Original Article

Association of serum uric acid levels with glycated haemoglobin in diabetic patients and healthy controls

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Abstract

Introduction: Uric acid is formed from purine degradation. Hyperuricemia has emerged as a risk factor for various metabolic diseases including Diabetes mellitus (DM). Uric acid may act as a glucometabolic indicator for Type 2 Diabetes mellitus (T2DM). Glycated haemoglobin (HbA1c) is an indicator of long-term glycaemic control used for diagnosing and monitoring T2DM. However, the association between HbA1c and uric acid is controversial. The present study aimed to study the association of serum uric acid (SUA) levels with HbA1c. **Materials and Methods:** This cross-sectional comparative study was conducted in a Tertiary Care Hospital in Northern India after permission from the institutional Ethical committee. The study included patients attending the Outpatient Department of the hospital during the study period. Diagnosed cases of DM as per World Health Organization criteria were included as cases. Controls comprised of apparently healthy subjects of the age group 18–50 years attending OPD Patients and Health Care workers. Both cases and control were divided into two groups those with normal uric acid levels and the hyperuricemia group in both males and females to study the association between HbA1c and uric acid levels. **Results:** The study constituted 1460 participants of which 880 control and 580 DM. The overall prevalence of hyperuricemia was 17.8%. HUA prevalence was 17.04%–18.9% in the control and diabetic population, respectively. SUA levels in T2DM patients were negatively correlated with glycated HbA1c, and FBS whereas positively correlated with glycated HbA1c in controls. **Conclusion:** While non-diabetic individuals tend to exhibit higher SUA levels, a decreasing trend has been observed in diabetic individuals. A negative association was observed between SUA level and HbA1c in DM in contrast to controls. Therefore, the utilization of SUA as a marker for assessing glucose metabolism should be approached with careful consideration taking care of these complex dynamics.

Keywords: Fasting blood sugar, glycated hemoglobin, hyperuricemia, uric acid

Introduction

Uric acid is the product of purine metabolism. Uric acid-induced endothelial dysfunction, inflammation, and oxidative stress are proposed to contribute to the pathogenesis of cardiovascular diseases (CVDs) such as coronary artery disease, myocardial infarction, and stroke. It has emerged as a contributing factor in the development of various metabolic diseases, including hypertension, CVDs, chronic kidney disease (CKD) and type 2 diabetes mellitus (T2DM).[1,2] T2DM is a prevalent and disabling metabolic disease, posing a global health burden. Therefore, it is of concern to discern the association between serum uric acid (SUA) and T2DM, a prevalent disabling metabolic disorder.

Uric acid is often used as an indicator of neurometabolic disorders like T2DM but the exact nature of the relationship between uric acid and glucose metabolism is not fully understood.[3-5] The American Diabetes Association has recommended HbA1c for identifying individuals at increased risk of T2DM. HbA1c is a retrospective index of integrated

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plasma glucose over the past 3 months. However, the relationship between SUA and HbA1c/fasting blood glucose is not consistent. Some studies show a positive correlation, some inverse association whereas some have no association revealing a nonlinear association.[6-8]

Despite the complexities of these relationships and inconsistent findings, understanding the role of uric acid in cardiovascular health and metabolic diseases is essential to determine the role of SUA levels as a biomarker for diabetes mellitus (DM). It would facilitate the development of effective prevention and management strategies, ultimately improving overall health outcomes. Despite reports on the relationship between SUA and diabetes globally, there remains a controversy. The present study aimed to address this complex interplay between SUA and FBG, HbA1c in diabetic and healthy controls in the north Indian population.

Materials and Methods

This cross-sectional comparative study was conducted in the central research laboratory of a Tertiary Care Hospital in Northern India after permission from the institutional Ethical Committee of the hospital. Informed written consent was taken from participants before study enrolment. The study included apparently healthy participants as controls in the age group 18–50 years attending OPD Patients and Health Care workers. Cases included diagnosed cases of T2DM attending the Outpatient Department of the hospital as per World Health Organization criteria (fasting plasma glucose ≥126 mg/dL, and/or 2-h oral glucose tolerance tests (OGTT) ≥ 200 mg/dL), or the use of anti-diabetic medicine not receiving any hyperuricemic drugs. Both cases and control were divided into two groups those with normal uric acid levels and the hyperuricemia group in both males (>7 mg/dL) and females (>6 mg/dL) for comparison between different parameters. Patients who were known cases of chronic liver, kidney, heart diseases, hypertension, bone disorders, malignancies or were on chemotherapy or radiotherapy, pregnant were excluded from the study. Further, patients with hyperuricemia or gout who continued to receive medication, unwilling to participate were also excluded from the study. The study variables included routine parameters serum glutamate pyruvate transaminase (SGPT), serum glutamate oxaloacetate transaminase (SGOT), alkaline phosphatase (ALP), low-density lipoprotein–cholesterol (LDL), high-density lipoprotein cholesterol (HDL), triglycerides (TG), cholesterol besides uric acid and blood glucose, HbA1c. Hyperuricemia was defined as SUA >7 mg/dL in men and >6 mg/dL in women. Clinical history relevant to fulfilling inclusion and exclusion criteria was collected. A total of 5 mL of venous blood samples were collected with strict aseptic measures in a plain vacutainer for serum, 2 mL in a fluoride vial for glucose, 2 mL in an EDTA vial for HbA1c. The plain vacutainer sample was allowed to clot for 30 minutes and was centrifuged properly for 3000 rpm for 10 minutes and serum separated was used for analysis in a fully automated VITROS XT 7600 dry chemistry integrated system autoanalyzer.

Statistical analysis

The parameters were presented as Mean ± Standard deviation. Comparison between different parameters in cases and controls was performed using an independent sample *t*-test. Pearson's correlation coefficients were used to describe the association between uric acid and biochemical variables. For statistical inference, a *P* value of <0.05 was considered statistically significant. All statistical analyses were carried out using SPSS v26 software.

Results

Baseline parameters

The total number of patients recruited was 1500 but 40 patients' information could not be collected and were not included in the study constituting 1460 as the study population. The overall prevalence of hyperuricemia was 260/1460 (17.8%). The control population consisted of 880 participants, 620 (70.4%) men aged (55 ± 12 years) and 260 (29.6%) women (50 ± 15 years) of age. HUA prevalence in the control population was 150/880 (17.04%). The T2DM patients comprised 580 of which 422 (72.7.1%) were men (57.00 ± 11.00 years of age) and 158 (27.2%) were women (51.00 ± 20.00 years of age). HUA prevalence in the diabetic population was 18.9% (110/580). Both the controls and cases were divided into two groups, Group 1 with normal UA level and Group 2 with hyperuricemia. The uric acid levels were lower in the diabetics HUA group (7.707 ± 0.8 mg/dL) compared to the HUA control group (7.9 ± 0.8 mg/dL). In the control population HUA group and participants with normal uric acid levels differed significantly in levels of uric acid, urea, creatinine, TG, Fasting blood sugar (FBS), HbA1c, SGPT, SGOT, ALP, TG and HDL [Table 1]. In the T2DM patients [Table 2], HUA and normal subjects significantly differ in uric acid, urea, creatinine, FBS, TG levels.

In addition, the controls and cases were segregated into male and female to compare the difference between the two groups in controls and cases. The mean age of diabetic cases was higher in both groups in both males and females. On comparison between the HUA group in the diabetic and control population uric acid level was comparatively lower in diabetics (7.09 ± 0.07 mg/dL) compared to controls (7.886 ± 0.77 mg/dL) both in males and females (Diabetics; 7.289 ± 0.323 mg/dL, controls; 7.54 ± 0.635 mg/dL) [Tables 3 and 4].

In the control HUA group male's FBS, HbA1c, and LDL levels were higher although not significant compared to normal UA levels. Whereas in the diabetic HUA group FBS, HbA1c was significantly lower compared to Normal UA level [Table 3].

Similarly in females in the HUA group in diabetics FBS, HbA1c was significantly lower than with normal UA level whereas vice versa in control. Further HUA group in both cases and controls had increased Urea and creatinine levels in females [Table 4].

Table 1: Biochemical Parameters of the controls in (Mean±SD) in two groups Group 1: Normal serum uric acid (SUA) levels, Group 2: Hyperuricemia (HUA)

Biochemical parameters	Mean±SD		*t*-test	*P*
	Normal uric acid 730 (82.9%)	Hyperuricemia 150 (17.04%)		
Age (years)	38.44±13.5	42.2±15	−2.83	0.01
Uric Acid (mg/dL)	3.991±1	7.9±0.8	−55.32	<0.001
Creatinine (mg/dL)	0.593±0.1	0.9±0.8	−4.57	<0.001
Blood Urea (mg/dL)	20.41±7.1	27.7±18.8	−13.26	<0.001
FBS ((mg/dL)	88.31±7.9	90.2±7.4	−2.81	0.01
HbA1c (%)	4.705±0.2	4.8±0.2	−2.87	0.004
SGPT (IU/L)	28.35±15	37.3±17.7	−6.93	<0.001
SGOT (IU/L)	33.54±10.5	37.1±11.4	−2.49	0.01
Alkaline Phosphatase (IU/L)	89.22±25.7	95.2±25.5	−2.39	0.02
Triglycerides (mg/dL)	145.8±73.1	157.9±75.9	−4.05	<0.001
Cholesterol (mg/dL)	179.5±42.6	183.3±44.5	−0.74	0.46
LDL (mg/dL)	98.47±52.7	107.7±58.5	−1.36	0.17
HDL (mg/dL)	49.54±13.4	44.3±12.3	2.71	0.01

SGPT, Serum Glutamate pyruvate Transaminase; SGOT, Serum Glutamate Oxaloacetate Transaminase (SGOT); GGT, glutamyl transpeptidase; serum creatinine; SUA, serum uric acid; TG, triglycerides; TC, total cholesterol; HDL, high density lipoprotein-cholesterol; LDL, low-density lipoprotein cholesterol; HbA1c, glycated hemoglobin; FBS, fasting blood sugar. *P*<0.05 was considered significant; *t*-test, independent *t*-test values used for comparison between 2 groups

Table 2: Biochemical Parameters of the cases with type 2 diabetes mellitus (T2DM) in (Mean±SD) in two groups Group 1: Normal serum uric acid (SUA) levels, Group 2: Hyperuricemic (HUA)

Biochemical parameters	Mean±SD		*t*-test	*P*
	Normal uric acid 470/580 (81.03%)	Hyperuricemia 110/580 (18.9%)		
Age (years)	45.29±13.7	49.3±14.8		0.01
Uric Acid (mg/dL)	4.193±1	7.707±0.8	−27.26	<0.001
Creatinine (mg/dL)	0.711±0.8	1.1±0.8	−4.15	<0.001
Blood Urea (mg/dL)	23.38±11.5	31.1±19.5	−3.95	0.03
FBS ((mg/dL)	177.4±73.9	159.5±55.3	2.65	0.03
HbA1c (%)	7.773 ± ± 2.6	7.2±1.9	2.65	0.39
SGPT (IU/L)	32.34±20.1	34.2±18	−0.86	0.53
SGOT (IU/L)	35.47±13.9	37.4±12.6	−0.63	0.29
Alkaline Phosphatase (IU/L)	97.77±27.1	99.7±25.7	−1.07	0.62
Triglycerides (mg/dL)	173.1±92.2	177.9±89.5	0.50	0.01
Cholesterol (mg/dL)	188.3±45	172±48.1	2.62	0.12
LDL (mg/dL)	100.7±52.6	83.5±55.3	1.54	0.09
HDL (mg/dL)	48.3±14.5	44.1±11.8	1.69	0.09

SGPT, serum glutamate pyruvate transaminase; SGOT, serum glutamate oxaloacetate transaminase (SGOT); GGT, glutamyl transpeptidase; serum creatinine; SUA, serum uric acid; TG, triglycerides; TC, total cholesterol; HDL, high density lipoprotein-cholesterol; LDL, low-density lipoprotein cholesterol; HbA1c, glycated haemoglobin; FBS, fasting blood sugar. *P*<0.05 significant, *t*-test, independent *t*-test values used for comparison between 2 groups

Correlation between biochemical parameters and SUA. A Pearson's correlation analysis was used to estimate the correlation between biochemical parameters and SUA in T2DM patients and the control population. In control, normal subjects without T2DM, SUA levels were significantly but weakly positively correlated with renal function (blood urea and serum creatinine), blood lipid (TG), FBS, glycated haemoglobin (HbA1c), liver enzymes (SGPT, SGOT, ALP) (*P* values < 0.05) and negatively correlated with HDL (*P* values < 0.05 [Table 5].

SUA levels in T2DM patients were positively correlated with blood urea, creatinine, triglycerides, SGPT, and SGOT, and negatively correlated with glycated HbA1c, and FBS. (*P* values < 0.05) and HDL. We found no significant correlation between SUA and TC, LDL, and ALP [Table 6].

Discussion

DM stands as a significant health challenge worldwide, affecting both developing and developed countries alike. HbA1c is a potential screening biomarker for diabetes. Uric acid is implicated in various pathological processes, including inflammation, oxidative stress and endothelial dysfunction, Renin-angiotensin-aldosterone system (RAAS) activation, dyslipidaemia contributing to insulin resistance, hypertension, and atherosclerosis which predisposes to cardiometabolic diseases.[9]

The role of uric acid as a risk factor for diabetes remains contentious. The present study aimed to assess the association of SUA with FBS and HbA1c levels amongst healthy and diabetic individuals. Overall, the prevalence of hyperuricemia was 17.8%, and HUA prevalence in the diabetic population was

Table 3: Comparison of Biochemical Parameters in men between 2 groups in Mean±SD (Group 1: Normal serum uric acid levels, Group 2: Hyperuricemic in both control and cases subjects with T2DM

	Basic characteristics of the population (men)							
	Control (Mean±SD)		*t*-test*	*P*	Cases (Mean±SD)		*t*-test*	*P*
	Normal uric acid	Hyperuricemia			Normal uric acid	Hyperuricemia		
Age (years)	38.44±13.48	41.43±15.95	−1.58	0.12	46.89±13.36	47.18±13.51	−0.14	0.89
Uric Acid (mg/dL)	3.991±0.9703	7.886±0.77	−30.50	<0.001	4.724±0.86	7.09±0.727	−16.3 ± ± 9	<0.001
Creatinine (mg/dL)	0.5925±0.1426	0.9545±0.67	−4.67	<0.001	1.006±1.33	0.9885±0.5571	0.09	0.92
Blood Urea (mg/dL)	20.41±7.101	26.09±11.4	−4.27	<0.001	25.97±14.27	28.48±13.33	−1.13	0.26
FBS ((mg/dL)	88.31±6.913	89.66±6.90	−1.63	0.10	180.978.26	158.9±59.13	2.08	0.04
HbA1c (%)	4.705±0.242	4.756±0.23	−1.74	0.08	7.931±2.731	7.166±2.064	2.07	0.04
SGPT (IU/L)	28.35±14.99	38.31±18.0	−4.69	<0.001	43.05±30.26	39.75±17.86	0.78	0.44
SGOT (IU/L)	33.54±10.46	35.64±9.70	−1.69	0.09	39.79±15.74	37.84±11.68	0.85	0.40
Alkaline Phosphatase (IU/L)	89.22±25.7	90.29±25.6	−0.35	0.73	96.44±27.04	95.28±26.67	0.27	0.79
Triglycerides (mg/dL)	145.8±73.06	164.9±70.2	−1.87	0.06	176±99.07	157.4±81.57	1.06	0.29
Cholesterol (mg/dL)	179.5±42.55	185.3±47.9	−0.96	0.34	180.8±46.39	167.3±51.25	1.49	0.14
LDL (mg/dL)	98.47±52.6	119.1±57.1	−2.68	0.01	108.3±50.93	84.59±53.22	2.26	0.03
HDL (mg/dL)	49.54±13.38	41.53±8.12	5.24	<0.001	42.41±12.18	42.07±7.845	0.13	0.89

*Independent *t* test. SGPT, serum glutamate pyruvate transaminase; SGOT, serum glutamate oxaloacetate transaminase (SGOT); GGT, glutamyl transpeptidase; serum creatinine; SUA, serum uric acid; TG, triglycerides; TC, total cholesterol; HDL, high density lipoprotein-cholesterol; LDL, low-density lipoprotein cholesterol; HbA1c, glycated haemoglobin; FBS, fasting blood sugar, *P*<0.05 significant, *t*-test, independent sample *t*-test values used for comparison between 2 groups

Table 4: Comparison of Biochemical Parameters in women in Mean±SD between 2 groups (Group 1: Normal serum uric acid levels, Group 2: Hyperuricemic in both control and subjects with T2DM

	Basic characteristics of the population (women)							
	Control (Mean±SD)		*t*-test	*P*	Cases (Mean±SD)		*t*-test	*P*
	Normal uric acid	Hyperuricemia			Normal uric acid	Hyperuricemia		
Age (years)	37.95±13.06	43.57±13.39	-2.81	0.01	44.73±13.77	52.17±16.06	-3.38	0.001
Uric Acid (mg/dL)	3.837±0.56	7.54±0.635	-21.81	<0.001	4.028±0.9744	7.289±0.323	-21.46	<0.001
Creatinine (mg/dL)	0.5641±0.1228	0.9239±1.082	-2.25	0.03	0.6188±0.4582	1.187±1.079	-3.53	0.001
Blood urea (mg/dL)	19.82±7.113	30.17±26.94	-2.60	0.01	22.56±10.44	34.63±25.3	-3.20	0.002
FBS (mg/dL)	88.34±6.936	91.07±5.446	-2.61	0.01	210.1±72.55	160.4±50.47	1.75	0.08
HbA1c (%)	4.705±0.2417	4.8±0.1909	-2.60	0.01	7.99±2.528	6.717±1.756	2.17	0.03
SGPT (IU/L)	26.72±13.09	35.51±17.03	-3.39	<0.001	29.1 ± *14.35	26.72±12.48	1.08	0.28
SGOT (IU/L)	32.55±9.367	36.96±13.96	-2.08	0.04	34.15±13.08	34.48±13.59	0.16	0.87
Alkaline phosphatase (IU/L)	89.37±26.5	103.7±23.31	-3.52	<0.001	96.78±25.84	105.7±23.42	-2.21	0.03
Triglycerides (mg/dL)	141.4±67.84	139.1±52	0.17	0.87	172.4±89.59	184.6±102.2	-0.61	0.54
Cholesterol (mg/dL)	179.2±39.7	178.7±35.79	0.06	0.95	191.6±44.01	180.7±41.17	1.13	0.26
LDL (mg/dL)	97.38±49.92	79.05±52.85	1.65	0.10	98.32±52.72	81.56±59.9	1.36	0.17
HDL (mg/dL)	50.5±14.16	50.61±17.16	-0.03	0.98	50.56±14.67	49.7±18.1	0.18	0.86

SGPT, serum glutamate pyruvate transaminase; SGOT, serum glutamate oxaloacetate transaminase (SGOT); GGT, glutamyl transpeptidase; serum creatinine; SUA, serum uric acid; TG, triglycerides; TC, total cholesterol; HDL, high density lipoprotein-cholesterol; LDL, low-density lipoprotein cholesterol; HbA1c, glycated haemoglobin; FBS, fasting blood sugar, *P*<0.05 significant; *t*-test, independent sample *t*-test values used for comparison between 2 groups

higher (18.9%) compared to 17.04% in non-diabetic control. The mean age of the diabetic population was higher than the control population age group. The mean age of males was higher compared to the female population. It was observed that in the control group, male participants often had a higher level of SUA compared to female individuals which was in congruence with other studies. It could be attributed to higher renal clearance of uric acid in women due to oestrogen in females whose levels are relatively higher compared to men.[10-12] Moreover, in diabetic individuals, SUA levels were comparatively lower than in the healthy participants and showed an inverse association with FBG and HbA1c concentration. This is in agreement with previous studies[13-18] where a decreasing trend of SUA was observed with increasing blood glucose concentration. Previously, some contradictory reports of positive association between elevated SUA and diabetes[19-23] were also reported, whereas others reported no correlation.[8]

Discrepancy in investigating the association between SUA levels and diabetes across various population groups, several methodological considerations arise. First, the reliance on small sample sizes, selected groups including either male or female rather than a broader population may limit the generalizability of findings, induce selection bias, and fail to extrapolate results to diverse populations. Second, the prevalence of diabetes and management therapy may vary amongst different age cohorts. Furthermore, the influence of confounding variables such as dietary habits, lifestyle choices, genetic predispositions and

Table 5: Correlation of uric acid with biochemical parameters in control population

	Correlation coefficient with uric acid (*r*)	*P* (two-tailed)
Creatinine (mg/dL)	0.3746	<0.0001
Blood urea (mg/dL)	0.1419	0.0001
FBS (mg/dL)	0.08903	0.0157
HbA1c (%)	0.08976	0.0149
SGPT (IU/L)	0.1917	<0.0001
SGOT (IU/L)	0.1602	<0.0001
Triglycerides (mg/dL)	0.2136	<0.0001
Cholesterol (mg/dL)	0.06801	0.1802
LDL (mg/dL)	0.01571	0.769
VLDL (mg/dL)	0.2337	0.0002
HDL (mg/dL)	−0.07783	0.211

SGPT, serum glutamate pyruvate transaminase; SGOT, serum glutamate oxaloacetate transaminase (SGOT); GGT, glutamyl transpeptidase; serum creatinine; SUA, serum uric acid; TG, triglycerides; TC, total cholesterol; HDL, high density lipoprotein-cholesterol; LDL, low-density lipoprotein cholesterol; HbA1c, glycated haemoglobin; FBS, fasting blood sugar, *P*<0.05 significant

Table 6: Correlation of uric acid with biochemical parameters in cases (type 2 diabetic population)

	Correlation coefficient with uric acid (*r*)	*P* (two-tailed)
Creatinine (mg/dL)	0.086	0.0616
Blood Urea (mg/dL)	0.141	0.0023
FBS (mg/dL)	−0.110	0.0173
HbA1c (%)	−0.211	0.0173
SGPT (IU/L)	0.154	0.0162
SGOT (IU/L)	0.057	0.0009
Triglycerides (mg/dL)	0.101	0.2196
Cholesterol (mg/dL)	0.045	0.0291
LDL (mg/dL)	0.109	0.4416
VLDL (mg/dL)	0.090	0.0641
HDL (mg/dL)	−0.114	0.8415

SGPT, serum glutamate pyruvate transaminase; SGOT, serum glutamate oxaloacetate transaminase (SGOT); GGT, glutamyl transpeptidase; serum creatinine; SUA, serum uric acid; TG, triglycerides; TC, total cholesterol; HDL, high density lipoprotein-cholesterol; LDL, low-density lipoprotein cholesterol; HbA1c, glycated haemoglobin; FBS, fasting blood sugar, *P*<0.05 significant

environmental factors must be carefully considered. Addressing these challenges is crucial for advancing our understanding of the complex interplay between SUA levels and diabetes risk across diverse population groups.

Glucose and uric acid are both reabsorbed in the proximal renal tubules hence the reabsorption mechanisms for both substances may overlap. When glucose levels are high, as in DM, it could competitively inhibit the reabsorption of uric acid, leading to increased uric acid excretion in the urine. This mechanism is supported by the fact that both glucose and uric acid utilize similar transporters in the proximal tubules for reabsorption. Specifically, the urate or anion exchanger and voltage-sensitive urate channel are involved in the reabsorption of uric acid, and glucose is also reabsorbed through similar mechanisms in the same region of the kidney.

Considering that about 80% of the filtered load of uric acid is normally reabsorbed in the proximal tubules, any factor that interferes with this reabsorption process could lead to increased uric acid excretion. However, it is important to note that while this mechanism provides a plausible explanation of low SUA in DM. Further research would be needed to fully elucidate the role of glucose and other factors in the regulation of SUA levels. GLUT9, a crucial transporter in the proximal tubules of the kidney, facilitates the movement of both glucose and uric acid into renal cells for reabsorption. This process is sensitive to various factors, including glucose levels and other ions. High glucose levels can competitively inhibit uric acid reabsorption by GLUT9, leading to increased uric acid excretion and lower SUA levels. Additionally, interactions with other ions and molecules further modulate uric acid reabsorption. This intricate interplay highlights the multifactorial nature of uric acid regulation in the kidney, with implications for understanding conditions such as hyperuricemia and gout.[24-27]

The relationship between UA and HbA1c may be bell-shaped and depends on insulin status. The variations in uric acid concentration were evident across different population groups, including those with impaired glucose tolerance and newly diagnosed T2DM. However, these distinctions became significant only in the presence of hyperinsulinemia as documented by Modan *et al.*[28] Insulin's role in uric acid metabolism is multifaceted. Hyperinsulinemia can induce hexose monophosphate shunt leading to increased purine synthesis thus increasing the rate of uricogenesis. However, it can enhance the reabsorption of uric acid from the kidneys by stimulating the urate anion transporter in the proximal tubular brush border membrane, leading to higher SUA concentrations. Conversely, high insulin levels typically result in lower blood glucose levels. This dual action allows insulin to concurrently regulate both uric acid and blood glucose concentrations. Thus, the inverse correlation between uric acid and blood glucose levels in the presence of elevated insulin levels may be explained by this mechanism, contrasting with controls exhibiting normal insulin levels. Moreover, the relationship between SUA and blood glucose does not follow a linear pattern but rather resembles a bell curve.[28-30] While uric acid levels tend to increase with rising blood glucose concentrations in the normal and prediabetes population, they may paradoxically decline in individuals with T2DM as blood glucose levels increase. This complex interplay underscores the intricate regulatory mechanisms involved in uric acid and glucose metabolism, with implications for understanding metabolic disorders such as diabetes.

The study's primary limitation lies in its cross-sectional design. Additionally, the absence of information on urinary uric acid levels in diabetic individuals limits the comprehensiveness of the analysis. Urinary uric acid levels may offer further clues regarding renal handling and excretion of uric acid in diabetic patients. Addressing these limitations through longitudinal studies with comprehensive data collection would enhance our understanding of the dynamic interplay between SUA and diabetes.

Conclusions

Uric acid is considered as a glycometabolic indicator by some studies because of its correlation with HbA1c. However, SUA

levels have shown a paradoxical trend in individuals with and without diabetes. While non-diabetic individuals tend to exhibit higher SUA levels, a decreasing trend has been observed in diabetic individuals. Therefore, the utilization of SUA as a marker for assessing glucose metabolism should be approached with careful consideration of these complex dynamics.

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Authors contribution

All the authors have equally contributed to the conception or design of the work; the acquisition, and interpretation of data, reviewed it critically for important intellectual content, and approved the final version maintaining the accuracy or integrity of data.

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Conflicts of interest

There are no conflicts of interest.

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