Original article

Association of serum uric acid with different levels of glucose and related factors

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Keywords: diabetes mellitus; serum uric acid; blood glucose; fractional excretion of uric acid; insulin

Background Previous studies have demonstrated that serum uric acid (UA) is an independent predictor of incident type 2 diabetes mellitus (T2DM) in general populations. This study aimed to investigate specific characteristics of UA and its relationship between UA and blood glucose and other risk factors in the Chinese population.

Methods A total of 946 subjects were included in this study. UA, glucose, insulin, fractional excretion of UA (FEua), creatinine clearance rate (Ccr), hemoglobin A1c (HbA1c), fructosamine (FA), blood pressure and lipids were studied and also reexamined after the patients underwent two weeks of combined therapeutics.

Results UA levels were the highest in subjects with impaired glucose regulation (IGR), followed by subjects with normoglycemia (NGT) and finally by subjects with T2DM. The level of the 2-hour postprandial insulin and the area under the curve for insulin (AUCins) showed a similar tendency. The UA levels initially increased with increasing fasting blood glucose (FBG) and postprandial blood glucose (PPBG) levels, up to 7 mmol/L and 10 mmol/L, respectively, and thereafter decreased at higher FBG and PPBG levels. Compared with subjects in the lower serum UA quartile, subjects in the upper quartile of serum UA levels had higher weights, triglyceride levels, and creatinine levels as well as lower Ccr and FEua levels. Compared with women's group, UA levels were higher, and FEua levels were lower in men's group. Sex, body mass index (BMI), mean arterial blood pressure (MAP), serum triglycerides (TG), FA and Ccr were independent correlation factors of UA. UA decreased and FEua increased after the patients underwent a combined treatment.

Conclusions UA increased initially and then decreased as glucose levels increased from NGT to IGR and T2DM. Compared with NGT and T2DM, IGR subjects had higher SUA levels, which related to its high levels of insulin. Under T2DM, male gender, BMI, MAP, Ccr, TG and FA are independent correlation factors of UA. Glucose-lowering, antihypertensive, lipemia-regulating combined treatments were of advantage to decline of SUA of T2DM.

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Type 2 diabetes mellitus (T2DM) always correlates with a cluster of metabolic abnormalities: obesity, hypertension, low high-density lipoprotein (HDL) cholesterol, hypertriglyceridemia, hyperuricemia, hyperinsulinemia and insulin resistance. Identifying risk factors for the development of T2DM is essential for early screening and prevention of the disease. Serum uric acid (UA) is the major product of purine metabolism. There are strong cross-sectional associations between hyperuricemia, gout, and the metabolic syndrome.[1-7] Increased levels of UA have been associated with insulin resistance[8] and with established T2DM.[9] Previous studies have demonstrated that UA is an independent predictor of incident T2DM in general populations.[10,11] UA is positively associated with serum glucose in healthy subjects.[8,12] However, this association is not consistent with diabetic individuals,[9,13,14] as a low serum UA level is reported during the hyperglycemic state.[15] The relationship between UA and diabetes is controversial, and sex and ethnic differences may influence this relationship.[10,13,14,16-19] It is unlikely that there was a systematic evaluation of relationships between UA and the different glucose tolerance statuses, which are relatively rare for Chinese people. Therefore, in current study, we investigated the specific characteristics of UA in subjects with different glucose tolerance levels and the influence of glycometabolism on UA. We also studied the association between UA and the components of the metabolic syndrome: obesity, hypertension, hyperlipemia, hyperinsulinemia, and insulin resistance. Furthermore, we sought to investigate the changes in UA levels in patients after undergoing a glucose-lowering, antihypertensive, lipemia-regulating combined treatment.

METHODS

Study population

The study population consisted of 946 individuals (240 normoglycemia (NGT), 334 impaired glucose regulation (IGR), and 372 T2DM subjects), who went to diabetes specialist outpatient clinics and specialist wards or underwent health screening at Henan Provincial People's

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Hospital in China between January 2006 and June 2009. Those subjects were excluded as the patients taking diuretics; those taking antihypertensive, antidiabetic, lipid-lowering agents, hyperuricemic or hypouricemic agents; and those with any clinical symptoms of malignancy, acute infectious disease, acute inflammatory disease or renal disease were also been removed.

Ethical approval for the present study and informed patient consent were obtained from the Henan Provincial People's Hospital in China.

Physical examination and blood pressure (BP)

Height and weight were measured using an automatic scale, and the subject's body mass index (BMI) was calculated from that data (kg/m^2). The measurement around the umbilical area while standing upright was used as the waist circumference, and the measurement around the greater trochanter of the femur was used as the hip circumference. BP was measured using a sphygmomanometer after the subjects had rested for more than 5 minutes. The BP was checked twice more after resting, and average values were then calculated.

Blood sampling

After a 12-hour fast, a venous blood sample was obtained from each subject in order to measure serum UA, hemoglobin A1c (HbA1c), fructosamine (FA), serum creatinine (Cr), total cholesterol (TC), serum triglycerides (TG), and high- and low-density lipoprotein cholesterol (HDL-c and LDL-c, respectively), as well as to perform oral glucose tolerance and insulin release test. The serum UA concentrations were measured using the urico-oxidase method (OLYMPUS AU1000, OLYMPUS, Japan), and blood glucose was measured by the oxidation enzyme method (OLYMPUS AU5400, OLYMPUS). The insulin concentration was determined using a chemiluminescence assay (Bayer ADVIA Centaur, Bayer, Germany; the intra- and inter-assay coefficients of variability were 2.2%–2.3% and 1.9%–3.9%, respectively). HbA1c was made a survey by a high-performance liquid chromatography analyzer (DREW DS5, Drew Scientific, United Kingdom). FA was checked using a biochemical enzyme-based method (Glypro analyzer, Genzyme, USA). TG, TC, LDL-c, and HDL-c were measured using the immunoturbidimetry method (OLYMPUS AU1000). Cr was tested using the carbazotic acid method (OLYMPUS AU5400). Urine was obtained from each subject over a 24-hour period and was used to measure FEua (OLYMPUS AU5400).

FBG, BP, TC, TG, UA, and FEua were re-measured after two weeks of combined treatment.

Criteria, calculations and treatments

Glucose tolerance status was defined in 1999 by the World Health Organization, criteria included: (1) NGT (n=240): fasting plasma glucose <5.6 mmol/L and 2-hour post-challenge glucose <7.8 mmol/L; (2) IGR (n=334): impaired fasting glucose (IFG; n=184): fasting plasma glucose between 5.6 mmol/L and <7.0 mmol/L; and impaired glucose tolerance (IGT; n=150): 2-hour post-challenge glucose ≥7.8 mmol/L and <11.1 mmol/L; or (3) T2DM (n=372): fasting plasma glucose ≥7.0 mmol/L and/or 2-hour concentrations ≥11.1 mmol/L.

Hyperuricemia was diagnosed when the serum UA concentration was ≥420 μmol/L in men and ≥360 μmol/L in women. The subjects were classified in two groups: (1) normal uric acid (n=768), and (2) hyperuricemia (n=178). Hypertension was identified based on the BP levels measured at the study visit (systolic BP (SBP) ≥140 mmHg or diastolic BP (DBP) ≥90 mmHg). Hyperlipemia was diagnosed when the TC concentration was ≥5.72 mmol/L or the TG concentration was ≥1.70 mmol/L.

Homeostatic model assessment (HOMA) indices were used as markers of insulin resistance and were calculated as follows:[20] HOMA index = (fasting insulin (μIU/ml) × fasting serum glucose (mmol/L))/22.5. Creatinine clearance rate (Ccr) = (140–age) × body weight × (0.85 female) / (72 × Scr), where body weight (kg) = (actual body weight + standard body weight)/2. AUCins = (fasting insulin + 3-hour insulin)/2 + 1-hour insulin + 2-hour insulin. Mean arterial blood pressure (MAP) = SBP/3 + DBP ×2/3.

We also administered combined treatment: T2DM, hypertensive and hyperlipemic patients received oral hypoglycemic, antihypertensive and lipemia-regulating agents, respectively, for two weeks. After the treatment, FBG, BP, TC, TG, UA and FEua levels were measured again.

Statistical analysis

Analyses were performed using SPSS, version 13.0 (SPSS Inc., USA). Statistical results were presented as the mean ± standard deviation (SD). The various values for the different glucose tolerance states and the four serum UA concentration groups were compared by one-way analysis of variance (ANOVA). We calculated partial correlation coefficients between UA and FBG, PPBG, HbA1c, FA, Ccr, and FEua after adjusting for sex, TG, and BMI.

Sex-specific values of the metabolic variables of the study population were examined using ANOVA and an independent samples t-test. Based on fasting serum UA concentrations, the subjects were divided into four groups: quartile 1, < 235 μmol/L (n=234); quartile 2, 235–286 μmol/L (n=226); quartile 3, 287–343 μmol/L (n=248); and quartile 4, ≥344 μmol/L (n=238). FBG levels were classified into nine groups: <5 mmol/L, 5 mmol/L ≤ FBG <6 mmol/L, 6 mmol/L ≤ FBG <7 mmol/L, 7 mmol/L ≤ FBG <8 mmol/L, 8 mmol/L ≤ FBG <9 mmol/L, 9 mmol/L ≤ FBG <10 mmol/L, 10 mmol/L ≤ FBG <11 mmol/L, 11 mmol/L ≤ FBG <12 mmol/L, and ≥12 mmol/L. PPBG levels were categorized into six groups: <8 mmol/L, 8 mmol/L ≤ PPBG <10 mmol/L, 10 mmol/L

≤ PPBG <13 mmol/L, 13 mmol/L ≤ PPBG <15 mmol/L, 15 mmol/L ≤ PPBG <19 mmol/L, and ≥19 mmol/L. The HbA1c percentage into six groups: <6.5%, 6.5% ≤ HbA1c <7.2%, 7.2% ≤ HbA1c <8.0%, 8.0% ≤ HbA1c <8.9%, 8.9% ≤ HbA1c <10.2% , and ≥10.2%. FA levels into six groups: <261.2 μmol/L, 261.2 μmol/L ≤ FA <318.9 μmol/L, 318.9 μmol/L ≤ FA <367.9 μmol/L, 367.9 μmol/L ≤ FA <450.7 μmol/L, 450.7 μmol/L ≤ FA <532 μmol/L, and ≥532 μmol/L. The paired *t*-test was used to assess the differences between the UA levels of paired groups. We performed stepwise multivariate regression analyses and binary logistic regression analyses to investigate the association between UA and the other variables. A paired *t*-test was used to compare pre- and post-treatment biochemical data in the hyperuricemic and normal groups. *P* values <0.05 were considered statistically significant.

RESULTS

Two-hour insulin and AUCins in IGR group were higher than those in NGT and T2DM groups (IGR > NGT > T2DM); Ccr was checked which showed as follows: T2DM > IGR > NGT; the same with FEua: T2DM > NGT > IGR and SUA showed as IGR > NGT > T2DM (*P* <0.05 or *P* <0.01) (Table 1). AUCins showed a significant positive correlation with UA (*P* <0.01), while FEua revealed a significant negative correlation with UA (*P* <0.01) in the IGR group. After adjusting for sexual distinction, the TG and BMI, UA levels showed a negative correlation with FBG, PPBG, HbA1c, and FA levels. FEua displayed a positive correlation with FBG, PPBG, HbA1c, and FA levels. Ccr was positively correlated with FBG, PPBG, and FA levels. The UA levels initially increased with increasing FBG and PPBG levels, up to 7 mmol/L and 10 mmol/L, respectively, and thereafter decreased with further increases in the FBG and PPBG levels. When compared with subjects in the lower UA level quartile, subjects in the upper quartile had higher weights, TG levels, blood urea nitrogen (BUN) levels, as well as Cr levels had lower Ccr and FEua levels. Compared with other quartiles, subjects in the first quartile had higher HbA1c and FA levels, while subjects in the third quartile had lower HbA1c and FA levels (Table 2). Both UA levels and TG was remarkably higher in men than in women, while FEua levels, TC, LDL-c and HDL-c levels were apparently lower. BP, FBG, HbA1c, and FA were not obviously different between men and women (Table 3). Stepwise multivariate regression analysis showed when UA was a dependent variable and sex, age, TC, TG, weight, BMI, waist, waist-to-hip ratio, PPBG, HbA1c, FA, CRP, Ccr, SBP, DBP, MAP, HOMA, AUC-ins were independent variables; male gender, TG, BMI, and MAP levels were positively correlated with UA. FA and Ccr were negatively correlated with UA. $Y=367.733 + 67.4\ (\text{male}) + 0.136 \times MAP + 5.927 \times TG + 3.967 \times BMI - 0.586 \times Ccr - 0.164 \times FA$ (Table 4). Based on the FA and UA concentrations, the subjects were independently divided into two groups. For

Table 1. Characteristics of the study population (*n*=946)

Variables	NGT	IGR	T2DM
Number	240	334	372
Men/women (*n*)	154/86	160/174	264/108
Age (years)	47±15	56±14	55±15
Weight (kg)	73.8±13.6	75.5±10.4	75.2±13.8
BMI (kg/m^2)	25.1±4.4	26.5±2.8	26.3±3.9
Waist (cm)	96.4±10.0	97.3±8.2	97.3±12.0
Waist-hip ratio	0.92±0.08	0.93±0.06	0.93±0.06
SBP (mmHg)	136.0±18.6	132.1±17.9	143.5±17.6
DBP (mmHg)	80.0±10.6	80.4±8.1	82.6±9.3
MAP (mmHg)	116±29	113±20	120±30
TG (mmol/L)	1.8±1.3‡	3.0±2.2	3.5±2.7
TC (mmol/L)	3.9±1.8	4.0±2.0	4.1±2.0
LDL-c (mmol/L)	2.72±0.28	2.80±0.81	3.17±0.78
HDL-c (mmol/L)	1.31±0.94‡	1.10±0.25	0.92±0.29
UA (μmol/L)	292±77†	325±100	283±86†
FEua (%)	9.1±3.2*	7.0±3.0	9.4±4.7†
Cr (μmol/L)	70.7±15.7	67.4±12.6	68.5±13.8
Ccr (ml/min)	107±43‡	112±34	118±39*
FBG (mmol/L)	5.3±0.4†§	6.3±0.3	10.3±3.0†
PPBG (2h) (mmol/L)	6.1±1.2†§	9.6±1.3	16.0±4.5†
HbA1c (%)	4.4±1.3*§	5.9±1.4	8.7±1.7†
FA (μmol/L)	145±78*§	346±126	426±147*
Insulin (fasting) (μU/ml)	8.7±9.8	7.9±5.1	6.8±6.5
Insulin (2h) (μU/ml)	29.1±17.7*	53.5±61.1	23.0±19.6*
AUCins	73.54±41.73†‡	102.35±94.50	61.85±55.05†
HOMA index	2.04±2.32*‡	3.10±1.38	3.55±3.89

$^{*}P$ <0.05, $^{\dagger}P$ <0.01, IGR vs. NGT; IGR vs. T2DM. $^{\ddagger}P$ <0.05, $^{\S}P$ <0.01, NGT vs. T2DM. NGT: normoglycemia. IGR: impaired glucose regulation. T2DM: type 2 diabetes mellitus. BMI: body mass index. SBP: systolic blood pressure. DBP: diastolic blood pressure. MAP: mean arterial blood pressure. TG: triglyceride. TC: total cholesterol. HDL-c: high-density lipoprotein cholesterol. LDL-c: low-density lipoprotein cholesterol. UA: uric acid. FEua: fractional excretion of uric acid. Cr: creatinine. Ccr: creatinine clearance rate. FBG: fasting blood glucose. PPBG: postprandial blood glucose. HbA1c: hemoglobin A1c. FA: fructosamine. AUCins: area under the curve for insulin. HOMA: homeostatic model assessment.

Table 2. Clinical and biochemical characteristics of the study population based on the quartile of serum uric acid levels

Variables	Quartile of UA (μmol/L)				*P* values
	1st (<235)	2nd (235–286)	3rd (287–343)	4th (≥344)	
Men/women	108/126	166/60	188/60	214/24	NS
Age (years)	57±16	62±17	56±14	56±16	NS
BUN (mmol/L)	4.5±1.3	4.7±1.5	5.5±1.8	6.0±2.8	0.012
Cr (μmol/L)	61±11	67±12	70±18	81±25	<0.001
Ccr (ml/min)	92±4	89±11	57±7	53±7	0.014
FEua (%)	12.1±5.6	7.9±2.3	6.8±2.3	6.0±2.8	0.013
Weight (kg)	68.4±10.7	73.3±10.7	76.7±12.8	81.3±14.8	<0.001
BMI (kg/m^2)	25.2±3.8	24.8±4.5	26.5±3.7	27.6±3.6	0.002
Waist (cm)	91.5±9.7	95.3±9.6	99.1±11.0	102.2±11.0	<0.001
Waist-to-hip ratio	0.92±0.06	0.93±0.06	0.95±0.11	0.96±0.06	0.003
SBP (mmHg)	133±20	137±18	136±18	154±19	NS
DBP (mmHg)	82±9	81±9	82±8	83±11	NS
MAP (mmHg)	99±12	100±9	100±10	101±11	NS
FBG (mmol/L)	9.5±3.8	8.9±3.2	8.3±3.1	9.0±3.0	NS
HbA1c (%)	8.8±1.9	8.2±1.9	7.9±1.9	8.0±1.6	0.028
FA (μmol/L)	460.8±145.7	402.1±144.0	364.6±142.3	360.8±152.3	0.01
TG (mmol/L)	1.7±1.1	1.8±1.0	2.3±2.6	3.1±3.1	0.001
TC (mmol/L)	5.1±1.1	5.0±1.2	5.1±1.4	5.1±1.5	NS
LDL-c (mmol/L)	2.9±0.7	3.0±0.9	3.0±1.0	3.1±1.0	NS
HDL-c (mmol/L)	1.2±0.4	1.2±0.8	1.1±0.2	1.0±0.2	NS
Insulin (fasting) (μU/ml)	10.0±7.8	7.6±7.2	6.5±3.4	7.4±5.5	NS
Insulin (2 hour) (μU/ml)	29.9±18.6	28.9±13.7	25.6±21.7	36.7±22.7	NS
AUCins	72.2±84.3	71.2±34.4	61.3±43.3	82.6±89.4	NS
HOMA index	3.7±2.3	2.6±1.8	2.6±1.8	2.5±2.0	NS

Table 3. Sex-specific values of the metabolic variables of the study population

Variables	Total (*n*=946)	Men (*n*=676)	Women (*n*=270)	*P* values (between genders)
UA (μmol/L)	292±88	310±88	247±71	<0.001
FEua (%)	8.2±4.3	7.6±4.2	9.7±4.0	0.001
Cr (μmol/L)	72.7±54.9	76.7±14.0	62.8±13.8	NS
Ccr (ml/min)	113.1±61.1	117.9±31.1	101.2±30.7	0.06
SBP (mmHg)	136.3±18.2	135.1±17.7	139.3±19.1	NS
DBP (mmHg)	82.0±9.5	82.2±9.4	81.5±9.7	NS
MAP (mmHg)	100.1±10.6	99.8±10.4	100.7±11.0	NS
FBG (mmol/L)	8.9±3.3	8.9±3.2	8.8±3.5	NS
HbA1c (%)	8.2±1.9	8.2±1.8	8.4±2.0	NS
FA (μmol/L)	393.0±150.8	398.0±150.7	380.6±151.9	NS
TG (mmol/L)	2.2±2.2	2.3±2.5	1.9±1.0	0.04
TC (mmol/L)	5.1±1.3	5.0±1.3	5.3±1.3	0.036
LDL-c (mmol/L)	3.0±0.9	3.0±0.8	3.2±0.9	0.035
HDL-c (mmol/L)	1.2±0.5	1.1±0.3	1.2±0.7	0.045

Table 4. Stepwise multivariate regression analysis with UA as a dependent variable

Variables	Standardized coefficients (B)	*t* values	*P* values
FA	-0.269	-3.491	0.001
Male	0.350	4.431	<0.001
MAP	0.173	2.230	0.028
Ccr	-0.275	-3.235	0.002
TG	0.186	2.407	0.018
BMI	0.187	2.245	0.027

FA, the groups were normal (FA <236 μmol/L) and hyperfructosamine (FA ≥236 μmol/L). In addition, for UA, the groups were normal (UA <360 μmol/L) and hyperuricemia (UA ≥360 μmol/L). Binary logistic regression analyses showed when UA was a dependent variable, the odds ratio (OR) of FA was 0.32. This illustrated that the incidence of hyperuricemia would decrease more than 30% if FA had increased one grade (Table 5). UA was significantly decreased and FEua was evidently increased in hyperuricemic subjects after undergoing combined glucose-lowering, antihypertensive and lipemia-regulating treatment, but the UA and FEua levels were not remarkably different in normal subjects (Table 6).

Table 5. Binary Logistic regression analysis with UA as a dependent variable

Variables	*OR*	95% *CI*	*P* values
FA	0.320	(0.097-1.056)	0.031
Waist	1.040	(0.999-1.083)	0.048
TG	1.178	(1.026-1.354)	0.020
Cr	1.041	(1.014-1.069)	0.003

Table 6. Comparison of pre- and post-treatment biochemical data in the hyperuricemic and normal groups

Pre- and post-treatment	Hyperuricemic			Normal		
	mean±SD	*t* values	*P* values	mean±SD	*t* values	*P* values
FBG1-FBG2	2.5±2.8	4.602	0.000	2.8±3.4	9.089	0.000
MAP1-MAP2	6.8±7.6	4.609	0.000	5.8±10.9	5.927	0.000
TC1-TC2	0.5±1.5	1.489	0.002	0.9±1.3	6.016	0.000
TG1-TG2	1.0±2.7	1.750	0.025	0.5±2.6	1.885	0.063
UA1-UA2	70±113	2.847	0.010	-(12±64)	-1.834	0.070
FEua1-FEua2	-(2.5±4.7)	-2.309	0.033	0.3±3.4	0.813	0.419

DISCUSSION

UA is influenced by a variety of conditions, including environmental and genetic factors. Overwhelming evidence suggests that UA is linked to many components of the metabolic syndrome.[5,21] Among environmental factors, our studies showed that blood glucose, BMI, TG, MAP, insulin levels and AUCins, etc were independent correlation factors of UA. The balance of derivation and excretion of UA is the main factor of maintaining SUA levels. What influence was blood glucose on SUA and excretion among T2DM subjects? In addition, what different effects did insulin resistance, obesity, hypertriglyceridemia, MAP, insulin level, AUCins have on SUA? For T2DM subjects, complex abnormality of hyperglycemia, hypertriglyceridemia, hypertension had various effects on SUA. It is still arguable what SUA levels will be after undergoing a glucose-lowering, antihypertensive, lipemia-regulating combined treatment. The discussion is as follows.

Several studies have shown that a moderate degree of hyperglycemia is associated with higher UA levels, while a higher degree of hyperglycemia is related with lower UA levels.[22-25] Similar results were obtained: the UA levels initially increased with increasing FBG and PPBG levels, up to 7 mmol/L and 10 mmol/L, respectively, and thereafter decreased with further increasing FBG and PPBG levels. Glucose and UA absorbed in renal proximal tubule through co-transporter which were competed with each other, while glucose level was up to renal glucose threshold, blood glucose had more obvious advantage of reabsorbtion. UA could not be fully reabsorbed, which increased along with excretion of urine as SUA decreased.

In comparison, the AUCins level was highest in the IGR group, second highest in the NGT group, and lowest in the T2DM group. UA levels showed a similar tendency with respect to AUCins. In addition, multiple regression analysis showed that AUCins had a positive correlation with UA and a negative correlation with FEua (P <0.01). Higher insulin levels are known to reduce the renal excretion of urate.[8,12,26-29] For example, exogenous insulin can reduce the renal excretion of urate in both healthy and hypertensive subjects.[3,26,27] Insulin may enhance renal urate reabsorption by stimulating the urate-anion exchanger URAT[30] and/or the Nat-dependent anion co-transporter in the brush border membranes of the renal proximal tubule.[31] Urinary uric acid clearance drops with decreasing insulin-mediated glucose disposal, and decreased uric acid excretion leads to hyperuricemia.[32] Hyperuricemia has been found to be an independent risk factor for the progression to hyperinsulinemia and preceded hyperinsulinemia in the 11-year follow-up of non-diabetic participants of the atherosclerosis risk in communities study.[32,33]

There are numerous cross-sectional studies and prospective studies on UA concentrations and the development of hypertension.[34,35] UA increases BP by acting on the renal interstitium, which may cause cardio-

and cerebrovasculature damage. It is possible that obesity correlates with UA levels by both reducing renal UA secretion and by causing the accumulation of substrates for UA production. Lipid metabolic disorder is usually coupled with hyperuricemia, possibly because increasing lipoprotein esterase levels may decrease the clearance of UA. Otherwise, hyperuricemia may reduce TG decomposition and increase TG levels by repressing lipoprotein lipase activity.

After a glucose-lowering, antihypertensive, lipemia-regulating combined treatment, UA levels significantly decreased and FEua levels significantly increased in hyperuricemic subjects, but UA and FEua levels were not remarkably different in normal subjects. This shows that the level of glucose was not the exclusive determining factor for UA levels in the synthetic metabolic disorder of T2DM or pre-diabetes, although hyperglycemia could enhance the excretion of UA. The improvements in blood pressure, glucose levels, and lipid levels could cause moderate improvements in the UA levels in patients with synthetic metabolic disorders. This evidence that improvements in the metabolic factors are associated with improvements in UA levels vigorously suggests that UA is closely linked to these components of the metabolic syndrome.

In general, as glucose levels increase from NGT to IGR and T2DM, UA increased with a moderate degree of hyperglycemia and thereafter decreased in the presence of a higher degree of hyperglycemia. FA was negatively correlated with UA. The incidence of hyperuricemia could decrease more than 30% if FA increases by one grade. All of these findings were associated with the relationship between UA and the combined effects of glucose, insulin and other metabolic risk factors.

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