

Research Article

Relationship of Visceral Adiposity Index with New-Onset Hyperuricemia in Hypertensive Patients

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Introduction

In recent years, an increasing trend in the prevalence of hyperuricemia has been observed in epidemiological studies [1,2]. Patients with hyperuricemia sustained increasing risk of gout, cardiovascular diseases (CVD), diabetes and chronic kidney disease (CKD) [3-6]. Hence, the discovery of more modifiable risk factors related to hyperuricemia is important for preventing hyperuricemia and reducing the risk of its related diseases.

Obesity is a major global health challenge and is also an important risk factor for cancer, diabetes and CKD [7-9]. Several studies have suggested that it is not the extent of obesity but the distribution of adiposity tissue that plays a decisive role in the impact of obesity on these diseases [10,11]. In addition, previous study has found that the an increase in visceral adiposity is associated with the higher risk prevalence of hyperuricemia [12].

There are several traditional methods like body mass index (BMI), waist-to-height ratio, waist circumference (WC), waist-to-hip ratio, but none of these can measure visceral adiposity accurately

Abstract

Background: Visceral adiposity index is a new type of indicator that accurately reflects distribution and function of visceral fat. The relation between VAI and new-onset hyperuricemia remains largely understudied.

Purpose: This study sought to further investigate the prospective association between VAI and the risk of hyperuricemia by examining possible effect modifies in hypertensive patients.

Methods: We enrolled 10,513 hypertensive patients with normal uric acid (UA) concentrations (<357 $\mu\text{mol/L}$ (6 mg/dL)) who participated the UA Sub-study of the China Stroke Primary Prevention Trial (CSPPT). Our primary outcome was new-onset hyperuricemia, which was defined as a UA concentration ≥ 417 $\mu\text{mol/L}$ (7 mg/dL) in men or ≥ 357 $\mu\text{mol/L}$ (6 mg/dL) in women at the exit visit.

Results: Over a median follow-up of 4.4 years, 1,642 (15.6%) participants developed new-onset hyperuricemia. When VAI was assessed as quartiles, a significantly higher risk of new-onset hyperuricemia was found in participants in quartile 4 (≥ 2.98 ; odds ratio, 1.17; 95% CI: 1.01-1.36) compared with those in quartile 1-3 (<2.98). Furthermore, we discovered that the positive relation was independent of abnormal VAI components or numbers of abnormal VAI components (all P-interactions > 0.05).

Conclusion: There was a positive relationship between baseline VAI and the risk of new-onset hyperuricemia in a sample of Chinese hypertensive individuals.

Keywords: Visceral adiposity index; Uric acid; New-onset hyperuricemia

[13]. The visceral adiposity index (VAI) is as accurate as magnetic resonance imaging (the gold standard method) in measuring visceral adiposity [14], and therefore, can be used as a valuable indicator of lipid accumulation and visceral adipose function for its convenience and accuracy. However, several cross-sectional studies [15,16] and only one prospective study [17] have evaluated the association between VAI and hyperuricemia, and reported inconsistent findings. Furthermore, few studies have been conducted in hypertensive population, who are proved to be at high risk for hyperuricemia [18].

To address the aforementioned gaps in the existing literature, we aimed to further investigate the prospective association between VAI and the risk of hyperuricemia by examining possible effect modifies in hypertensive patients who joined the UA Sub-study of the China Stroke Primary Prevention Trial (CSPPT) [19].

Methods

Study design and population

The study procedures have been described in previous studies [19-23], and are therefore only briefly explained here. The CSPPT

was a multi-community, randomized, double-blind controlled trial with 20,702 hypertensive adults in 32 communities in Jiangsu and Anhui provinces of China, which was conducted from May 19, 2008 to August 24, 2013.

The UA sub-study of the CSPPT enrolled 15,364 eligible participants with complete data on UA and without the usage of UA-lowering drugs at baseline from 20 communities in Jiangsu province. The current study is a post-hoc analysis of the UA Sub-study. The flow of the participants is presented in Supplemental Figure 1.

Intervention and follow-up

Eligible participants were randomly assigned, in a 1:1 ratio, to one of two treatment groups: a daily oral dose of one tablet containing 10mg enalapril and 0.8mg folic acid (single pill combination, the enalapril-folic acid group), or a daily oral dose of one tablet containing 10mg enalapril only (the enalapril group).

Participants were scheduled for followed up every three months. At each follow-up visit, BP was measured; study drug adherence, concomitant medication use, adverse events and possible endpoint events were documented by trained research staff and physicians. During the trial period, if blood pressure (BP) was not adequately controlled, other classes of anti-hypertensive medications, mostly nitrendipine or hydrochlorothiazide, could be prescribed concomitantly. At the exit visit, final blood samples were collected and assessed.

Anthropometric measurements

Height was measured without shoes to the nearest 0.1 cm on a portable stadiometer. Weight was measured in light indoor clothing without shoes to the nearest 0.1 kg. BMI was calculated as weight (kilograms)/height (meters) squared. WC was measured as the minimum circumference between the inferior margin of the ribcage and the crest of the ileum [24-26].

Laboratory assays

Serum concentrations of UA, fasting glucose, total homocysteine (tHcy) and lipids were measured with automatic analyzers (Beckman Coulter) at the core laboratory of the National Clinical Research Center for Kidney Disease, Nanfang Hospital, Guangzhou, China. The estimated glomerular filtration rate (eGFR) was calculated using the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equation [27].

Outcomes

The primary outcome was new-onset hyperuricemia in hypertensive participants with normal UA concentrations ($<357\mu\text{mol/L}$ (6mg/dL)) at baseline. Hyperuricemia was defined as a UA concentration $\geq 417\mu\text{mol/L}$ (7mg/dL) in men or $\geq 357\mu\text{mol/L}$ (6mg/dL) in women [19,28,29].

The secondary outcome was change in UA concentrations, defined as UA concentrations at the exit visit minus that at baseline.

Major definitions

The VAI, a reliable index based on WC, BMI, TG and HDL-C, was calculated using the following formulas 14:

Abnormal VAI components were identified as the presence of any of the following one components 30, 31: (1) higher BMI (BMI

$\geq 28\text{ kg/m}^2$); (2) higher WC (WC $\geq 85\text{ cm}$ for females and $\geq 90\text{ cm}$ for males); (3) elevated TG ($\geq 1.7\text{ mmol/L}$); (4) lower HDL-C ($<1.04\text{ mmol/L}$ for males and $<1.30\text{ mmol/L}$ for females).

The Chinese VAI (CVAI) was estimated as follows: Males: $-267.93 + 0.68*\text{age} + 0.03*\text{BMI} + 4.00*\text{WC} + 22.00*\text{Log}_{10}\text{TG} - 16.32*\text{HDL-C}$; Females: $-187.32 + 1.71*\text{age} + 4.23*\text{BMI} + 1.12*\text{WC} + 39.76*\text{Log}_{10}\text{TG} - 11.66*\text{HDL-C}$ 32.

Statistical analyses

Baseline characteristics of study population are expressed as mean \pm standard deviation (SDs) for continuous variables and as frequencies and percentages for categorical variables, respectively. To assess whether there were significant differences in baseline levels of participants by VAI quartiles, we used analysis of variance tests for continuous variables or chi-square tests for categorical variables.

The relationship of baseline VAI with primary and secondary outcomes were examined using multivariable logistic regression models and generalized linear regression models, respectively, without and with adjustment for covariates including age, sex, treatment group, UA, fasting glucose, total cholesterol, total homocysteine (tHcy), estimated glomerular filtration rate (eGFR), SBP, smoking and drinking status, use of antihypertensive drugs, as well as time-averaged SBP during treatment period in Model 2; and all the variables in Model 2 plus BMI, WC, TG/HDL-C ratio at baseline in Model 3. As additional exploratory analysis, possible modifications on the association between VAI and new-onset hyperuricemia were also evaluated by stratified analyses and interaction testing.

A two-tailed $P < 0.05$ was considered to be statistically significant in all analyses. Statistical analyses were performed using R software, version 3.6.3 (<http://www.R-project.org/>).

Results

Study participants and baseline characteristics

A total of the 10,513 participants with complete data on baseline VAI and exit UA, who were not using UA lowering drugs during the follow up period, as well as whose baseline UA levels were $<357\mu\text{mol/L}$ (6mg/dL) in the UA Sub-study of CSPPT (Supplemental Figure 1) were included in the final analysis.

Baseline characteristics of the study participants by VAI quartiles are shown in Table 1. The mean age of the participants was 59.4 ± 7.4 years; 3317 (31.6%) were men. The median baseline VAI was 1.87 (interquartile range: 1.18-2.98). Participants with higher VAI were more likely to be females and younger; tend to be current smoker and alcohol drinker; had higher BMI, WC, fasting glucose, TG, TC and eGFR levels, as well as higher time-averaged SBP during the treatment period; lower HDL-C, tHcy, folate levels; higher frequency usage of antihypertensive drugs, glucose-lowering drugs; and higher prevalence of self-reported diabetes and hyperlipidemia at baseline.

Additionally, participants with higher baseline VAI had a higher frequency in the use of glucose-lowering drugs and antiplatelet drugs during the treatment period (Supplemental Table 1).

Relationship of VAI level with study outcome

During a median follow-up duration of 4.4 years, a total of 1663 (15.7%) participants developed new-onset hyperuricemia.

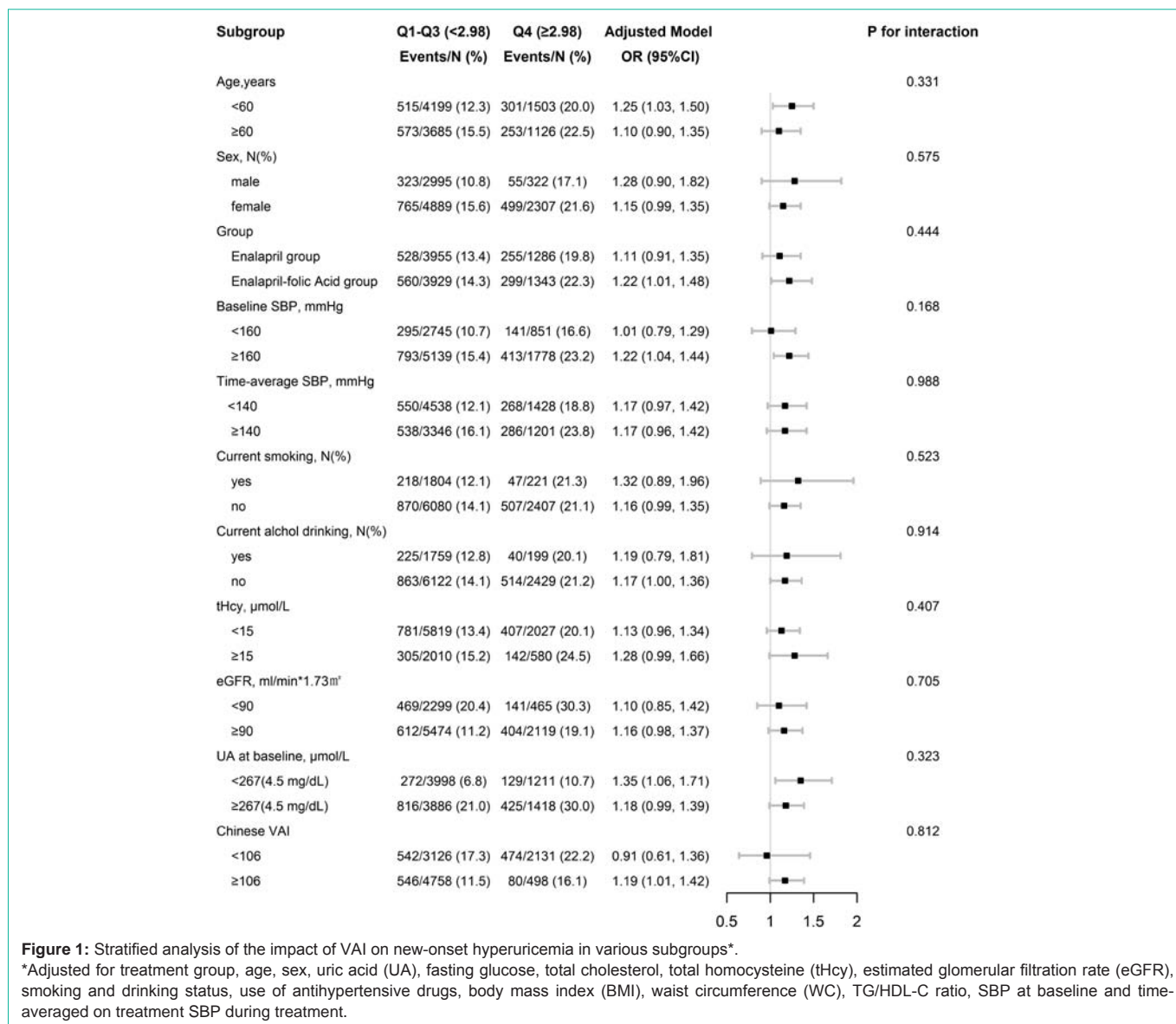


Figure 1: Stratified analysis of the impact of VAI on new-onset hyperuricemia in various subgroups*.
 *Adjusted for treatment group, age, sex, uric acid (UA), fasting glucose, total cholesterol, total homocysteine (tHcy), estimated glomerular filtration rate (eGFR), smoking and drinking status, use of antihypertensive drugs, body mass index (BMI), waist circumference (WC), TG/HDL-C ratio, SBP at baseline and time-averaged on treatment SBP during treatment.

Subsequently, participants were stratified into quartiles according to VAI (quartile 1, lowest; quartile 4, highest). And when we used the lowest quartile 1 (Q1: <1.18) as a reference, the ORs for the second (Q2: 1.18-1.87), third (Q3: 1.87-2.98), and fourth quartiles (Q4: ≥2.98) of (95%CI) for participants were 1.10 (0.91-1.32), 1.18 (0.97-1.43), and 1.33 (1.06-1.65), respectively (P for trend = 0.010).

Consistently, higher risk of new-onset hyperuricemia (OR, 1.27; 95% CI: 1.12-1.45) was discovered in participants in quartile 4 of VAI level (≥ 2.98) compared with those in quartile 1-3 (< 2.98). Moreover, further adjustment for BMI, WC, TG/HDL-C ratio did not substantially affect the relationship of higher VAI level (≥ 2.98) with new-onset hyperuricemia (OR, 1.17; 95% CI: 1.01-1.36) (Table 2). The similar results were found for the secondary outcome (Table 3). The similar results were also observed when UA concentrations <417 μmol/L for male and <357 μmol/L for female at baseline were included the analysis (Supplemental Tables 2 and 3).

Of note, further adjustment for the use of glucose-lowering

drugs and antiplatelet drugs during the treatment period also did not significantly change the results (Supplemental Table 4).

Subgroup analysis by single VAI components

Subgroup analyses were conducted to examine whether the positive association confounded by single VAI components (Table 4). Then, we found that the positive relation was consistent in participants with or without higher BMI, higher WC, elevated TG and decreased HDL-C and there were no significant interactions between VAI and single VAI components or abnormal numbers of VAI components (≤1, 2, and ≥3) on new-onset hyperuricemia (all P for interactions > 0.05) (Table 4).

Stratified analyses by other potential effect modifiers

Stratified analyses were performed using several identified risk factors to further assess the relationship of VAI (Figure 1) with the risk of new-onset hyperuricemia. None of the variables, including age (<60 vs. ≥60 years), sex (male vs. female), treatment group (enalapril

Table 1: Characteristics of study participants by quartiles of visceral adiposity index.

Variables	Visceral adiposity index				P value
	Q1 (<1.18)	Q2 (1.18-<1.87)	Q3 (1.87-<2.98)	Q4 (≥2.98)	
N	2628	2628	2628	2629	
Age, y	60.0 ± 7.6	59.3 ± 7.5	59.3 ± 7.4	59.1 ± 7.2	<0.001
Male, n (%)	1637 (62.3)	837 (31.8)	521 (19.8)	322 (12.2)	<0.001
Waist circumference, cm	79.8 ± 8.4	83.8 ± 9.1	86.8 ± 8.9	89.2 ± 8.5	<0.001
Body mass index, kg/m ²	23.7 ± 3.0	25.1 ± 3.3	26.3 ± 3.4	27.0 ± 3.4	<0.001
Visceral adiposity index	0.8 ± 0.2	1.5 ± 0.2	2.4 ± 0.3	4.8 ± 3.9	<0.001
Current smoking	971 (36.9)	512 (19.5)	321 (12.2)	221 (8.4)	<0.001
Current alcohol drinking	1015 (38.6)	455 (17.3)	289 (11.0)	199 (7.6)	<0.001
Self-reported diabetes	48 (1.8)	82 (3.1)	101 (3.8)	169 (6.4)	<0.001
Self-reported hyperlipidemia	35 (1.3)	47 (1.8)	87 (3.3)	100 (3.8)	<0.001
BP, mmHg					
Baseline SBP	168.8 ± 20.6	168.4 ± 20.9	169.1 ± 21.3	169.5 ± 20.3	0.32
Baseline DBP	95.2 ± 12.1	94.6 ± 11.9	94.9 ± 11.6	95.1 ± 11.6	0.299
SBP during treatment period	139.1 ± 10.8	138.9 ± 10.7	139.3 ± 10.9	139.8 ± 10.9	0.014
DBP during treatment period	83.3 ± 7.2	83.1 ± 7.2	83.1 ± 7.0	83.4 ± 7.0	0.33
Laboratory results					
Total cholesterol, mmol/L	5.6 ± 1.1	5.7 ± 1.1	5.8 ± 1.2	5.8 ± 1.3	<0.001
Folate, ng/mL	7.7 ± 3.3	7.8 ± 3.2	7.9 ± 3.4	7.5 ± 3.0	<0.001
Fasting glucose, mmol/L	5.8 ± 1.4	6.0 ± 1.7	6.1 ± 1.9	6.4 ± 2.3	<0.001
Triglycerides, mmol/L	0.9 ± 0.2	1.3 ± 0.3	1.7 ± 0.4	2.7 ± 2.1	<0.001
HDL-C, mmol/L	1.6 ± 0.4	1.4 ± 0.3	1.3 ± 0.2	1.1 ± 0.2	<0.001
TG/HDL-C ratio	0.8 ± 0.4	1.2 ± 0.6	1.5 ± 1.0	2.1 ± 2.2	<0.001
Total homocysteine, μmol/L	14.7 ± 8.9	13.9 ± 7.9	14.0 ± 8.6	13.7 ± 8.0	<0.001
eGFR, mL/min/1.73m ²	93.6 ± 11.1	93.6 ± 11.7	95.1 ± 11.6	98.6 ± 12.0	<0.001
UA, μmol/L	266.6 ± 52.3	261.3 ± 52.7	263.4 ± 51.3	268.4 ± 51.4	<0.001
Medication use, n (%)					
Antihypertensive drugs	1007 (38.3)	1214 (46.2)	1328 (50.5)	1438 (54.7)	<0.001
Glucose-lowering drugs	30 (1.1)	35 (1.3)	55 (2.1)	72 (2.7)	<0.001
Antiplatelet drugs	93 (3.5)	85 (3.2)	89 (3.4)	94 (3.6)	0.901

Variables are presented as Mean ± SD or n (%).

Abbreviations: BP: Blood Pressure; DBP: Diastolic Blood Pressure; SBP: Systolic Blood Pressure; eGFR: estimated Glomerular Filtration Rate; UA: Uric Acid; TG: Triglycerides; HDL-C: High Density Lipoprotein Cholesterol.

group vs. enalapril-folic acid group), SBP (<160 vs. ≥160 mmHg), tHcy (<15 vs. ≥15 μmol/L), eGFR (<90 vs. ≥90 mL/min/1.73m²), current smoking status (yes vs. no), UA (<267 vs. ≥267 μmol), Chinese VAI (median, <106 vs. ≥106), current alcohol drinking (yes vs. no) at baseline and time-averaged SBP (<140 vs. ≥140 mmHg) during treatment, significantly modified the association between VAI and the risk of new-onset hyperuricemia in hypertensive patients (all P for interactions > 0.05) (Figure 1).

Discussion

The current study demonstrates that baseline VAI was positively associated with the risk of new-onset hyperuricemia during a median follow-up of 4.4 years in Chinese hypertensive patients. The positive relationship was independent of VAI components (BMI, WC, TG and HDL-C).

To our knowledge, inconsistent results have been reported regarding the relationship of VAI with hyperuricemia in several cross-sectional studies. Dong et al. found that there was a significant positive relation of the VAI with hyperuricemia in the Chinese populations [15]. In contrast, Liu et al. reported that VAI was not associated with the prevalence of hyperuricemia among Chinese population [16]. Only a prospective cohort study of 1936 healthy workers aged 6 to 82 years in Mexico had been conducted to examine the association between VAI and the risk of hyperuricemia, and showed that individuals in the highest VAI quartile had higher odds for hyperuricemia compared with individuals from the lowest quartile [17]. However, this study only adjusted for age, alcohol consumption, smoking status and physical activity, and did not consider the effect of other important confounders. As such, the study could not provide an accurate measurement for the independent relation of VAI with

Table 2: The association between baseline visceral adiposity index and new-onset hyperuricemia.

Visceral adiposity index	Events/N (%)	Model 1		Model 2		Model 3	
		OR (95%CI)	P value	OR (95%CI)	P value	OR (95%CI)	P value
Quartiles							
Q1 (<1.18)	276/2628 (10.5)	ref.		ref.		ref.	
Q2 (1.18-<1.87)	365/2628 (13.9)	1.12 (0.94, 1.34)	0.205	1.16 (0.97, 1.40)	0.107	1.10 (0.91, 1.32)	0.327
Q3 (1.87-<2.98)	447/2628 (17.0)	1.25 (1.04, 1.49)	0.015	1.30 (1.08, 1.57)	0.005	1.18 (0.97, 1.43)	0.106
Q4 (≥2.98)	554/2629 (21.1)	1.42 (1.19, 1.69)	<0.001	1.52 (1.26, 1.83)	<0.001	1.33 (1.06, 1.65)	0.012
P for trend		<0.001		<0.001		0.01	
Categories							
Q1-Q3 (<2.98)	1088/7884 (13.8)	ref.		ref.		ref.	
Q4 (≥2.98)	554/2629 (21.1)	1.23 (1.09, 1.40)	<0.001	1.27 (1.12, 1.45)	<0.001	1.17 (1.01, 1.36)	0.039

Model 1: Adjusted for age, sex and uric acid (UA) at baseline.

Model 2: Adjusted for age, sex, UA, fasting glucose, total cholesterol (TC), total homocysteine (tHcy), estimated glomerular filtration rate (eGFR), systolic blood pressure (SBP), smoking and drinking status, use of antihypertensive drugs at baseline, treatment group, and mean SBP during the treatment period.

Model 3: Adjusted for the variables in model 2 plus body mass index (BMI), waist circumference (WC), TG/HDL-C ratio.

Table 3: The association between baseline visceral adiposity index and change in uric acid concentrations.

Visceral adiposity index	UA change, $\mu\text{mol/L}$	Model 1		Model 2		Model 3	
	Mean \pm SD	β (95%CI)	P value	β (95%CI)	P value	β (95%CI)	P value
Quartiles							
Q1 (<1.18)	40.7 \pm 64.4	ref.		ref.		ref.	
Q2 (1.18-<1.87)	41.8 \pm 62.8	5.53 (2.02, 9.04)	0.002	6.65 (3.12, 10.17)	<0.001	4.47 (0.86, 8.08)	0.015
Q3 (1.87-<2.98)	42.1 \pm 65.5	8.81 (5.19, 12.43)	<0.001	10.40 (6.72, 14.08)	<0.001	6.25 (2.28, 10.21)	0.002
Q4 (≥2.98)	42.2 \pm 66.9	12.12 (8.39, 15.84)	<0.001	14.63 (10.72, 18.54)	<0.001	8.32 (3.49, 13.15)	<0.001
P for trend		<0.001		<0.001		<0.001	
Categories							
Q1 (<1.18)	40.7 \pm 64.4	ref.		ref.		ref.	
Q2-Q4 (≥1.18)	42.1 \pm 65.1	6.64 (3.76, 9.52)	<0.001	9.89 (6.83, 12.95)	<0.001	5.39 (2.08, 8.71)	0.001

*Change in uric acid concentrations was defined as the uric acid concentration at the exit visit minus that at baseline;

Model 1: Adjusted for age, sex, and uric acid (UA) at baseline.

Model 2: Adjusted for age, sex, UA, fasting glucose, total cholesterol (TC), total homocysteine (tHcy), estimated glomerular filtration rate (eGFR), systolic blood pressure (SBP), smoking and drinking status, use of antihypertensive drugs at baseline, treatment group, and mean SBP during the treatment period.

Model 3: Adjusted for the variables in model 2 plus body mass index (BMI), waist circumference (WC), TG/HDL-C ratio.

hyperuricemia.

Of note, a CVAI was also created in a previous study in Chinese [32]. As were reported, VAI was significantly correlated with visceral adipose volume measured by MRI, while CVAI was well associated with visceral adipose area measured by CT [32,33]. Base on a large sample of individuals, comprehensive adjustments of major traditional risk factors for hyperuricemia and the components of VAI and CVAI, we discovered that VAI levels was prospective positively associated with the risk of new hyperuricemia in patients with hypertension. Moreover, the positive relationship persisted in those with or without higher BMI, higher WC, elevated TG, decreased HDL-C and elevated CVAI. Therefore, our results suggest that VAI can be used as both an indicator of adipose tissue distribution and a functional indicator to assess the risk of hyperuricemia, independent of BMI, WC, TG, HDL-C or even CVAI.

The potential mechanisms by which higher VAI increases the risk of hyperuricemia is unclear, but it is biologically plausible. Many studies have shown that pathological visceral adipose tissue is considered to be metabolically active. In this condition, adipose

tissue abnormally releases cytokines such as leptin and adiponectin [15,34,35]. Abnormal release of these adipocytokines may cause insulin resistance which may enhance renal proximal tubular reabsorption of UA with a subsequent increase in serum UA levels [36,37]. The increase in visceral adiposity accumulation provides excess free fatty acids - products of fatty breakdown - that may be associated with purine synthesis, which may accelerate UA production [38]. Third, the visceral fat volume may be more accurate in reflecting the visceral fat accumulation. Further research is required to identify mechanisms underlying an association between VAI and new-onset hyperuricemia.

Indeed, several limitations in our study that merit emphasis. First, in this post-hoc analysis, many covariates had been adjusted in the regression models; however, residual confounding from unmeasured or unrecorded factors may work. Second, this post-hoc analysis focused on Chinese hypertensive participates, so the generalizability of these findings to other types of populations remains to be unknown. Third, serum UA levels were measured only at baseline and exit visits. More frequent measurements of serum uric acid levels are needed to

Table 4: Stratified analysis of the impact of VAI on new-onset hyperuricemia by VAI components.

Subgroups [†]	Q1-Q3 (<2.98) Events/N (%)	Q4 (≥2.98) Events/N (%)	Adjusted Model* OR (95% CI)	P for interaction
Higher BMI[†]				0.658
yes	285/1429 (19.9)	232/931 (24.9)	1.12 (0.89, 1.40)	
No	803/6455 (12.4)	322/1698 (19.0)	1.19 (1.00, 1.42)	
Higher WC[†]				0.864
Yes	671/4042 (16.6)	494/2260 (21.9)	1.16 (0.99, 1.35)	
No	417/3842 (10.9)	60/369 (16.3)	1.12 (0.81, 1.56)	
Elevated TG[†]				0.66
Yes	223/1435 (15.5)	518/2445 (21.2)	1.28 (1.05, 1.56)	
No	865/6449 (13.4)	36/184 (19.6)	1.16 (0.77, 1.74)	
Lower HDL-C[†]				0.877
Yes	329/2158 (15.2)	459/2192 (20.9)	1.10 (0.92, 1.33)	
No	759/5726 (13.3)	95/437 (21.7)	1.13 (0.94, 1.35)	
Number of abnormal VAI components[†]				0.932
≤1	578/5053 (11.4)	14/89 (15.7)	1.08 (0.58, 2.03)	
2	332/1945 (17.1)	101/587 (17.2)	1.06 (0.80, 1.39)	
≥3	178/886 (20.1)	439/1953 (22.5)	1.23 (0.98, 1.53)	

*If not stratified, adjusted for age, sex, UA, fasting glucose, total cholesterol (TC), total homocysteine (tHcy), estimated glomerular filtration rate (eGFR), systolic blood pressure (SBP), smoking and drinking status, use of antihypertensive drugs at baseline, treatment group, and mean SBP during the treatment period, body mass index (BMI), waist circumference (WC), TG/HDL-C ratio.

[†] Higher body mass index was defined as BMI ≥28 kg/m²; higher waist circumference was defined as WC ≥80 in females or WC ≥90 in males; elevated triglycerides were defined as TG ≥1.7 mmol/L; lower high-density lipoprotein was defined as HDL-C <1.30 mmol/L in females or HDL-C <1.04 mmol/L in males; number of abnormal VAI components was defined as number of high body mass index, higher circumference, high triglycerides or low high density lipoprotein cholesterol.

more accurately assess the relationship between VAI and new-onset hyperuricemia in the duration. Although there are many limitations, our results serve as the basis for future relevant randomized trials.

Conclusions

In conclusion, our results suggest that higher VAI is significantly associated with increased risk of new-onset hyperuricemia in Chinese hypertensive patients, independent of single VAI components. VAI can be easily measured and applied to clinical practice. Thus, VAI has important implications for primary prevention and early detection of new-onset hyperuricemia.

Declaration

Contributors: Study conception and design: Binyan Wang, Xianhui Qin, Xiping Xu, Shaojie Zhang; Acquisition of data: Binyan Wang, Xianhui Qin; Analysis and interpretation of data: Shaojie Zhang, Xianhui Qin; Drafting of the manuscript: Shaojie Zhang, Xianhui Qin; All authors critically revised the manuscript, gave final approval and agree to be accountable for all aspects of work ensuring integrity and accuracy.

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