric acid predicts adult blood pressure: the Bogalusa Heart Study. *HYPERTENSION* (2005) 45: 34-38.
20. Feig DI, Soletsky B, Johnson RJ. Effect of allopurinol on blood pressure of adolescents with newly diagnosed essential hypertension: a randomized trial. *JAMA* (2008) 300: 924-932.
21. Rathmann W, Funkhouser E, Dyer AR, Roseman JM. Relations of hyperuricemia with the various components of the insulin resistance syndrome in young black and white adults: the CARDIA study. Coronary Artery Risk Development in Young Adults. *ANN EPIDEMIOL* (1998) 8: 250-261.
22. Keenan T, Blaha MJ, Nasir K, Silverman MG, Tota-Maharaj R, Carvalho JA *et al*. Relation of uric acid to serum levels of high-sensitivity C-reactive protein, triglycerides, and high-density lipoprotein cholesterol and to hepatic steatosis. *AM J CARDIOL* (2012) 110: 1787-1792.
23. Choi YJ, Shin HS, Choi HS, Park JW, Jo I, Oh ES *et al*. Uric acid induces fat accumulation via generation of endoplasmic reticulum stress and SREBP-1c activation in hepatocytes. *LAB INVEST* (2014) 94: 1114-1125.
24. Tapia E, Cristobal M, Garcia-Arroyo FE, Soto V, Monroy-Sanchez F, Pacheco U *et al*. Synergistic effect of uricase blockade plus physiological amounts of fructose-glucose on glomerular hypertension and oxidative stress in rats. *Am J Physiol Renal Physiol* (2013) 304: F727-F736.
25. Sanchez-Lozada LG, Andres-Hernando A, Garcia-Arroyo FE, Cicerchi C, Li N, Kuwabara M *et al*. Uric acid activates aldose reductase and the polyol pathway for endogenous fructose and fat production causing development of fatty liver in rats. *J BIOL CHEM* (2019) 294: 4272-4281.
26. De Miguel E, Puig JG, Castillo C, Peiteado D, Torres RJ, Martin-Mola E. Diagnosis of gout in patients with asymptomatic hyperuricaemia: a pilot ultrasound study. *ANN RHEUM DIS* (2012) 71: 157-158.
27. Kim SM, Lee SH, Kim YG, Kim SY, Seo JW, Choi YW *et al*. Hyperuricemia-induced NLRP3 activation of macrophages contributes to the progression of diabetic nephropathy. *Am J Physiol Renal Physiol* (2015) 308: F993-F1003.
28. Kang DH, Park SK, Lee IK, Johnson RJ. Uric acid-induced C-reactive protein expression: implication on cell proliferation and nitric oxide production of human vascular cells. *J AM SOC NEPHROL* (2005) 16: 3553-3562.
29. Lu J, Sun M, Wu X, Yuan X, Liu Z, Qu X *et al*. Urate-lowering therapy alleviates atherosclerosis inflammatory response factors and neointimal lesions in a mouse model of induced carotid atherosclerosis. *FEBS J* (2019) 286: 1346-1359.

30. Corry DB, Eslami P, Yamamoto K, Nyby MD, Makino H, Tuck ML. Uric acid stimulates vascular smooth muscle cell proliferation and oxidative stress via the vascular renin-angiotensin system. *J HYPERTENS* (2008) 26: 269-275.
31. Liu N, Xu L, Shi Y, Fang L, Gu H, Wang H *et al*. Pharmacologic targeting ERK1/2 attenuates the development and progression of hyperuricemic nephropathy in rats. *Oncotarget* (2017) 8: 33807-33826.
32. Asakawa S, Shibata S, Morimoto C, Shiraishi T, Nakamura T, Tamura Y *et al*. Podocyte Injury and Albuminuria in Experimental Hyperuricemic Model Rats. *OXID MED CELL LONGEV* (2017) 2017: 3759153.

Figures

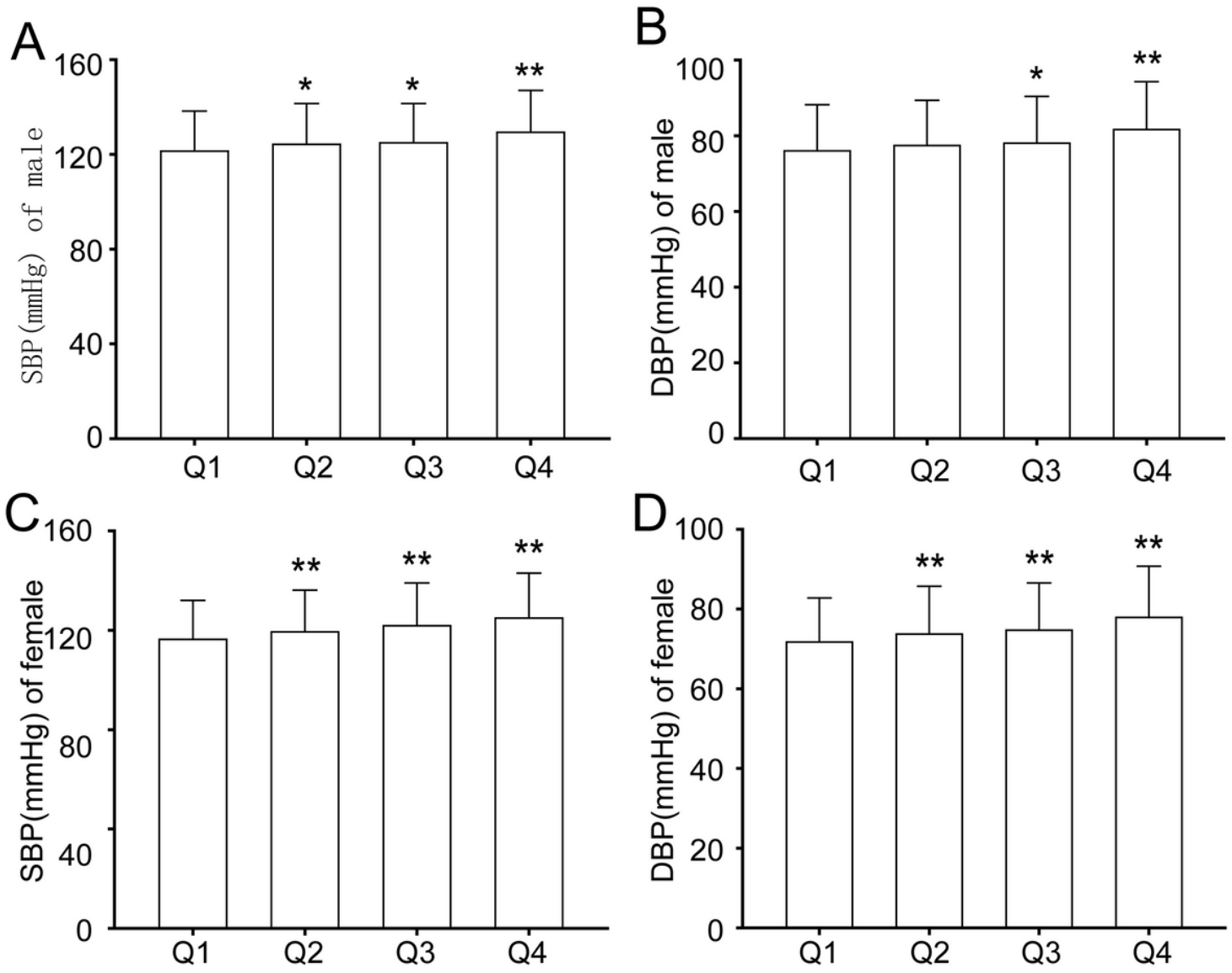

Figure 1

Prevalence of SBP and DBP between the SUA quartiles. *P <0.05 and **P <0.001 when compared with Q1.

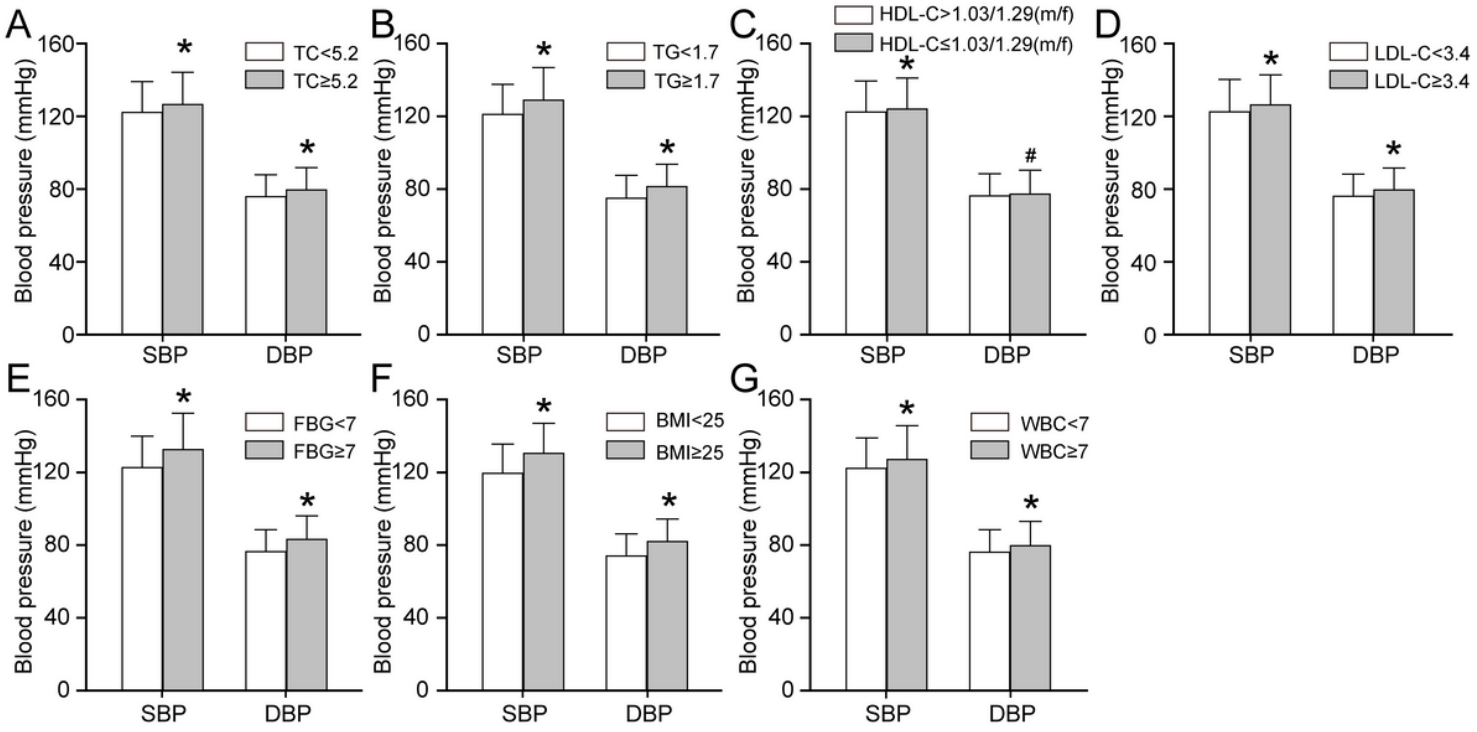

Figure 2

Correlation between blood pressure and TC (A), TG (B), HDL-C (C), LDL-C (D), FBG (E), BMI (F), and WBC (G). *P <0.001 and #P <0.005.

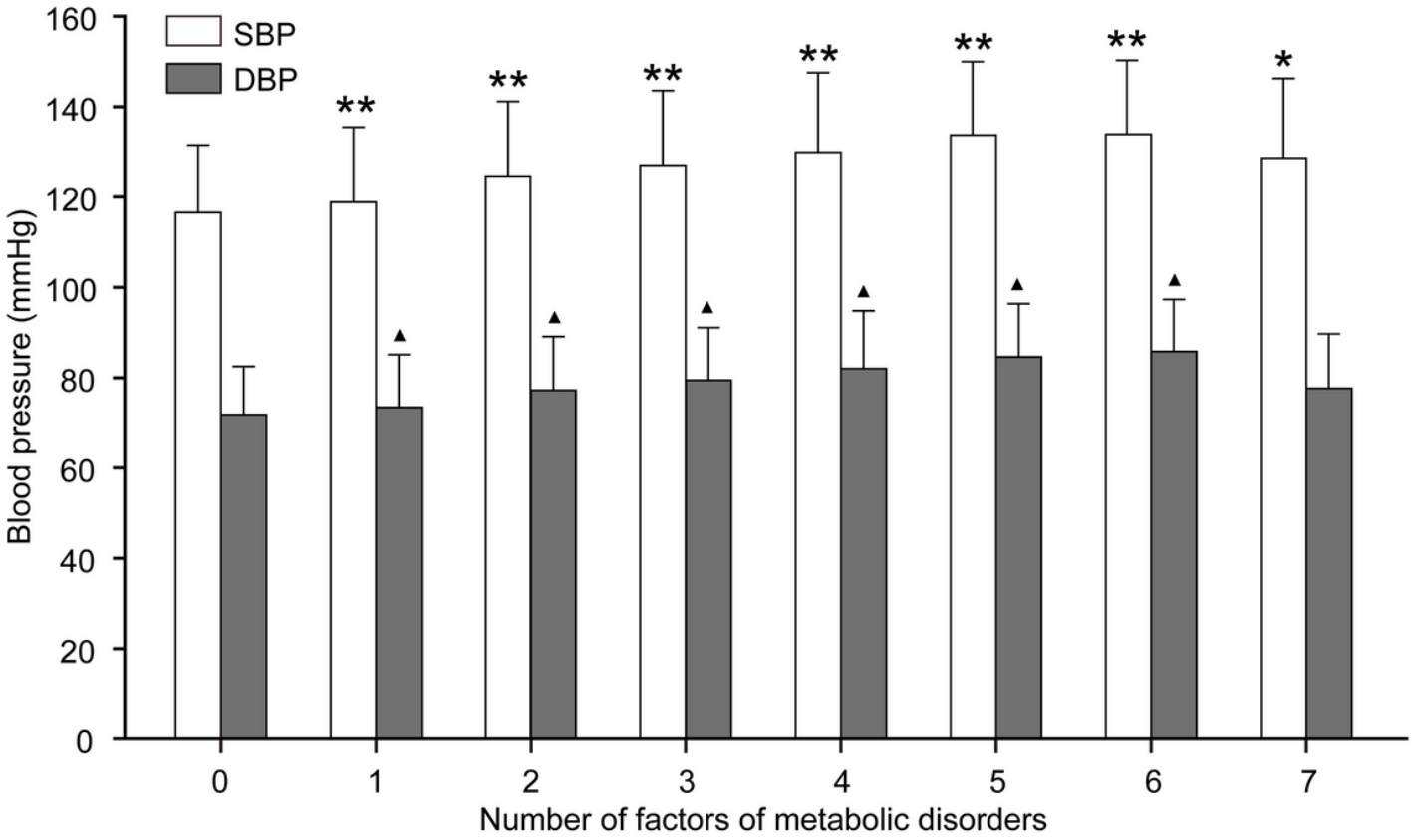

Figure 3

The relationship between blood pressure and the number of factors of metabolic disorders in the population. *P <0.05 and **P/▲P <0.001 when compared with subjects who exhibited no factors of metabolic disorders.