

## ASSESSMENT OF SERUM URIC ACID IN TYPE 2 DIABETES MELLITUS AND ITS CORRELATION WITH GLYCEMIC STATUS INDICES

<sup>1</sup>DR. ZARIN KAUSER, <sup>2</sup>DR. ARCHANA A DHARWADKAR, <sup>3</sup>DR. PRAVEENA S, <sup>4</sup>DR. MADANIKA P

<sup>1</sup>Associate Professor, Department of Biochemistry, Kamineni Academy of Medical Sciences and Research centre, L. B. Nagar, Hyderabad, Telangana – 500068, India

<sup>2</sup>Professor and Head, Department of Biochemistry, Department of Biochemistry, Kamineni Academy of Medical Sciences and Research centre, L. B. Nagar, Hyderabad, Telangana – 500068, India

<sup>3</sup>Professor, Department of Biochemistry, Department of Biochemistry, Kamineni Academy of Medical Sciences and Research centre, L. B. Nagar, Hyderabad, Telangana – 500068, India

<sup>4</sup>Professor, Department of Biochemistry, Department of Biochemistry, Kamineni Academy of Medical Sciences and Research centre, L. B. Nagar, Hyderabad, Telangana – 500068, India

### Corresponding Author

DR. ZARIN KAUSER, Associate Professor, Department of Biochemistry, Department of Biochemistry, Kamineni Academy of Medical Sciences and Research centre, L. B. Nagar, Hyderabad, Telangana – 500068, India

Contact: +91 – 8639080278

Email: [drzarinkauser@gmail.com](mailto:drzarinkauser@gmail.com)

### Abstract

**Background:** Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder characterized by persistent hyperglycemia resulting from impaired insulin secretion, insulin action, or both. Altered serum uric acid (SUA) levels have been linked to insulin resistance, oxidative stress, and diabetic complications.

**Objectives:** To compare SUA and glycemic status using indices—fasting blood sugar (FBS), post-prandial blood sugar (PPBS) and glycated hemoglobin (HbA1c) between patients with T2DM and healthy controls, and to evaluate the correlation between SUA and glycemic indices in T2DM.

**Materials and Methods:** This hospital-based comparative cross-sectional study included 100 participants: 50 patients with T2DM and 50 age and sex matched healthy controls. SUA was estimated by the enzymatic uricase method, FBS and PPBS by the glucose oxidase-peroxidase (GOD-POD) method and HbA1c using high performance liquid chromatography (HPLC) method. Group comparisons were performed using the independent samples *t*-test and Pearson's correlation coefficient assessed associations. *p*-value <0.05 was considered statistically significant.

**Results:** Mean SUA was significantly higher in patients with T2DM than in controls ( $8.73 \pm 0.59$  vs.  $4.78 \pm 0.68$  mg/dL,  $p < 0.0001$ ). FBS, PPBS and HbA1c were also significantly elevated in diabetic patients (all  $p < 0.0001$ ). SUA showed weak but significant negative correlations with FBS ( $r = -0.287$ ,  $p = 0.043$ ) and HbA1c ( $r = -0.285$ ,  $p = 0.045$ ), whereas its correlation with PPBS was weak and not statistically significant ( $r = 0.206$ ,  $p = 0.151$ ).

**Conclusion:** T2DM patients had noticeably higher SUA levels. SUA may function as an additional biochemical marker indicating metabolic changes in type 2 diabetes.

**Keywords:** Type 2 diabetes mellitus, serum uric acid

## INTRODUCTION

Chronic hyperglycemia is associated with disturbances in carbohydrate, fat, and protein metabolism and affects multiple organ systems, particularly the eyes, kidneys, nerves, heart, and blood vessels. Among the various forms of diabetes, T2DM accounts for approximately 90–95% of all cases worldwide.<sup>1</sup> Urbanization, unhealthy diets, physical inactivity, obesity and aging have contributed to the rising prevalence of T2DM, with India carrying a major global diabetes burden.<sup>2</sup>

T2DM involves insulin resistance and progressive  $\beta$ -cell dysfunction. Impaired insulin compensation causes hyperglycemia, promoting oxidative stress, inflammation, endothelial dysfunction, and Advanced Glycation End products (AGES) formation, leading to vascular complications.<sup>3</sup>

FBS reflects basal glucose levels, PPBS evaluates post-meal glucose control, and HbA1c indicates average glucose over 2–3 months, serving as the gold standard for long-term glycemic control.<sup>4</sup>

SUA, the end product of purine metabolism, is a potential marker of metabolic disturbances and diabetic complications. It is produced by hepatic xanthine oxidase, excreted mainly by the kidneys, and acts as an extracellular antioxidant.<sup>5</sup>

Despite its antioxidant role, elevated SUA has been linked to hypertension, obesity, metabolic syndrome, chronic kidney disease, cardiovascular disease, and insulin resistance. Increased uric acid may promote endothelial dysfunction, oxidative stress and reduced nitric oxide availability, contributing to impaired glucose metabolism.<sup>6,7</sup>

Early insulin resistance increases uric acid levels, while prolonged hyperglycemia may reduce them through urinary loss. SUA varies with disease stage, glycemic control, renal function, and metabolic status.<sup>8</sup>Elevated SUA may predict type 2 diabetes risk and is associated with obesity, dyslipidemia, hypertension, and insulin resistance.<sup>9</sup>

Studies on SUA and glycemic control show inconsistent associations with fasting blood glucose and HbA1c, possibly due to differences in population, disease duration, renal function, medications, diet, and ethnicity.<sup>10,11,12</sup>

### **Aim and Objectives:**

The present study aimed to compare SUA levels in patients with T2DM and healthy controls and assess its correlation with FBS, PPBS and HbA1c. The study may help clarify the role of SUA as an adjunctive marker of glycemic status and metabolic risk.

### **Materials and Methods**

A comparative cross-sectional study was conducted in the Department of Biochemistry in Kamineni hospital. A total of 100 participants were enrolled, comprising 50 patients with T2DM and 50 healthy controls. Adults aged 30–70 years with diagnosed T2DM were included. Individuals with chronic kidney disease, gout, liver disease, pregnancy, malignancy, or treatment with uric acid-lowering drugs were excluded. Following an overnight fast, venous blood samples were collected for estimation of FBS, SUA and HbA1c. A second sample was collected two hours after a meal for PPBS estimation. SUA was measured using the enzymatic uricase-peroxidase method, glucose by the GOD-POD method and HbA1c using HPLC method. Data were analyzed using SPSS version 14.0. Data for continuous variables were summarized using the mean and standard deviation (mean  $\pm$  SD). The independent samples *t*-test was used to compare groups, and Pearson's correlation coefficient was calculated to assess the relationship between SUA and glycemic indices. Statistical significance was defined as  $p < 0.05$ .

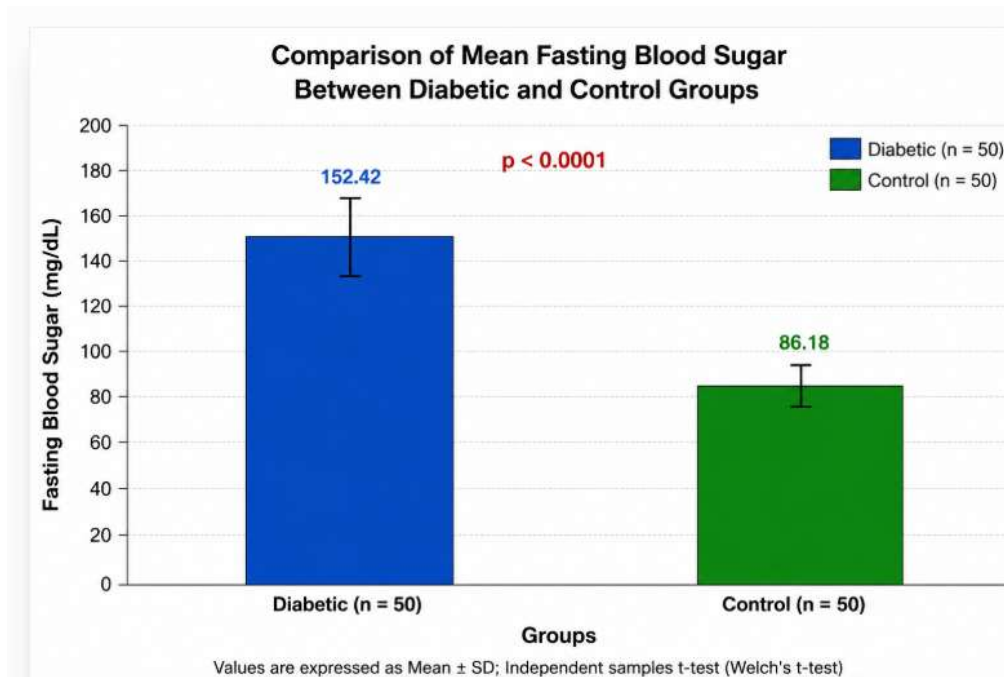
**Results:****TABLE 1: Biochemical Parameter Comparison Between Patients with Diabetes and Healthy Controls**

that observed in the control group ( $4.78 \pm 0.68$  mg/dL). The difference between the two groups was highly statistically significant ( $p < 0.0001$ ), indicating elevated SUA levels among patients with T2DM.

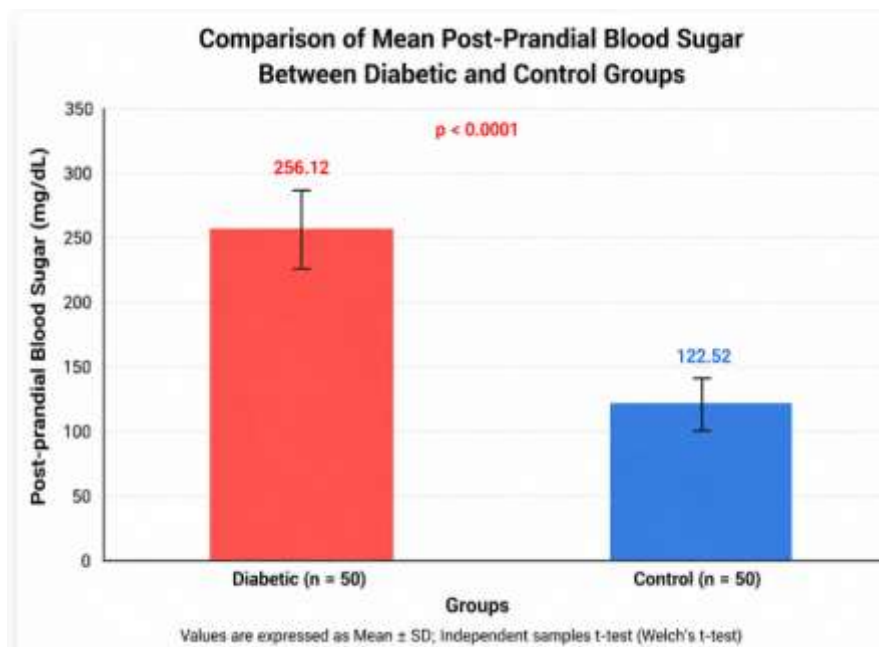
Similarly, the mean FBS level was markedly elevated in the diabetic group ( $152.42 \pm 17.07$  mg/dl) compared with the control group ( $86.18 \pm 7.65$  mg/dl). This difference was found to be highly statistically significant ( $p < 0.0001$ ), reflecting poor fasting glycemic control in diabetic patients. The mean PPBS level was also significantly higher among diabetic patients ( $256.12 \pm 23.00$  mg/dl) than among healthy controls ( $122.52 \pm 6.50$  mg/dl). Statistical analysis demonstrated a highly significant difference between the two groups ( $p < 0.0001$ ), confirming the presence of marked post-prandial hyperglycemia in individuals with T2DM.

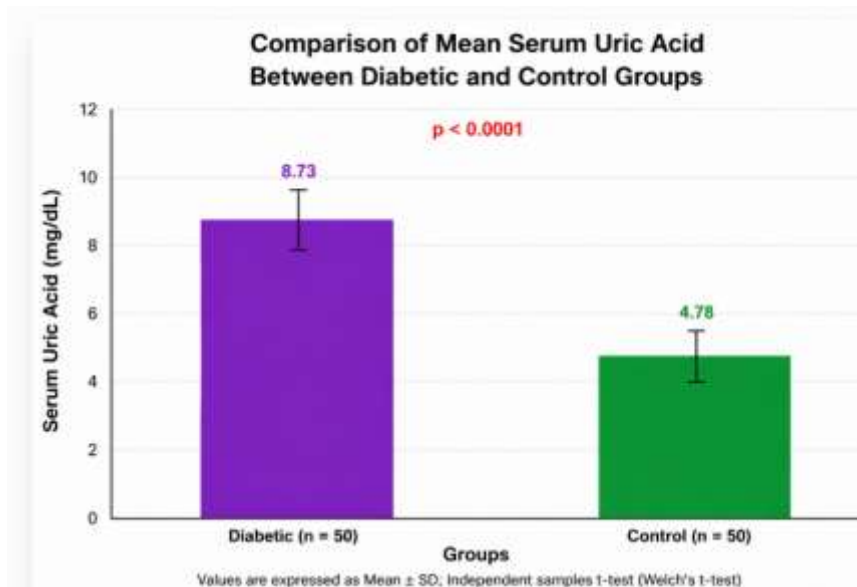
**GRAPH 1: Mean Fasting Blood Sugar Comparison between Diabetic and Control Groups**

| Parameter                               | Diabetic (n = 50)<br>Mean $\pm$ SD | Control (n = 50)<br>Mean $\pm$ SD | P-Value   | Level of Significance |
|-----------------------------------------|------------------------------------|-----------------------------------|-----------|-----------------------|
| Serum Uric acid (mg/dl)                 | $8.73 \pm 0.59$                    | $4.78 \pm 0.68$                   | $<0.0001$ | Highly significant    |
| Fasting blood sugar (FBS) (mg/dl)       | $152.42 \pm 17.07$                 | $86.18 \pm 7.65$                  | $<0.0001$ | Highly significant    |
| Postprandial blood sugar (PPBS) (mg/dl) | $256.12 \pm 23.00$                 | $122.52 \pm 6.50$                 | $<0.0001$ | Highly significant    |
| HbA1c (%)                               | $7.57 \pm 0.51$                    | $4.94 \pm 0.39$                   | $<0.0001$ | Highly significant    |



**GRAPH 2: Post- Prandial Blood Sugar Comparision between Diabetic and Control Groups**



**GRAPH 3: Mean Serum Uric Acid Comparison between Diabetic and Control Groups**

Assessment of long-term glycemic control revealed that the mean HbA1c level in diabetic patients was  $7.57 \pm 0.51\%$ , whereas the corresponding value in the control group was  $4.94 \pm 0.39\%$ . The increase in HbA1c among diabetic patients was highly statistically significant ( $p < 0.0001$ ), indicating poor long-term glycemic control compared with healthy individuals.

Pearson's correlation analysis was performed to determine the relationship between serum uric acid and glycemic indices within the diabetic group. Correlation analysis within the diabetic group showed a weak but significant negative correlation between SUA and FBS ( $r = -0.287$ ,  $p = 0.043$ ) and HbA1c ( $r = -0.285$ ,  $p = 0.045$ ). SUA and PPBS showed a weak positive, non-significant correlation ( $r = 0.206$ ,  $p = 0.151$ ).

Overall, the study demonstrated that patients with T2DM had significantly higher serum uric acid, FBS, PPBS and HbA1c levels than healthy controls. While SUA showed statistically significant but weak inverse correlations with FBS and HbA1c, its association with PPBS was weak and not statistically significant.

## Discussion

T2DM is a long-term metabolic disease marked by increasing  $\beta$ -cell failure and hyperglycemia brought on by insulin resistance. SUA has surfaced as a possible biomarker linked to cardiovascular disease, oxidative stress, insulin resistance, and endothelial dysfunction in recent years. The present study evaluated SUA levels in patients with T2DM and examined their relationship with glycemic indices.

The present study demonstrated that the mean SUA level was significantly higher in diabetic patients ( $8.73 \pm 0.59$  mg/dL) than in healthy controls ( $4.78 \pm 0.68$  mg/dL;  $p < 0.0001$ ). These findings support the growing evidence that hyperuricemia is frequently associated with T2DM. Elevated SUA has been implicated in the pathogenesis of insulin resistance through inhibition of endothelial nitric oxide synthesis, activation of inflammatory pathways and impaired glucose uptake by peripheral tissues.<sup>13,14</sup>

The present findings are consistent with the meta-analysis by Kodama et al., which showed that elevated SUA levels increase the risk of developing type 2 diabetes.<sup>15</sup> Bhole et al. reported that hyperuricemia independently predicted incident T2DM in prospective cohort studies.<sup>16</sup>

Several recent studies have also reported similar findings. Patel et al. (2024) observed significantly higher SUA levels among patients with T2DM than healthy controls and concluded that SUA may serve as an additional biochemical marker of metabolic dysfunction.<sup>17</sup> Argoons et al. (2024) reported significant associations between SUA and metabolic risk factors in diabetic patients, emphasizing the influence of renal function on uric acid levels.<sup>18</sup>

In the present study, FBS ( $152.42 \pm 17.07$  mg/dL), PPBS ( $256.12 \pm 23.00$  mg/dL) and HbA1c ( $7.57 \pm 0.51\%$ ) were significantly higher in diabetic patients than in controls ( $p < 0.0001$ ). These findings are expected because chronic hyperglycemia is the defining biochemical abnormality in T2DM and reflects impaired insulin action and progressive  $\beta$ -cell dysfunction. Similar observations have been reported by the American Diabetes Association and other international diabetes guidelines.<sup>19</sup>

A weak but significant negative correlation was observed between SUA and FBS ( $r = -0.287$ ,  $p = 0.043$ ). Persistent hyperglycemia may increase urinary uric acid loss through glycosuria, explaining the inverse association despite the hyperuricemic effect of insulin resistance.<sup>20,21</sup>

Our findings agree with those of Nan et al., who reported that SUA levels decreased in patients with poorly controlled diabetes because glycosuria enhanced urinary uric acid excretion.<sup>20</sup> Qin et al. (2021) reported that increased urinary glucose excretion reduced SUA levels in T2DM patients with preserved renal function.<sup>21</sup> These studies suggest that the relationship between SUA and FBS is dynamic and depends on the balance between insulin resistance and renal uric acid handling.

The present study demonstrated a weak positive correlation between SUA and PPBS ( $r = 0.206$ ), which was not statistically significant ( $p = 0.151$ ). This finding indicates that SUA is unlikely to reflect acute post-prandial glucose excursions. Instead, SUA is influenced by multiple factors including purine metabolism, renal tubular function, oxidative stress, inflammation, obesity, and insulin resistance.<sup>14,18</sup> Similar observations have been reported in previous studies where no significant relationship was observed between SUA and PPBS after adjustment for confounding variables.<sup>14</sup>

Another important observation in the present study was the weak but statistically significant negative correlation between SUA and HbA1c ( $r = -0.285$ ,  $p = 0.045$ ). HbA1c reflects average blood glucose concentrations over the preceding two to three months and is considered the gold standard for assessing long-term glycemic control. The inverse association observed in our study may be explained by increased glycosuria accompanying poor glycemic control, which enhances urinary uric acid excretion despite the presence of insulin resistance.

Comparable findings were reported by Imtiaz et al. (2024), who observed significant associations between SUA, insulin resistance, and HbA1c among patients with T2DM.<sup>22</sup> Similarly, Patel et al. (2024) found altered SUA concentrations in diabetic patients and emphasized that the relationship between SUA and HbA1c is influenced by multiple metabolic and renal factors.<sup>17</sup> Li et al. also concluded that SUA demonstrates variable associations with glycemic indices depending upon disease duration, insulin sensitivity, obesity, and renal function.<sup>23</sup>

Shaikh et al. (2024) demonstrated significantly higher SUA concentrations in patients with longer duration of diabetes and suggested that hyperuricemia reflects progressive oxidative stress and chronic inflammation.<sup>24</sup> A systematic review and meta-analysis by Zhang et al. (2024) concluded that elevated SUA was associated with diabetic peripheral neuropathy, indicating its role as a marker of chronic diabetic complications.<sup>25</sup>

These findings suggest that SUA reflects metabolic pathways involving insulin resistance, oxidative stress, inflammation, endothelial dysfunction, and renal urate handling. As it is inexpensive and routinely available, it may serve as an adjunctive biomarker in T2DM. However, weak correlations indicate that it should not replace, established glycemic markers but rather complement them in the assessment of metabolic health and cardiovascular risk.

Overall, the present study demonstrates that serum uric acid concentrations are significantly elevated in patients with T2DM compared with healthy controls. Although weak inverse correlations were observed between SUA and FBS as well as HbA1c, these associations suggest that SUA reflects complex metabolic interactions rather than glycemic status alone.

### Conclusion

Patients with T2DM had significantly higher SUA concentrations than healthy controls. Significant elevations in FBS, PPBS and HbA1c confirmed poorer glycemic status in the diabetic group. SUA showed weak but statistically significant inverse correlations with FBS and HbA1c, whereas its association with PPBS was not statistically significant. These findings indicate that SUA may serve as an adjunctive biochemical marker reflecting metabolic changes in T2DM. Larger multicenter prospective studies are required to determine whether SUA can be incorporated into routine risk stratification and prognostic assessment of patients with T2DM.

### References:

1. American Diabetes Association. Standards of Care in Diabetes—2025. *Diabetes Care*. 2025;48(Suppl 1):S1–S350.
2. International Diabetes Federation. IDF Diabetes Atlas. 11th ed. Brussels: International Diabetes Federation; 2025.
3. DeFronzo RA, Ferrannini E, Groop L, Henry RR, Herman WH, Holst JJ, et al. Type 2 diabetes mellitus. *Nat Rev Dis Primers*. 2015;1:15019.
4. World Health Organization. Use of Glycated Haemoglobin (HbA1c) in Diagnosis of Diabetes Mellitus. Geneva: WHO; 2011.
5. Johnson RJ, Nakagawa T, Jalal D, Sánchez-Lozada LG, Kang DH, Ritz E. Uric acid and chronic kidney disease: which is chasing which? *Nephrol Dial Transplant*. 2013;28(9):2221–8.

6. Sautin YY, Johnson RJ. Uric acid: the oxidant-antioxidant paradox. *Nucleosides Nucleotides Nucleic Acids*. 2008;27(6-7):608-19.
7. Feig DI, Kang DH, Johnson RJ. Uric acid and cardiovascular risk. *N Engl J Med*. 2008;359(17):1811-21.
8. Choi HK, Ford ES. Prevalence of the metabolic syndrome in individuals with hyperuricemia. *Am J Med*. 2007;120(5):442-7.
9. Kodama S, Saito K, Yachi Y, et al. Association between serum uric acid and development of type 2 diabetes. *Diabetes Care*. 2009;32(9):1737-42.
10. Bhole V, Choi JWJ, Kim SW, de Vera M, Choi HK. Serum uric acid levels and the risk of type 2 diabetes. *Diabetes Care*. 2010;33(11):2473-9.
11. Li C, Hsieh MC, Chang SJ. Metabolic syndrome, diabetes and hyperuricemia. *Curr Opin Rheumatol*. 2013;25(2):210-6.
12. Sánchez-Lozada LG, Rodríguez-Iturbe B, Kelley EE, et al. Uric acid and hypertension: an update with recommendations. *Am J Hypertens*. 2020;33(7):583-94.
13. Feig DI, Kang DH, Johnson RJ. Uric acid and cardiovascular risk. *N Engl J Med*. 2008;359(17):1811-1821.
14. Sautin YY, Johnson RJ. Uric acid: the oxidant-antioxidant paradox. *Nucleosides Nucleotides Nucleic Acids*. 2008;27(6-7):608-619.
15. Kodama S, Saito K, Yachi Y, Asumi M, Sugawara A, Totsuka K, et al. Association between serum uric acid and development of type 2 diabetes: A meta-analysis. *Diabetes Care*. 2009;32(9):1737-1742.
16. Bhole V, Choi JWJ, Kim SW, de Vera MA, Choi HK. Serum uric acid levels and the risk of type 2 diabetes: A prospective study. *Diabetes Care*. 2010;33(11):2473-2479.
17. Patel S, Singh M, Kahlon N, et al. Association of serum uric acid levels with glycated haemoglobin in diabetic patients and healthy controls. *J Fam Med Prim Care*. 2024;13(11):5040-5046.
18. Argoons SA, Mahmoud ET, Madkour RA. The association of serum uric acid level with metabolic risk factors in patients with type 2 diabetes and their relation to eGFR status. *Egypt J Intern Med*. 2024;36:52.

19. American Diabetes Association. Standards of Care in Diabetes—2025. *Diabetes Care*. 2025;48(Suppl 1):S1-S350.
20. Nan H, Dong Y, Gao W, et al. Diabetes associated with a low serum uric acid level in a general Chinese population. *Diabetes Res Clin Pract*. 2010;90(1):68-74.
21. Qin Y, Zhang S, Cui S, 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(9):1981-1988.
22. Imtiaz M, Saeed S, Aqeel M, et al. Correlation between serum uric acid, insulin and HbA1c in type 2 diabetes mellitus. *J Rawalpindi Med Coll*. 2024;28(2):150-156.
23. Li C, Hsieh MC, Chang SJ. Metabolic syndrome, diabetes and hyperuricemia. *Curr Opin Rheumatol*. 2013;25(2):210-216.
24. Shaikh S, Bhoi B, Panchal M, Maheshwari A. Study of serum uric acid and adenosine deaminase as markers of oxidative stress in patients with type 2 diabetes mellitus. *GAIMS J Med Sci*. 2024;4(2):27-34.
25. Zhang X, Zhang X, Li X, et al. Association between serum uric acid levels and diabetic peripheral neuropathy in type 2 diabetes: A systematic review and meta-analysis. *Front Endocrinol (Lausanne)*. 2024;15:1416311.