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Association of Serum Uric Acid with Cardiovascular Diseases in Pakistani Adults: A Cross-Sectional Analysis

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ABSTRACT

Numerous researchers have identified a strong link between increased levels of serum uric acid and cardiovascular disease. **Objectives:** To find out the association of serum uric acid with cardiovascular disease, independent of major confounding variables including age, sex, hypertension, diabetes, dietary habits, and lifestyle factors. **Methods:** A descriptive cross-sectional study was carried out at Fazaia Ruth Pfau Medical College. Data collection involved demographic, anthropometric, blood pressure, biochemical measurements, and electrocardiography. SPSS-22 was used for data analysis. Statistical methods included t-tests. one-way ANOVA, Mann-Whitney U test, and Pearson correlation were applied. To find the strength of association, a multivariate regression model was applied, and the odds ratio was calculated. **Results:** The frequency of hyperuricemia was 27.5%. Previous medical history of hypertension found a strong, significant association among the groups. The Frequency of cardiovascular diseases, including acute coronary disease, myocardial infarction, and cardiac failure, was 47%, 29.1% and 6% in the normouricemia group and 54.9%, 25.5% and 6.9% in the hyperuricemia group, respectively. Multivariate regression analysis revealed that the severity of cardiovascular diseases increased linearly with increasing serum uric acid concentration. Interestingly, the serum uric acid concentration was high in the cases of myocardial infarction in comparison to other cardiovascular diseases. The cardiovascular disease odds ratio was 1.84 to 2.45 times as the serum uric acid concentration rose above 9mg/dL. **Conclusions:** The Current study identified a significant association of hyperuricemia with cardiovascular diseases. The severity of cardiovascular diseases was observed to rise with increasing serum uric acid levels, and this link remained significant.

INTRODUCTION

Uric acid is a metabolic byproduct generated from the purine metabolism, derived from both endogenous sources and dietary intake [1]. Early research highlighted a potent effect of hyperuricemia in the pathophysiology of hypertension, cardiovascular diseases, diabetes, and kidney disorders [2]. Several physiological explanations have been suggested for its adverse effects on vascular function and blood pressure regulation [3]. Hypertension and diabetes are the known leading risk factors for cardiovascular disease-related deaths. The study on global burden of disease reported that cardiovascular diseases are responsible for nearly 31% of all deaths worldwide [4]. Among cardiovascular disease-related fatalities, around 90% result from coronary artery disease, which involves restricted blood supply to the heart muscle caused by narrowed or obstructed coronary vessels. Maintaining vascular homeostasis is crucial for cardiovascular function [5]. Hypertension and diabetes contribute to vascular

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damage, and hyperuricemia leads to vascular damage through mechanisms such as increased oxidative stress, stimulation of the renin-angiotensin-aldosterone system (RAAS), depletion of mitochondrial DNA, and a decline in intracellular ATP levels [6]. Hypertension may damage vascular structures due to continuous mechanical stress, while elevated uric acid has also been implicated in vascular injury. serum uric acid (Sr.UA) enhances oxidative stress by stimulating NADPH oxidase enzymes, which are responsible for synthesizing reactive oxygen species in vascular cells. Additionally, it inhibits endothelial nitric oxide synthase, resulting in decreased nitric oxide production. This reduction impairs vasodilation, promotes vasoconstriction, and ultimately contributes to endothelial dysfunction [7, 8]. Moreover, serum uric acid can activate pro-inflammatory molecules and the RAAS pathway, which together disrupt vascular integrity and facilitate atherosclerotic plaque formation, ultimately reducing cardiac blood supply [8]. Many researchers have identified a correlation between elevated levels of Sr.UA and cardiovascular disease (CVD). However, variables such as age, sex, ethnicity, lifestyle, diet, and coexisting conditions like hypertension, diabetes, and dyslipidemia can influence this relationship [9]. These confounding factors make a connection between increased Sr.UA levels and CVD somewhat contentious [10, 11].

This study aims to investigate the contribution of Sr.UA to cardiovascular disease, independent of major confounding variables including age, sex, hypertension, diabetes, dietary habits, and lifestyle factors.

METHODS

A descriptive cross-sectional study was carried out from December 2024 to February 2025 at Fazaia Ruth Pfau Medical College. The study got ethical approval from the Fazaia Ruth Pfau Medical College (Ref. No: FRPMC-IRB-2024-69). Informed consent was taken before the study. Data confidentiality was strictly upheld, and anonymization procedures were implemented before analysis. The study included 370 participants aged 18 and above, encompassing both male and female, diagnosed with cardiovascular diseases, hypertension, or diabetes, while those patients were excluded who were either having any chronic infection or diagnosed case of cancer, or were pregnant, lactating, or taking uric acid-lowering medications. The Open Epi calculator was used to find out the sample size. Participants in the study were categorized into 2 categories according to the Sr.UA level, including normouricemia and hyperuricemia groups. Data collection involved demographic, anthropometric, and biochemical measurements. Participants were assessed in the morning following a minimum fasting duration of 12 hours. Demographic information, medical history, and lifestyle behaviors such as diet and physical activity were collected via a structured questionnaire. Measurements of anthropometric data like height, weight, and waist circumference were recorded by a Secastadiometer and a digital weighing scale. A standardized formula (kg/m^2) was used to calculate BMI, and central obesity was labelled if the waist circumference exceeded 94cm and 80cm in male and female respectively, while obesity was classified at a BMI of 30 kg/m^2 or more. Blood pressure was measured twice using the OMRON 907 automated device after a minimum five-minute rest, and the mean was calculated. If systolic blood pressure was ≥140 mmHg or diastolic blood pressure was ≥90 mmHg, then the patient was labelled as hypertensive. An expert cardiologist diagnosed the cardiovascular disease by physical examination and electrocardiogram (ECG). The cardiovascular diseases were classified into three sub-classes, including acute coronary syndrome (ACS), myocardial infarction (MI), and heart failure (HF). Sr.UA concentration was tested using the Mindray BS-200E analyzer from venous blood samples. Sr.UA concentration more than 7mg/dL in men and more than 6mg/dL in women was used to define hyperuricemia. A semi-automated clinical chemistry analyzer was used to measure random blood sugar, total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), and triglycerides. Data were analyzed by Statistical Package for Social Sciences (SPSS), version 22.0. Numerical variables were presented as means with standard deviations, while categorical variables were summarized using frequencies and percentages. Statistical analyses included independent t-tests and one-way ANOVA for normally distributed data, while for the data that did not follow a normal distribution, the Mann-Whitney U test was used. Qualitative data were assessed by chi-square tests. Pearson's correlation was utilized to evaluate associations among variables such as age, BMI, blood pressure, Sr.UA levels, and CVD incidence. Results were significant if the p-value was ≤0.05. To determine the association of cardiovascular diseases in relation to rising Sr.UA concentration, a multivariate regression analysis was conducted, and the odds ratio at a 95% confidence interval was calculated.

RESULTS

About 370 participants were included in the study; out of them, 268 participants had normal uric acid levels, while 102 participants had hyperuricemia. The frequency of hyperuricemia was 27.5% cases, among them 21.1% were male, while 6.4% were their counterparts. The mean age of the study participants was 38.95 ± 10.9 years and 42.31 ± 9.7 years among normouricemia and hyperuricemia groups, respectively, with a significant association. Previous medical history of hypertension found a strong, significant

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association among the groups, but no association of diabetes mellitus or smoking was reported. At the time of study, the systolic blood pressure, diastolic blood pressure, body mass index (BMI), and waist circumference measurements also reported a strong and significant association among the groups. Frequency of CVD, including ACS, MI, and HF, was 47%, 29.1% and 6% in the normouricemia group and 54.9%, 25.5% and 6.9% in the hyperuricemia group, respectively, while no cardiac disease was found in 17.9% and 12.7% cases of the normouricemia and hyperuricemia group, respectively. Characteristics of the study participants of the two groups are presented in table 1.

Table 1: Characteristics of Study Participants (n=370)

Variables	Normouricemia (n=268)	Hyperuricemia (n= 102)	p-Value
Demographic Variables			
Age (Years)	38.95 ± 10.9	42.31 ± 9.7	0.024
Gender			
Male	167 (62.3%)	66 (64.7%)	0.242
Female	101 (37.7%)	36 (35.3%)	
History			
Diabetes mellitus	139 (51.8%)	55 (53.9%)	0.451
Hypertension	158 (58.9%)	57 (55.9%)	0.002
Smoking	153 (57.1%)	50 (49%)	0.582
Clinical Findings			
Systolic BP (mmHg)	134.6 ± 14.6	139.2 ± 12.4	0.001
Diastolic BP (mmHg)	85.1 ± 11.7	89.5 ± 12.9	0.007
BMI (kg/m^2)	26.9 ± 4.7	28.7 ± 5.2	0.000
Waist Circumference (cm)	91.8 ± 11.1	94.8 ± 10.6	0.000
Biochemical Parameters			
Glucose (mg/dL)	153 ± 2.5	162 ± 3.4	0.925
Sr.UA (mg/dL)	6.15 ± 1.05	12.4 ± 1.7	0.000
TC (mg/dL)	172.5 ± 38	168 ±32	0.243
HDLC (mg/dL)	42 ± 11	48 ± 13	0.032
LDLC (mg/dL)	105 ± 18	82 ± 15	0.004
Triglycerides (mg/dL)	187 ± 42	209 ± 32	0.012
Diagnosed Cases of Cardiovascular Disease			
No	48 (17.9%)	13 (12.7%)	0.000
Acute Coronary Syndrome	126 (47.0%)	56 (54.9%)	
Myocardial Infarction	78 (29.1%)	26 (25.5%)	
Cardiac failure	16 (6.0%)	7 (6.9%)	

Results showed a link between hyperuricemia and the severity of cardiovascular disease as the non-cardiac study participants were having 5.6 ± 1.9mg/dL mean serum uric acid level with standard deviation while 6.9 ± 2.1mg/dL, 7.7 ± 2.5mg/dL and 10.4 ± 2.7mg/dL mean serum uric acid concentration with standard deviation were noted among patients of ACS, MI and HF respectively, as mentioned in figure 1.

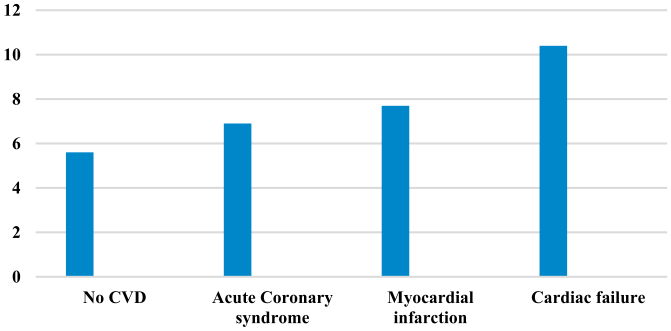

Figure 1: An Increase in Sr.UA with Severity of Cardiovascular Disease

Sr.UA concentration was divided into quartiles, including less than 5mg/dl uric acid concentration, 5-7mg/dl, 7-9mg/dl, and more than 9mg/dl uric acid concentration, and then the frequency of cardiovascular disease was assessed in each quartile. Results found that the severity of cardiovascular diseases increased linearly with increasing Sr.UA. Interestingly, higher levels of Sr.UA were found in the cases of MI when compared to other cardiovascular diseases, as shown in figure 2.

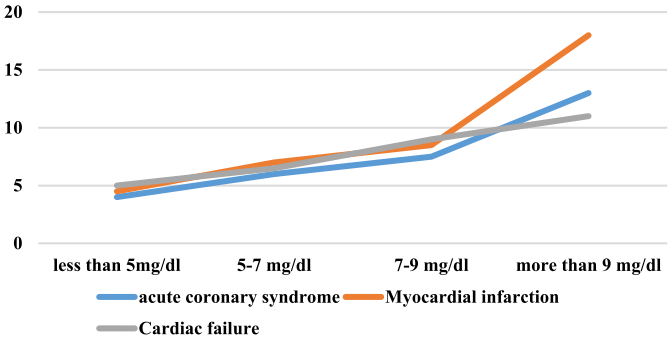

Figure 2: Sr.UA Quartile and Frequency of CVD

Multivariate regression analysis was done to find out the strength of association of CVD in each quartile of Sr.UA. Results reported that the odds ratio of cardiovascular disease was 1.42 times when the Sr.UA level was 5-7mg/dL and 1.84 times in the 3rd quartile, while it reached up to 2.45 times as the serum uric acid level rose above 9mg/dL. On the other hand, when confounding factors like age, gender, TC, HDLC, LDLC, triglycerides, hypertension and diabetes, were adjusted, the odd ratio of cardiovascular diseases remained significant in 3rd and 4th quartile of Sr.UA (7-9mg/dL and ≥9mg/dL) but it decreased to 1.64 times in 3rd quartile and 2.09 times in 4th quartile as mentioned in table 2.

Table 2: Multivariate Regression Model of Sr.UA Quartile and Risk of CVD

Sr.UA Concentration	Model 1	Model 2	p-Value
Quartile	Odd Ratio (95% Confidence Interval)		
5-7 mg/dl (2nd)	1.42 (0.96-1.88)	1.23 (0.88-1.72)	0.091
7-9 mg/dl (3rd)	1.84 (1.35-2.52)	1.64 (1.05-2.12)	<0.001
≥9 mg/dl (4th)	2.45 (1.84-3.39)	2.09 (1.32-2.98)	<0.001

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DISCUSSIONS

Literature revealed a strong link between elevated Sr.UA and a rise in blood pressure, although the strength and nature of this association can vary depending on individual demographic characteristics such as age and gender. Studies also indicate that higher uric acid may increase the likelihood of CVD; the exact causal relationship is still being debated [12]. The current study noted a strong correlation of Sr.UA with age, BMI, systolic and diastolic blood pressure, waist circumference, and risk of developing cardiovascular disease. Similar patterns were reported in a Ghanaian study, particularly among women over 45, where Sr.UA was statistically correlated with age, BMI, and waist circumference [13]. In another large-scale Chinese study, higher BMI and waist circumference were identified as risk factors for developing hyperuricemia [14]. U.S.-based research found that individuals who were both overweight and had hyperuricemia had a significantly higher chance of hypertension and developing cardiovascular diseases. Longitudinal data from the Gusu cohort further suggested that obesity may contribute to hyperuricemia, which in turn partially explains the development of high blood pressure. Mediation analysis showed that uric acid played a partial intermediary role between excess weight and increased blood pressure, leading to coronary artery disease [15]. The present study also reported a strong association of hyperuricemia with CVD, leaving behind the commonly known confounding factors such as age, gender, total cholesterol, HDL, LDL, and triglycerides. The severity of cardiovascular diseases was observed to rise with increasing serum uric acid levels, and this link remained significant even when diabetes and hypertension, both established cardiovascular disease risk factors, were accounted for. Current results reported that the odds ratio of cardiovascular disease was 1.42 times when the Sr.UA was 5-7mg/dL and reached up to 2.45 times as the serum uric acid level rose above 9mg/dL. On the other hand, when confounding factors were adjusted, the odds ratio of cardiovascular diseases remained significant, but it decreased to 1.64 to 2.09 fold. Over the years, numerous large-scale investigations, such as the NHANES I follow-up study, the URRAH study, the Brisighella Heart Study, and the AMORIS study, examined this association. Data from the URRAH (Uric Acid Right for Heart Health) project indicated a higher chance of developing lethal cardiac issues with hyperuricemia and suggested threshold values for reduced risk at <5.26mg/dL and 5.49mg/dL for both genders [16, 17]. Likewise, another analysis of the AMORIS data, which followed 417,734 individuals for 11.8 years, concluded that hyperuricemia increased the likelihood of acute myocardial infarction and both ischemic and hemorrhagic strokes [18]. In the Brisighella Heart Study, involving 1,557 participants, serum uric acid levels were used to predict MI, left ventricular hypertrophy, and arrhythmias detected via ECG [19]. In addition, a meta-analysis of 21 cohort studies reported a link between hyperuricemia and cardiovascular diseases in both healthy and high-risk populations, with a stronger correlation in the latter group [20]. Another large meta-analysis involving 402,997 individuals found only a modest increase in coronary heart disease risk linked to serum uric acid, casting some doubt on its function as an independent risk determinant [21]. Likewise, reviews and experimental data from the United Kingdom noted that serum uric acid's association with coronary heart disease might be influenced by other risk factors [22]. Further support comes from research on obese individuals and populations in China, Turkey, Korea, and Pakistan, where increasing Sr.UA was strongly correlated with more serious vascular disease [23, 24]. The current study also found an increased frequency of hyperuricemia in cases of cardiovascular disease, aligning with previous findings from Pakistan, which reported a correlation of hyperuricemia with heart failure risk indicators. The current study reported that ACS, MI, and HF were 54.9%, 25.5% and 6.9% in hyperuricemia patients. A large-scale study by Wheeler et al. encompassing over 9,000 cases and approximately 155,000 controls from eight nations, concluded that hyperuricemia is not a reliable predictor of CVD in asymptomatic individuals [25]. Likewise, NHANES III data involving over 11,000 participants did not identify any Sr.UA for CVD or vascular disease mortality, making the overall evidence on serum uric acid's role in cardiovascular disease somewhat inconclusive. A potential reason for these conflicting findings may be differences in population characteristics, such as lifestyle and diet, that can significantly influence the Sr.UA and CVD relationship. Despite various studies, none have comprehensively examined the association while fully accounting for lifestyle and diet. The current study's strength lies in its adjustment for these additional variables, demonstrating that hyperuricemia can enhance the risk of cardiovascular disease by approximately 2.09 times after controlling for both conventional and lifestyle-related confounders.

CONCLUSIONS

The current study identified a significant association of hyperuricemia with cardiovascular diseases. The severity of cardiovascular diseases was observed to rise with increasing serum uric acid levels, and this link remained significant. Therefore, individuals who do not show clear symptoms of cardio-metabolic disorders but exhibit hyperuricemia should undergo cardiovascular evaluations.

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Authors Contribution

Conceptualization: NA
Methodology: NA, MZ, MKA, SZA
Formal analysis: MK, SZA
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All authors have read and agreed to the published version of the manuscript

Conflicts of Interest

All the authors declare no conflict of interest.

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