The elevation of serum uric acid depends on insulin resistance but not fasting plasma glucose in hyperuricaemia

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Abstract

Objective

The association between serum uric acid (SUA) and fasting plasma glucose (FPG) has not been fully outlined, in particular in hyperuricaemic population. This study aimed to address this issue, along with the exploration of the role of insulin resistance that was assessed by triglyceride-and-glucose (TyG) index.

Methods

A total of 16,297 participants without known diabetes from the SENSIBLE and SENSIBLE-Addition studies were included in the present analysis. Hyperuricaemia was defined as SUA ≥6 mg/dL. Generalised addictive model was applied to establish the relationship of SUA with FPG, and mediation analysis was performed to assess how insulin resistance affected the relationship.

Results

SUA showed an inverted U-shaped association with FPG, with the turning point of FPG at 6.1 mmol/L and 7.5 mmol/L in normouricaemic and hyperuricaemic participants, respectively. However, the significant relationship between SUA and FPG disappeared in hyperuricaemic participants (form B=3.3, 95% CI: 0.6–5.9, p=0.016 to B= -0.2, 95% CI: -3.1–2.7, p=0.894), and attenuated in normouricaemic participants (from B=9.8, 95% CI: 8.0–11.7, p<0.001 to B=7.3, 95% CI: 5.3–9.2, p<0.001) after controlling for TyG index. In the ascending segment, the relationship between SUA and FPG was partially mediated by TyG index in normouricaemic participants, but fully in hyperuricaemic participants.

Conclusion

SUA had an inverted U-shaped relationship with FPG, and their positive relationship was fully mediated by insulin resistance in participants with hyperuricaemia but not those without.

Key words

uric acid, fasting plasma glucose, TyG index, hyperuricaemia

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Introduction

Uric acid, the final product of purine metabolism in human due to the evolutionary loss of hepatic uricase (1), manifests an anti-oxidant function at the physiological level, but a pro-oxidant property at an increased level. Hyperuricaemia, which occurs as a result of the abnormal increased uric acid production and/or the impaired excretion (2), is implicated in the development of a series of chronic metabolism-related disorders such as gout, cardiovascular disease (3, 4), chronic kidney disease (5) and diabetes (6).

There is accumulating evidence that purine metabolism is closely related to glucose metabolism. Serum uric acid (SUA) is increased in response to elevated fasting plasma glucose (FPG) in adults without diabetes, but declined in those with diabetes (7-11). One cross-sectional study suggested an inverted U-shaped curve for the relationship between SUA and FPG in Chinese adults without known diabetes (12). Yet there is a lack of evidence whether the relationship between SUA and FPG differs based on the presence of hyperuricaemia. Moreover, previous studies pointed out that the negative relationship between SUA and FPG might be explained by the evidence that increased glucose in the urine led to urate efflux across the apical membrane of the proximal tubule (13, 14). However, no studies attempted to outline the intrinsic mechanism of the relationship between SUA and FPG when they were positively correlated.

Insulin resistance is considered the most crucial pathogenesis in the development of glucose intolerance (15-17) and a core stimulation for hyperuricaemia (18, 19). The onset of hyperuricaemia is assumed to be attributed to the attendant compensatory hyperinsulinaemia caused by insulin resistance (20). This could be supported by the observation that amelioration of insulin resistance resulted in decreased SUA (19, 21). Moreover, Cui *et al*. found that the inverse correlation between SUA and haemoglobin A1c (HbA1c) turned out to be non-significant in patients with newly diagnosed type 2 diabetes when taking hyperinsulinaemia into consideration (22). Taken together, it seems likely that insulin resistance may play a remarkable role in the relationship between glucose and purine metabolism. However, it is still unclear whether or to what extent insulin resistance could explain the positive relationship between glucose and purine metabolism in general population, especially in the population with hyperuricaemia.

Given these, the primary aim of this study was to outline the association between SUA and FPG in population stratified by the presence of hyperuricaemia, based on the Study on Evaluation of iNnovated Screening tools and determination of optimal diagnostic cut-off points for type 2 diaBetes in Chinese muLti-Ethnic (SENSIBLE) (23) and SENSIBLE-Addition (24) studies. Our secondary aim was to investigate whether insulin resistance, which was assessed by triglyceride-and-glucose (TyG) index (25-28), would mediate the association between SUA and FPG.

Methods

Study design and population

Data used in this study were driven from the SENSIBLE (23) and SENSIBLE-Addition studies (24). The details of the sampling approach and the designs of both studies were described elsewhere (23, 24). Yet in this study, we did not incur a strict inclusion criterion on age (that is to say, participants aged below 20 years or over 70 years were also incuded), aiming to provide a larger sample size. The protocols of the studies were approved by the ethics committee of Zhongda Hospital, Southeast University and the involved sub-centre hospitals. Written informed consent was obtained from each participant.

A total of 17,629 participants were included upon the completion of face-to-face questionnaire and physical examination by trained research staff, and laboratory examination. After excluding 902 participants with self-reported diabetes, 332 with missing information on questionnaire (including history of diabetes, and smoking and drinking statuses), gender, or important laboratory biomarkers (including FPG, SUA and triglyceride), 98 with important laboratory biomarkers (including FPG,

SUA and triglyceride) considered outliers (defined as >99.9 percentile or <0.1 percentile), a total of 16,297 participants were eligible for inclusion in the final analysis (Fig. 1).

Procedure

Questionnaires were used to obtain information on sociodemographic characteristics, medical history and lifestyle factors by trained interviewers. Body weight, height, and waist circumference (WC) were measured using standardised protocols. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured 3 times at the non-dominant arm after 5-minute rest at a seated position using an automated device (YE680E, yuwell, China).

All participants were informed to maintain their usual lifestyle for at least 3 days and fasted for at least 10 hours. After taking fasting blood samples, which were used to measure HbA1c, FPG, triglyceride (TG), total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), SUA, serum creatinine (SCr) and blood urea nitrogen (BUN), all participants were instructed to swallow a standard 75 g glucose solution. Two hours later, the blood samples were taken again for the 2-hour postprandial glucose (2hPG) measurement. All blood samples were centrifuged on site within 30 minutes after collection. The serum and the whole blood samples were shipped at 4 °C by air to the central laboratory in Nanjing Adicon Clinical Laboratories. FPG, 2hPG, TG, TC, HDL-C, LDL-C, SUA, SCr and BUN were measured using an automatic chemistry analyser (Synchron LX-20, Beckman Coulter Inc., CA, USA), and HbA1c was measured with high-performance liquid chromatography (D-10™ Haemoglobin Analyser, Bio-Rad Inc., CA, USA).

Definitions

Hyperuricaemia was defined as SUA ≥357 μmol/L (6 mg/dL) as suggested (29). Body mass index (BMI) was calculated as body weight (kg) divided by squared height (m). TyG index was calculated as ln[TG(mg/dL) × FPG(mg/dL)/2]. Mean arterial pressure (MAP) was calculated as [SBP(mmHg) + 2 × DBP(mmHg)]/3. The estimated glomerular filtration rate (eGFR) was calculated using an equation from the Modification of Diet in Renal Disease (MDRD), on the basis of the data from Chinese subjects with chronic kidney disease. The MDRD equation is as follows: eGFR (ml/min/1.73 m^2) =175 × [SCr (mg/dl)] $^{-1.234}$ × [age (years)] $^{-0.179}$ (for females × 0.79) (30).

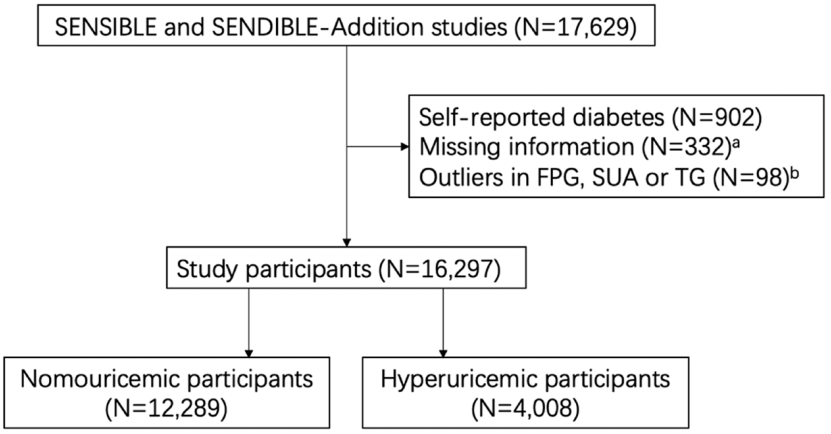

Fig. 1. Flow chart of the research.
SENSIBLE: Study on Evaluation of iNnovated Screening tools and determination of optimal diagnostic cut-off points for type 2 diaBetes in Chinese muLti-Ethnic; FPG: fasting plasma glucose; SUA: serum uric acid; TG: triglyceride.
[a] This included data on questionnaire (including history of diabetes, and smoking and drinking statuses), gender, or important laboratory biomarkers (including FPG, SUA and TG).
[b] Outliers were defined as >99.9 percentile or <0.1 percentile.

Statistical analysis

Data were analysed using SPSS 26.0 (SPSS Inc., Chicago, IL, USA) and Empower Stats (www.empowerstats.com, X&Y solutions, Inc. Boston MA). Empty data (including age, HbA1c, 2hPG, TC, HDL-C, LDL-C, SCr, BUN, WC, BMI, and MAP), and outliers of WC, BMI, and MAP (defined as >99.9 percentile or <0.1 percentile) were substituted with the means. Continuous data were presented as means and standard deviations (SDs) or standard errors (SEs), and compared using Student's t-test. Categorical variables were expressed as numbers and percentages, and compared by χ^2 test. The relationship between SUA and FPG was explored using generalised smoothing spline which was generated automatically in generalised additive model by Empower Stats. We further employed a two-piecewise linear regression model to examine the threshold effect of FPG on SUA based on the smoothing spline. The inflection point was determined by trial and error, including selection of the inflection point along a predefined interval and then the inflection point that gave the maximum likelihood. Meanwhile, linear regression analysis was performed to assess the relationship between SUA and FPG within each stratum of FPG, with Wald χ^2 test being used to test the difference of regression coefficients between stratums. Mediation analysis was applied to assess the total, direct and indirect effects of FPG on SUA with TyG index as a mediator. In this approach, the "total effect" can be broken down into a "direct effect" (not mediated TyG index) and an "indirect effect" (mediated by TyG index). Mediation effect was calculated as indirect effect/total effect × 100%. We used the bootstrap test to evaluate the significance of the mediation effect. Moderation analysis was performed to explore whether TyG index moderated the relationship between SUA and FPG. Centred scores were used for the interaction terms to avoid multicollinearity. Partially adjusted model included age, gender, BMI, WC, MAP, TG, TC, HDL-C, LDL-C, BUN, eGFR, and drinking and smoking statuses as covariates, and fully adjusted model was with further adjustment for TyG index. A two-tailed *p*-value <0.05 was considered to be statistically significant.

Results

Participants' characteristics

Characteristics of the enrolled participants are shown in Table I, and 24.6% (4,008/16,297) of them were found hyperuricaemia. Compared to participants without hyperuricaemia, those with hyperuricaemia were older, had a higher BMI and larger WC, and were more likely to smoke or consume alcohol (all $p<0.001$). Moreover, the hyperuricaemic participants exhibited worse metabolic related parameters such as higher blood pressure, TyG index, plasma glucose, and lipoprotein cholesterol levels, as well as poorer renal function (all $p<0.001$).

Table I. General characteristics of study participants by hyperuricaemia.

	Hyperuricaemia	Nomouricaemia	*p*-value
n (%)	4,008 (24.6%)	12,289 (75.4%)	
Age, years	51 ± 12.2	50 ± 11.7	<0.001
Gender (male), n (%)	2,779 (69.3%)	2,768 (22.5%)	<0.001
Height, m	163.7 ± 8.24	158.2 ± 7.66	<0.001
Weight, kg	70.2 ± 12.05	61.9 ± 10.95	<0.001
WC, cm	87.8 ± 10.18	82.1 ± 10.38	<0.001
SBP, mmHg	137 ± 20.2	130 ± 20.5	<0.001
DBP, mmHg	85 ± 12.2	80 ± 11.9	<0.001
MAP, mmHg	102 ± 13.7	96 ± 13.7	<0.001
FPG, mmol/L	5.8 ± 1.04	5.6 ± 1.17	<0.001
2hPG, mmol/L	7.5 ± 2.94	7.1 ± 2.92	<0.001
HbA1c, %	5.6 ± 0.70	5.5 ± 0.78	<0.001
SUA, μmol/L	424 ± 59.7	267 ± 51.5	<0.001
TG, mmol/L	2.2 ± 2.26	1.5 ± 1.33	<0.001
TC, mmol/L	5.2 ± 1.14	5.0 ± 1.09	<0.001
HDL-C, mmol/L	1.5 ± 0.39	1.6 ± 0.39	<0.001
LDL-C, mmol/L	3.0 ± 0.85	2.8 ± 0.81	<0.001
BUN, mmol/L	5.5 ± 1.52	5.0 ± 1.36	<0.001
eGFR, ml/min/1.73m^2	109.9 ± 31.13	125.1 ± 35.19	<0.001
eGFR<60 ml/min/1.73m^2	100 (2.5%)	105 (0.9%)	<0.001
BMI, kg/m^2	26.1 ± 3.74	24.7 ± 3.80	<0.001
TyG index	8.9 ± 0.71	8.6 ± 0.65	<0.001
Smoking status (smoker), n (%)	1270 (31.7%)	1335 (10.9%)	<0.001
Drinking status (drinker), n (%)	1597 (39.8%)	1852 (15.1%)	<0.001

WC: waist circumference; SBP: systolic blood pressure; DBP: diastolic blood pressure; MAP: mean arterial pressure; FPG: fasting plasma glucose; 2hPG: 2-hour postprandial glucose; HbA1c: haemoglobin A1c; SUA: serum uric acid; TG: triglyceride; TC: total cholesterol; HDL-C: high-density lipoprotein cholesterol; LDL-C: low-density lipoprotein cholesterol; BUN: blood urea nitrogen; eGFR: estimated glomerular filtration rate; BMI: body mass index; TyG index: triglyceride-and-glucose index. Continuous data are presented as means ± standard deviations, and categorical variables are presented as numbers (percentages).

Relationship between SUA and FPG stratified by the presence of hyperuricaemia

Generalised smoothing splines showed an inverted U-shaped relationship between SUA and FPG in total (Fig. 2A-C) and normouricaemic (Fig. 2D-F) population in both crude and adjusted models (all $p<0.001$). In the hyperuricaemic population, no significant relationship between SUA and FPG was observed in crude model (Fig. 2G, $p=0.077$); however, the relationship became significant in partially (Fig. 2H, $p=0.041$) and fully adjusted model (Fig. 2I, $p=0.035$).

Threshold effects and regression analysis of FPG on SUA

As shown in Table II, the significant threshold effect of FPG on SUA was found to be at 6.1 mmol/L for normouricaemic population in either partially or fully adjusted model. In partially adjusted model, the regression coefficient (*B*) was 9.8 (95% confidence interval [CI]: 8.0–11.7, $p<0.001$) for FPG <6.1 mmol/L, while -4.7 (95% CI: -5.6– -3.7, $p<0.001$) for FPG ≥6.1 mmol/L. However, in fully adjusted model (with further adjustment for TyG index), the regression coefficient was weakened to be 7.3 (95% CI: 5.3–9.2, $p<0.001$) and -5.6 (95% CI: -6.6– -4.6, $p<0.001$) for FPG below and above 6.1 mmol/L, respectively. Similarly, the threshold point of FPG on SUA was found to be at 7.5 mmol/L for hyperuricaemic population. In partially adjusted model, the regression coefficient was 3.3 (95% CI: 0.6–5.9, $p=0.016$) and -4.4 (95% CI: -8.1– -0.6, $p<0.001$) for FPG below and above 7.5 mmol/L, respectively. But in fully adjusted model, the linear relationship between SUA and FPG turned non-significant for FPG <7.5 mmol/L (*B*= -0.2, 95% CI: -3.1–2.7, $p=0.894$) while remained significant for FPG ≥7.5 mmol/L (*B*= -5.3, 95% CI: -9.0 – -1.6, $p=0.005$).

Mediation analysis of insulin resistance on the relationship between SUA and FPG

Figure 3 shows the results on mediation analysis. In the normouricaemic population with FPG <6.1 mmol/L and hyperuricaemic population with FPG <7.5 mmol/L, the association between SUA and FPG was consistently found to be mediated by TyG index, with the mediation effect calculated to be 24.6% (bootstrap 95% CI: 1.608–3.302) and 100% (bootstrap 95% CI: 1.851–4.687), respectively. However, TyG index exhibited no significant moderating effect on the association between SUA and FPG (Suppl. Table S2).

Discussion

Our study showed the following major findings: 1. an inverted U-shaped relationship between SUA and FPG was observed in the normouricaemic and hyperuricaemic population without known diabetes; and 2. in the ascending segment of the curve, the relationship was dependent on insulin resistance with the presence of hyperuricaemia, whereas it was attenuated in the population without hyperuricaemia.

Previous studies observed that with the gradual elevation of blood glucose, SUA tended to rise and then fall (7-12). As a supplementation to the observation, we found that SUA had an inverted U-shaped relationship with FPG in both the normouricaemic and hyperuricaemic population. We further observed that the turning point of FPG in normouricaemic population was 6.1 mmol/L, which was consistent with the diagnostic cut-off point for impaired fasting glucose.

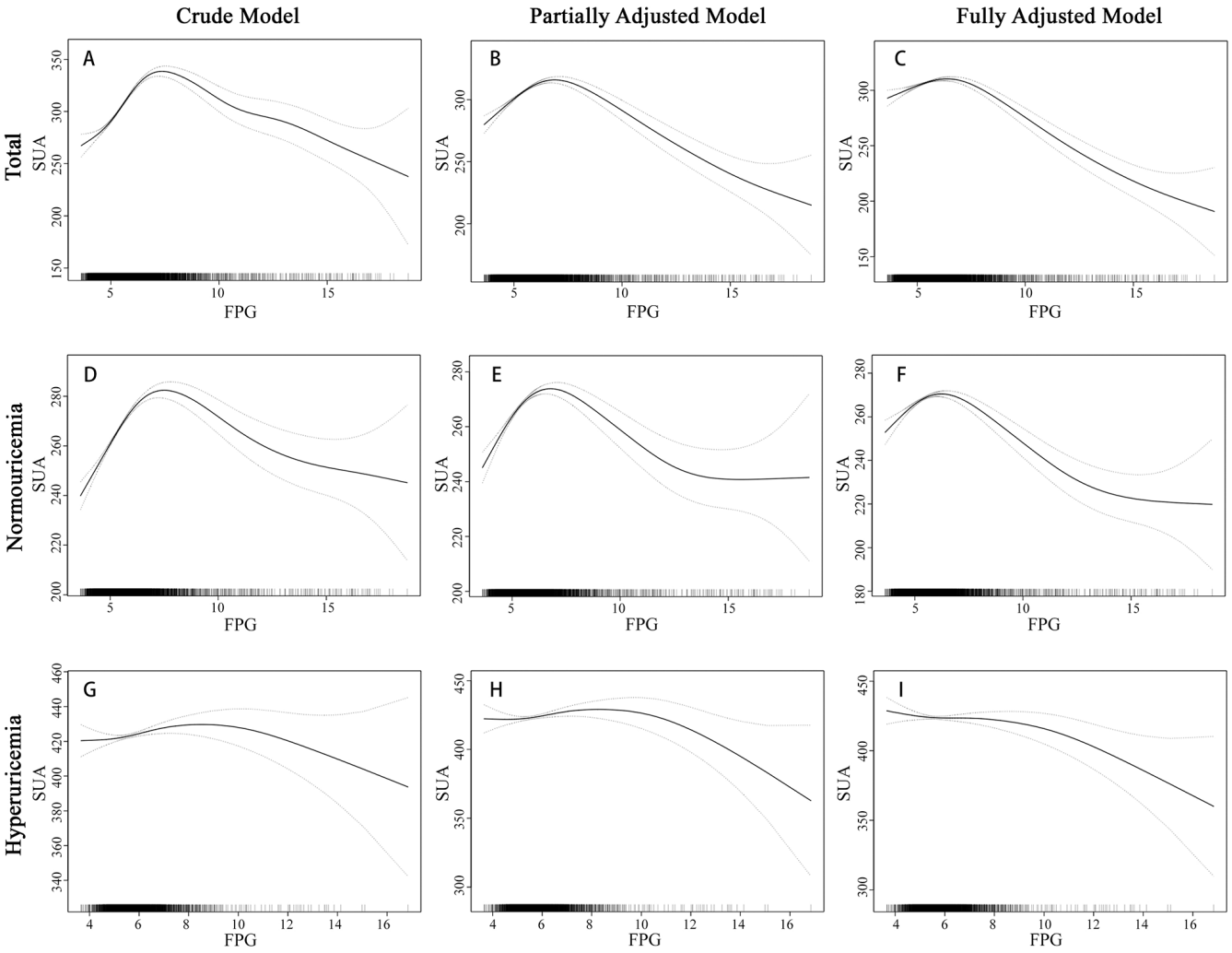

Fig. 2. Relationship between serum uric acid and fasting plasma glucose (solid lines) and their 95% confidence intervals (dashed lines) in total (**A**, **B** and **C**), normouricaemic (**D**, **E** and **F**) and hyperuricaemic (**G**, **H** and **I**) participants.
SUA: serum uric acid; FPG: fasting plasma glucose.
Figure A, D and G were in crude model; Figure B, E and H were in partially adjusted model; Figure C, F and I were in fully adjusted model. In total and normouricaemic participants, inverted U-shaped curves between SUA and FPG were significant (p<0.001) in all three models, while in hyperuricaemic participants, p-value was 0.077, 0.041 and 0.035, respectively.

In the hyperuricaemic population, the turning point of FPG was 7.5 mmol/L. It is speculated that the right shifting of the turning point might be attributed to the worse renal handling of glucose and urate in this population group who were more likely under metabolic disorders.

Our study showed that at the right turning point of FPG, SUA showed an inverse association with FPG. This could be explained by the following mechanism. It has been suggested that the downward trend of SUA responding to continuous increase of FPG was an affiliated effect due to the renal compensation of hyperglycaemia instead of the decreased production of urate. Normally, almost all the filtered glucose would be reabsorbed; however, when blood glucose rises and exceeds the maximum reabsorption capacity of the kidney (renal threshold for glucose excretion), glucose is excreted into the urine (14). Glucose transporter 9, a high-capacity urate transporter, is also a facilitative glucose transporter (31-34). Increased glucose in the urine could accelerate glucose transporter 9-mediated urate efflux across the apical membrane of the proximal tubule (13).

In our study, more analyses had been conducted on the ascending segment of the relationship curve. This is, on the one hand, because of the evidence that the majority of participants was distributed in this region [normouricemia: 82.7% (10,169/12,289); hyperuricaemia: 95.0% (3,808/4,008)]. On the other hand, participants in the ascending segment region were under better metabolic conditions compared with those in the descending segment region (Supplementary table III). Therefore, an enriched understanding about the mechanisms underlined for the ascending segment would benefit more in the prevention and management of hyperuricaemia.

As evidenced by the mediation analysis, insulin resistance, which was assessed by TyG index, may mediate the positive relationship between SUA and FPG. This could be supported by the following explanations. Firstly, in the

Table II. Threshold effects of fasting plasma glucose on serum uric acid in normouricaemic and hyperuricaemic participants.

	Normouricaemia					Hyperuricaemia				
	Inflection point of FPG	n	SUA (mean±SD)	*B* (95% CI)	*p*-value	Inflection point of FPG	n	SUA (mean±SD)	*B* (95% CI)	*p*-value
Crude model	<6.4 mmol/L	10,930	265±51.6	15.1(13.4-16.7)	<0.001	<7.5 mmol/L	3,803	424±59.5	3.6(1.0-6.2)	0.007
	≥6.4 mmol/L	1,359	278±49.4	-3.2(-4.3- -2.1)	<0.001	≥7.5 mmol/L	205	427±63.1	-3.0(-6.8-0.9)	0.132
Difference between 2 stratums				-18.3(-20.5- -16.0)	<0.001				-6.6(-11.9- -1.2)	0.016
p-value for likelihood ratio test					<0.001					0.016
Predicted SUA level at inflection point			281.5±0.92[a]					430.2±2.60[a]		
Partially adjusted model										
	<6.1 mmol/L	10,169	265±51.7	9.8(8.0-11.7)	<0.001	< 7.5 mmol/L	3,803	424±59.5	3.3(0.6-5.9)	0.016
	≥6.1 mmol/L	2,120	278±49.1	-4.7(-5.6- -3.7)	<0.001	≥ 7.5 mmol/L	205	427±63.1	-4.4(-8.1- -0.6)	0.022
Difference between 2 stratums				-14.5(-16.8- -12.2)	<0.001				-7.6(-12.9- -2.4)	0.004
p-value for likelihood ratio test					<0.001					0.004
Predicted SUA level at inflection point				278.5±0.82[a]					430.2±2.60[a]	
Fully adjusted model	<6.1 mmol/L	10,169	265±51.7	7.3(5.3-9.2)	<0.001	< 7.5 mmol/L	3,803	424±59.5	-0.2(-3.1-2.7)	0.894
	≥6.1 mmol/L	2,120	278±49.1	-5.6(-6.6- -4.6)	<0.001	≥ 7.5 mmol/L	205	427±63.1	-5.3(-9.0- -1.6)	0.005
Difference between 2 stratums				-12.8(-15.1- -10.5)	<0.001				-5.1(-10.4-0.2)	0.060
p-value for likelihood ratio test					<0.001					0.060
Predicted SUA level at inflection point				278.5±0.82[a]					430.2±2.60[a]	

SUA: serum uric acid; FPG: fasting plasma glucose; SD: standard deviation; CI: confidence interval.
[a] Data are presented as mean ± standard error.

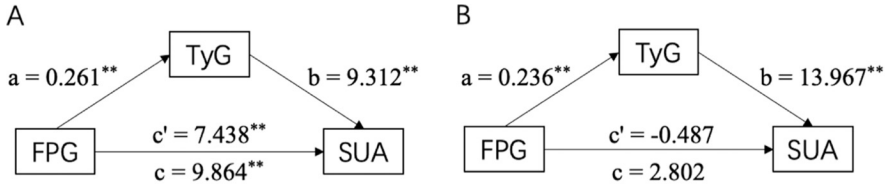

Fig. 3. Triglyceride-and-glucose index as a mediator of the relationship between serum uric acid and fasting plasma glucose in normouricaemic participants with fasting plasma glucose below 6.1 mmol/L (A) and hyperuricaemic participants with fasting plasma glucose below 7.5 mmol/L (B).
TyG: triglyceride-and-glucose; SUA: serum uric acid; FPG: fasting plasma glucose.
***p*<0 .001; a×b, indirect effect; c, total effect; c', direct effect.
A: in normouricaemic participants with FPG below 6.1 mmol/L, inclusion of TyG index in the model reduced the strength of the direct relationship between SUA and FPG by 24.6% [(0.261×9.312) / 9.864] (a×b = 2.426, bootstrap 95%CI: 1.608–3.302).
B: in hyperuricaemic participants with FPG below 7.5 mmol/L, the indirect effect was significant (a×b = 3.289, bootstrap 95%CI: 1.851–4.687), but neither total nor direct effect was significant.
This analysis was adjusted by age, gender, body mass index, waist circumference, mean arterial pressure, triglyceride, total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, blood urea nitrogen, estimated glomerular filtration rate, and drinking and smoking statuses.

context of insulin resistance, increased insulin exerted an anti-uricosuric effect via increased expression of reabsorptive urate exchanger urate transporter 1 and decreased expression of secretory urate exchanger ATP-binding cassette subfamily G member 2 in the proximal tubular (31, 35). Secondly, insulin resistance acted on lipid profiles indirectely, which may contribute to increased production of uric acid (36, 37). Finally, increased insulin promoted the activation of xanthine dehydrogenase and purine nucleoside phosphorylase, resulting in accelerated uricogenesis (38).

However, the mediating effect of insulin resistance on the link between SUA and FPG differed in the normouricaemic and hyperuricaemic population. The partial mediating role of TyG index on the link between SUA and FPG in the normouricaemic population could be interpreted as that blood glucose contributed to the elevation of SUA partially independent on insulin resistance. We speculated that increased purine biosynthesis and turnover with its attendant increase in SUA was the result of increased activity of the hexose monophosphate shunt which can be conceptually linked to higher blood glucose levels (19). In hyperuricaemic stage, FPG did not directly contribute to the increased SUA, which indicated that the association between SUA and FPG was dependent on insulin resistance. Thus, the improvement of insulin resistance but not the control of blood glucose alone would benefit the management of SUA. This finding could be also supported by other observations. For example, troglitazone, an insulin sensitising agent, could decrease SUA in both type 2 diabetics and non-diabetics (19), and amelioration of hyperinsulinaemia and insulin resistance by either weight reduction or troglitazone significantly decreased SUA in overweight hypertensive patients (21).

Our study had a large sample size with appropriate representativeness. Moreover, our study restricted participants to those without known diabetes, which may minimise the influence of anti-

diabetic medications on SUA. Yet our study has several limitations. Firstly, due to the nature of cross-sectional design, we cannot infer causality about the relation between SUA, FPG and TyG index; therefore, longitudinal studies might be required. Secondly, the definition of hyperuricaemia in our study was based solely on spot SUA. This may cause the risk of misclassification of hyperuricaemia because of the failure to repeat the measurement. Finally, although we had controlled for possible confounding variables when analysing the association of SUA with FPG, residual confounding by other unmeasured factors could not be completely excluded.

In conclusion, the positive relationship between SUA and FPG depended on insulin resistance in the hyperuricaemic population with FPG below 7.5 mmol/L, while, it was partially independent on insulin resistance in the normouricaemic population with FPG below 6.1 mmol/L. These results indicate that insulin resistance may affect the relationship between glycometabolism and purine metabolism, in particular in the hyperuricaemic population, highlighting the importance of ameliorating insulin resistance in decreasing SUA.

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