ORIGINAL ARTICLE

Serum Uric Acid: A Missing Link between Metabolic Syndrome and Cardiovascular Risk? A Cross-sectional Study

Kadeejath Mubeenath Erfana, Shaheena Yassir

Department of Biochemistry, Yenepoya Medical College, Yenepoya (Deemed to be University), Mangaluru, Karnataka, India

Abstract

Background: The study was aimed to evaluate serum uric acid (SUA) levels in patients with and without metabolic syndrome (MetS) with the Framingham risk score (FRS) and MetS components. **Materials and Methods:** The current cross-sectional study was carried out in a medical college hospital from September 2024 to September 2025 with prior informed consent, involving 88 participants, 44 in each group, aged 18–50 years, with or without MetS as per revised National Cholesterol Education Program guidelines. The institutional ethics approval ID is YEC-2/2024/224. Demographic and clinical data were collected. SUA and lipid profile were estimated by the colorimetric method in Vitros 5600. FRS was calculated using an online calculator. The independent *t*-test, Pearson correlation, and Chi-square tests were used for statistical analysis. **Results:** The participants' mean age was 44.04 ± 7.67 years, and 54.5% of the participants were men. Body mass index, diastolic blood pressure, fasting blood glucose (FBS), total cholesterol (TC), triglycerides, high-density lipoprotein, and FRS were significantly different between the MetS and non-MetS groups ($P < 0.05$). FRS exhibited a positive correlation with TC ($r = 0.314$, $P = 0.038$), and SUA exhibited a significant negative correlation with FBS ($r = -0.46$, $P = 0.002$) in patients with MetS. **Conclusion:** The inverse correlation between SUA and fasting blood glucose in individuals with MetS suggests a potential interplay between the metabolism of uric acid and glycemic regulation.

Key words: Cardiovascular disease, diabetes mellitus, dyslipidemia, hypertension

INTRODUCTION

Globally, metabolic syndrome (MetS) represents a significant clinical problem.[1] The World Health Organization initially defined MetS in 1998. Three years later, the National Cholesterol Education Program (NCEP) defined MetS as the co-occurrence of multiple metabolic conditions, including abdominal obesity, elevated blood sugar, elevated cholesterol, elevated blood pressure, and an inappropriate lipid profile, all of which increase the risk of cardiovascular diseases (CVD).[2]

The uric acid (UA), an end product of purine metabolism, produced by the liver and excreted by the kidneys, gradually rises with the growth of the body from early childhood to the ages of 15–17 years.[3] Research has shown that UA levels are associated with atherosclerosis, mortality, and CVD. There was evidence of elevated plasma renin-angiotensin activity in hyperuricemia.[2] According to studies, hyperuricemia at the serum UA (SUA) level is defined as more than 6.0 mg/dL and has also been linked to elevated inflammatory markers.[4] According to the largest systematic review and meta-analysis (n = 951,083), MetS is linked to a 1.5-fold increase in the risk of all-cause death and a two-fold increase in the risk of CVD and its mortality, and stroke.[5] MetS and diabetes mellitus (DM) also have modestly increased SUA. Approximately 7.7 times as many people with MetS and DM have hyperuricemia as the general population. However, hypouricemia people also have a high frequency of MetS.[6] Although several studies have investigated the association between SUA and components of MetS, the

Address for correspondence:
Shaheena Yassir, Department of Biochemistry, Yenepoya Medical College, Yenepoya (Deemed to be University), Mangaluru - 575018, Karnataka, India.
Phone: 09591170967.
E-mail: drshaheenayassir@yenepoya.edu.in

Received: 19-05-2026
Revised: 18-06-2026
Accepted: 26-06-2026

novelty of the present study lies in exploring the additional role of SUA as a potential marker for cardiovascular risk stratification using the Framingham risk score (FRS). It is a tool to estimate 10 year risk of CVD.[7] Hence, the purpose of the current study was to evaluate SUA levels in patients with and without MetS with the FRS and MetS components.

MetS is a major global public health concern. It is the grouping of multiple cardiovascular risk factors that raises the chance of mortality from CVD. Therefore, it is critical to examine the causes of the sharp increase in MetS and look at indicators that can predict early MetS risk as well as the likelihood of future adverse occurrences.

MATERIALS AND METHODS

The current cross-sectional study, which was carried out at the Yenepoya Medical College Hospital between September 2024 and September 2025 with prior informed consent from the study participants, involved 88 participants, 44 in each group, aged 18–50 years, with or without MetS. The sampling method used is convenience sampling.

The Institutional Ethics Committee gave its approval to the study (YEC-2/2024/224). The 2013 Helsinki Declaration and its later modifications, ethical guidelines were followed in this investigation.

Sample size calculation

Using G* power software, under an independent *t*-test, it is suggested to collect 88 samples (44 from each group) at 99% confidence level and 95% power. The effect size = 0.9253 is calculated using mean and standard deviations reported in Yilmaz *et al*.[2]

Inclusion criteria

Group I (MetS)

The study included participants who met the MetS requirements according to the revised NCEP guidelines and were between the ages of 18 and 50. Three or more of the five cardiovascular risk factors listed below are considered to be part of the MetS: The five cardiovascular risk factors that are considered part of the MetS include: Systemic hypertension (130/85 mmHg); elevated fasting blood sugar (FBS) (100 mg/dL); high-density lipoprotein (HDL) cholesterol levels (men <40 mg/dL; women <50 mg/dL); waist circumference (WC) measurements (men 102 cm; women 88 cm); and triglycerides (TG) at 150 mg/dL.[8]

Group II (Non-MetS)

Participants who were aged between 18 and 50 years and not fulfilling the MetS criteria as per revised NCEP guidelines.

Exclusion criteria

Pregnant women and lactating mothers, chronic illness (Kidney disease, Cardiac disease), and those on hypouricemia drugs were excluded.

Sample and data collection

A 5 mL fasting blood sample in plain tubes and 2 mL in grey vacutainer fasting plasma glucose (FBS) were collected from the subjects. The lipid profile and SUA were estimated using the plain sample. The participant's demographic information, age, gender, height, weight, history of smoking, history of diabetes and hypertension, and family history of diabetes and CVD were among the data gathered from their medical records and the study participants.

Body mass index (BMI) calculation

BMI is calculated by: https://www.calculator.net/bmi-calculator.html.

Laboratory investigation

The SUA, FBS, and lipid profile were estimated using the VITROS 5600 Integrated system by reflectance spectrophotometry.[9] The data is expressed as mg/dL.

FRS calculator

It provides a 10-year risk prediction for CVDs such as heart failure, angina, myocardial infarction, coronary mortality, and ischemic stroke. An online calculator was used to calculate it:

https://www.framinghamheartstudy.org/fhs-risk-functions/cardiovascular-disease-10-year-risk

Age, diabetes, smoking history, systolic blood pressure, total cholesterol (TC), HDL cholesterol, and BMI are among the predictors.

Statistical analysis

The MS Excel was used to code the data points, and IBM Statistical Package for the Social Sciences 27 was used for the statistical analysis. The normality was checked using the Shapiro-Wilk test. The mean and standard deviation were used for quantitative variables. The summary of categorical variables was reported in terms of frequencies and charts. The Chi-square test was used to assess the association between the categories. The significant difference between the two groups was assessed through an independent *t*-test. The $P < 0.5$ was considered as significant.

RESULTS

Baseline characteristics of the study population are shown in Table 1. The mean ± standard deviation of age of the entire study population is 44.04 ± 7.67. Gender distribution of the entire population has female of 40 (45.5%) and male of 48 (54.5%). The current study shows a statistically significant difference in BMI (kg/m^2), diastolic blood pressure (DBP) (mmHg), FBS (mg/dL), TC (mg/dL), TG (mg/dL), HDL (mg/dL), and FRS (%) between MetS and non-MetS patients.

Table 1 displays the study population's baseline characteristics. The study population as an entire group has a mean age of 44.04 ± 7.67 years. Among the total population, 40 (45.5%) are female, and 48 (54.5%) are male. BMI (kg/m^2), DBP (mmHg), FBS (mg/dL), TC (mg/dL), TGs (mg/dL), HDL (mg/dL), and FRS (%) were significantly different between individuals with and without MetS, according to the current study.

The association of categorical variables with or without MetS patients is shown in Table 2. The current study shows a statistically significant with a history of diabetes and family history of diabetes and no significant with other variables.

Correlation of UA with MetS components is shown in Table 3, which shows statistically significant positive correlation in FBS (mg/dL) (r = −0.46, P = 0.002) in MetS patients.

In Table 4, we tried to correlate FRS with MetS components, which shows statistically significant positive correlation in TC (mg/dL) (r = 0.314, P = 0.038) in MetS patients.

DISCUSSION

The purpose of the current study was to evaluate SUA levels in patients with and without MetS with the FRS and MetS components. The study population was majority middle-aged individuals, with a mean age of 44.04 ± 7.67 years and a nearly equal gender distribution (45.5% females and 54.5% males). In the findings of the current study, there were significant differences between the MetS and non-MetS groups in terms of WC (P < 0.001), BMI (P < 0.001), DBP (P = 0.026), FBS (P < 0.001), TC (P = 0.003), TG (P < 0.01), and HDL cholesterol (P = 0.031) [Table 1]. These results align with those of Sah *et al*., who reported significant correlations between SUA levels and BMI (P = 0.03), FBS (P = 0.097), and HDL (P = 0.004).[1] Similarly, in children who were obese or overweight, Ozalp Kizilay *et al*. found significant correlations between SUA and TG (P = 0.028) and BMI (P = 0.01).[10] Furthermore, Khichar *et al*., found strong correlations between SUA and all MetS indicators (P < 0.001), supporting the concept that hyperuricemia may be a component of MetS.[11] Nejatinamini *et al*., observed that SUA was highly correlated with TG (P = 0.004) and inversely correlated with HDL (P = 0.003), concluding that an increase in SUA independently increased the risk of MetS by nearly twofold.[12] Recently, Kolahi Ahari *et al*., showed strong correlations between SUA and all components of MetS in the large MASHAD cohort (n = 9,637).[13] The concept that SUA functions as a significant biomarker associated with cardiometabolic disorders and might predict cardiovascular consequences in at-risk persons is supported by these studies.

Patients with MetS and those without were compared on categorical variables [Table 2]. While other characteristics were not statistically significant, there were significant

Table 1: Baseline characteristics of study population

Parameter	Entire population	MetS	Non-MetS	*P*-value
Age	44.04±7.67	44.70±6.64	43.38±8.61	0.424
BMI (kg/m^2)	25.56±2.38	26.50±1.48	24.27±2.27	<0.001*
WC (cm)	86.1±9.06	91.1±4.20	81.0±98.2	<0.001*
SBP (mmHg)	121.02±3.80	121.70±4.81	120.34±2.26	0.093
DBP (mmHg)	80.55±1.44	80.79±1.85	80.11±0.75	0.026*
FBS (mg/dL)	133.55±59.77	156.68±65.29	110.43±43.25	<0.001*
TC (mg/dL)	187.48±49.05	202.59±41.28	172.38±51.94	0.003*
TG (mg/dL)	163.63±62.01	201.75±65.32	125.63±23.47	<0.001*
HDL (mg/dL)	49.136±18.17	44.97±13.57	53.29±21.17	0.031*
LDL (mg/dL)	116.88±36.85	121.32±35.76	111.84±37.60	0.201
Uric acid (mg/dL)	5.00±1.88	4.86±1.50	4.67±1.80	0.117
F. Risk score	5.76±2.42	7.65±1.50	3.86±1.50	<0.001*

Data expressed as mean±standard deviation. Statistical test used is the independent sample *t*-test. *P<0.05 is considered as significant. BMI: Body mass index, WC: Waist circumference, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, FBS: Fasting blood sugar, TC: Total cholesterol, TG: Triglyceride, HDL: High density lipoprotein, LDL: Low density lipoprotein, MetS: Metabolic syndrome, F risk score: Framingham risk score

Table 2: Association of categorical variables with or without MetS patients

Components	Categories	MetS (%)	Non-MetS (%)	Chi-square value	*P*-value
Gender	Male	27 (30.7)	21 (23.9)	1.65	0.199
	Female	17 (1.3)	23 (26.1)		
Diabetes	Yes	33 (37.5)	9 (10.2)	26.2	<0.001*
	No	11 (12.5)	35 (39.8)		
H/o diabetes	Yes	16 (18.2)	7 (8.0)	2.96	0.085
	No	28 (31.8)	37 (42)		
Family h/o diabetes	Yes	24 (27.3)	6 (6.8)	16.4	<0.001*
	No	20 (22.7)	38 (43.2)		
Family h/o CAD	Yes	24 (27.3)	16 (18.2)	2.93	0.087
	No	20 (22.7)	28 (31.8)		
H/o smoking	Yes	15 (17.0)	23 (26.1)	2.96	0.085
	No	29 (33.0)	21 (23.9)		
H/o hypertension	Yes	19 (21.6)	14 (15.9)	1.21	0.271
	No	25 (28.4)	30 (34.1)		

Data expressed as frequency and percentage statistical test, Chi-square analysis. *P<0.05 is considered as significant. CAD: Coronary artery disease

Table 3: Correlation of uric acid with components of MetS

Parameter	Total population		Metabolic syndrome		Non-metabolic syndrome	
	r-value	*P*-value	*r*-value	*P*-value	*r*-value	*P*-value
BMI (kg/m^2)	0.026	0.81	−0.03	0.548	−0.077	0.618
WC (cm)	0.032	0.172	0.210	0.172	−0.026	0.867
SBP (mmHg)	0.038	0.727	−0.008	0.961	0.045	0.772
DBP (mmHg)	0.021	0.847	−0.029	0.853	0.045	0.773
FBS (mg/dL)	−0.221	0.039*	−0.46	0.002*	−0.062	0.688
TC (mg/dL)	0.074	0.491	0.123	0.426	−0.063	0.686
Trig (mg/dL)	0.213	0.046	0.188	0.22	0.008	0.6
HDL (mg/dL)	−0.064	0.553	0.084	0.589	−0.107	0.491
LDL (mg/dL)	0.111	0.303	−0.02	0.898	0.21	0.172

Data expressed as Mean±standard deviation, Statistical *t*-test used is Pearson's correlation. *P<0.05 is considered as significant. BMI: Body mass index, WC: Waist circumference, SBP: Systolic blood pressure, DSP: Diastolic blood pressure, FBS: Fasting blood sugar, TC: Total cholesterol, Trig: Triglyceride, HDL: High density lipoprotein, LDL: Low density lipoprotein, F risk score: Framingham risk score

correlations with family history of diabetes ($P < 0.001$) and history of diabetes ($P < 0.001$). Understanding the main factors that contribute to MetS can help guide preventative efforts aimed at lowering blood pressure and blood glucose levels in high-risk populations, which will ultimately lessen the incidence of stroke and other CVD-related consequences.[14]

In the MetS group, the correlation analysis between SUA and MetS components showed a significant negative correlation between SUA and FBS (r = −0.46; $P = 0.002$) [Table 3]. This inverse association raises the possibility of a complicated or compensating metabolic interaction that needs more research. nevertheless, Cibickova *et al*., and Inanir discovered positive correlations between SUA and FBS ($P < 0.001$), indicating that methodological and population-based differences might have an impact on these associations.[15,16] To clarify the physiological processes behind this unanticipated inverse correlation in the current cohort, more research with larger sample sizes is required.

The correlation of FRS with components of MetS and SUA was analyzed in Table 4. The result showed a significant correlation in FBS, BMI, TC, and TG in the total population and in MetS patients signification correlation was seen only with TC ($P = 0.03$). In addition, Yousefzadeh *et al*., discovered that in an Iranian sample, TC and FRS were significantly correlated ($P < 0.001$), while no other MetS components were significant.[17] According to Jahangiry *et al*., TG and HDL did not significantly correlate with FRS, indicating that TC is still the most reliable lipid predictor of cardiovascular risk in MetS populations.[18] The reduced

Table 4: Correlation of Framingham risk score with components of MetS

Parameter	Total population		Metabolic syndrome		Non-metabolic syndrome	
	r-value	*P*-value*	*r*-value	*P*-value	*r*-value	*P*-value
BMI (kg/m^2)	0.477	<0.001	0.155	0.315	−0.033	0.832
WC (cm)	0.471	<0.001*	0.041	0.78	0.109	0.482
SBP (mmHg)	0.083	0.443	−0.158	0.305	0.014	0.928
DBP (mmHg)	0.146	0.175	−0.109	0.482	0.014	0.928
FBS (mg/dL)	0.286	0.007*	−0.112	0.469	0.08	0.604
TC (mg/dL)	0.312	0.003*	0.314	0.038*	−0.04	0.799
TG (mg/dL)	0.5	<0.001*	0.103	0.507	−0.166	0.281
HDL (mg/dL)	0.1	0.077	0.105	0.497	−0.091	0.555
LDL (mg/dL)	0.163	0.129	0.177	0.252	0.007	0.964
Uric acid mg/dL	0.127	0.237	0.092	0.551	−0.126	0.413

Data expressed as Mean±standard deviation, Statistical *t*-test used is Pearson's correlation. *P<0.05 is considered as significant. BMI: Body mass index, WC: Waist circumference, SBP: Systolic blood pressure, DSP: Diastolic blood pressure, FBS: Fasting blood sugar, TC: Total cholesterol, Trig: Triglyceride, HDL: High density lipoprotein, LDL: Low density lipoprotein, F risk score: Framingham risk score

sample size and demographic variability may be the reason for the current study's lack of significant associations with the exception of TC.

Although the inverse correlation between SUA and FBS seen here as a contrast, it raises the possibility of dietary, lifestyle, or cultural effects that warrant more research. In addition, hyperinsulinemia due to insulin resistance resulting in high glucose level particularly with glycosuria, may alter the renal UA excretion, resulting in low SUA.[19] In order to establish SUA as an acceptable marker in the clinical assessment of MetS and CVD risk and to elucidate causal links, larger longitudinal studies are necessary.

CONCLUSION

The inverse correlation between SUA and FBS that has been discovered points to intricate metabolic relationships that need more research. Larger longitudinal investigations are often required to validate these correlations and elucidate SUA's causal role in the development of MetS and CVD.

REFERENCES

1. Sah SK, Khatiwada S, Pandey S, Kc R, Das BK, Baral N, *et al*. Association of high-sensitivity C-reactive protein and uric acid with the metabolic syndrome components. Springerplus 2016;5:269.
2. Yılmaz AS, Kahraman F, Ergul E, Koc H, Çetin M. Serum uric acid level independently predicted metabolic syndrome in non-diabetic hypertensive patients. Arter Hypertens 2022;26:146-52.
3. Mirhafez SR, Ebrahimi M, Saberi Karimian M, Avan A, Tayefi M, Heidari-Bakavoli A, *et al*. Serum high-sensitivity C-reactive protein as a biomarker in patients with metabolic syndrome: Evidence-based study with 7284 subjects. Eur J Clin Nutr 2016;70:1298-304.
4. Foster C, Smith L, Alemzadeh R. Excess serum uric acid is associated with metabolic syndrome in obese adolescent patients. J Diabetes Metab Disord 2020;19:535-43.
5. Suhett LG, Hermsdorff HH, Rocha NP, Silva MA, Filgueiras MD, Milagres LC, *et al*. Increased C-reactive protein in Brazilian children: Association with cardiometabolic risk and metabolic syndrome components (PASE study). Cardiol Res Pract 2019;2019:3904568.
6. Niu SW, Lin HY, Kuo IC, Zhen YY, Chang EE, Shen FC, *et al*. Hyperuricemia, a non-independent component of metabolic syndrome, only predicts renal outcome in chronic kidney disease patients without metabolic syndrome or diabetes. Biomedicines 2022;10:1719.
7. Bosomworth NJ. Practical use of the Framingham risk score in primary prevention: Canadian perspective. Can Fam Physician 2011;57:417-23.
8. Grundy SM, Brewer HB, Cleeman JI, Smith SC, Lenfant C. Definition of metabolic syndrome: Report of the National Heart, Lung, and Blood Institute/American Heart Association conference on scientific issues related to definition. Circulation 2004;109:433-8.
9. Cume HG, Columbus RL, Dappen GM, Eder TW, Fellows WD, Figureas J *et al.* Multilayer film elements for clinical analysis: General concepts. Clin Chem 1978;24:1335-42.
10. Ozalp Kizilay D, Sen S, Ersoy B. Associations between serum uric acid concentrations and cardiometabolic risk and renal injury in obese and overweight children. J Clin Res Pediatr Endocrinol 2019;11:262-9.
11. Khichar S, Choudhary S, Singh VB, Tater P, Arvinda RV, Ujjawal V. Serum uric acid level as a determinant of the metabolic syndrome: A case control study. Diabetes Metab Syndr Clin Res Rev 2017;11:19-23.
12. Nejatinamini S, Ataie-Jafari A, Qorbani M,

Nikoohemat S, Kelishadi R, Asayesh H, *et al*. Association between serum uric acid level and metabolic syndrome components. J Diabetes Metab Disord 2015;14:1-7.
13. Kolahi Ahari R, Mansoori A, Sahranavard T, Miri MS, Feizi S, Esmaily H, *et al*. Serum uric acid to high-density lipoprotein ratio as a novel indicator of inflammation is correlated with the presence and severity of metabolic syndrome: A large-scale study. Endocrinol Diabetes Metab 2023;6:e446.
14. Marhl M, Grubelnik V, Magdic M, Markovic R. Diabetes and metabolic syndrome as risk factors for COVID-19. Diabetes Metab Syndr 2020;14:671-7.
15. Cibickova L, Langova K, Vaverkova H, Kubickova V, Karasek D. Correlation of uric acid levels and parameters of metabolic syndrome. Physiol Res 2017;66:481.
16. Inanir M. Serum uric acid (SUA) in morbidly obese patients and its relationship with metabolic syndrome. Aging Male 2020;23:1165-9.
17. Yousefzadeh G, Shokoohi M, Najafipour H, Shadkamfarokhi M. Applying the Framingham risk score for prediction of metabolic syndrome: The Kerman Coronary Artery Disease Risk Study, Iran. ARYA Atheroscler 2015;11:179.
18. Jahangiry L, Farhangi MA, Rezaei F. Framingham risk score for estimation of 10-years of cardiovascular diseases risk in patients with metabolic syndrome. J Health Popul Nutr 2017;36:1-6.
19. Qin Y, Zhang S, Cui S, Shen X, Wang J, Cui X, *et al*. High urinary excretion rate of glucose attenuates serum uric acid level in type 2 diabetes with normal renal function. J Endocrinol Invest 2021;44:1981-8.

Source of Support: Nil. **Conflicts of Interest:** None declared.