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Prevalence and risk factors of hyperuricaemia in non-obese Chinese: a single-centre cross-sectional study

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ABSTRACT

Objectives Hyperuricaemia is closely related to metabolic diseases and is receiving increasing attention from all over the world. This study aimed to investigate the prevalence and factors associated with hyperuricaemia in non-obese Chinese population.

Design Retrospective cross-sectional study.

Setting A large general hospital that can provide health check-ups in Hangzhou, China.

Participants A total of 5731 apparently healthy Chinese adults (2349 men and 3382 women) who took their health check-ups during the year of 2019. Exclusion criteria: (1) those with body mass index ≥24 kg/m^2; (2) those with incomplete anthropometric and biochemical data; (3) those with a history of malignancy and (4) those under urate-lowering treatment.

Primary and secondary outcome measures The prevalence and factors associated with hyperuricaemia in non-obese Chinese adults.

Results Of the 5731 non-obese subjects enrolled, 538 (9.4%) were identified as having hyperuricaemia, specifically 16.3% in men and 4.6% in women. The prevalence of hyperuricaemia markedly increased in women aged above 50 years. The prevalence of hyperuricaemia was significantly higher in metabolically unhealthy participants with normal weight than in metabolically healthy participants with normal weight. Participants with hyperuricaemia showed a higher prevalence of metabolic syndrome and fatty liver disease than participants with normouraemia. Age, waist circumference, estimated glomerular filtration rate, blood urea nitrogen, excessive drinking and fatty liver were associated with hyperuricaemia in both genders.

Conclusion The prevalence of hyperuricaemia was 9.4% in non-obese Chinese adults. Non-obese participants with hyperuricaemia also showed multiple metabolic disorders. We suggest that clinicians pay attention to serum uric acid level in non-obese patients.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This study included a large sample size of participants (more than 5000 adults), which made our findings more convincible.
⇒ This is the first study that has evaluated the prevalence of hyperuricaemia among non-obese adults in China.
⇒ A multivariate logistic model was used to correct selection biases by adjusting for potential confounders.
⇒ It is a single-centre cross-sectional study, and further multicentre cohort studies are needed.
⇒ Patients currently undergoing urate-lowering treatment were excluded, which might cause a selection bias in the prevalence of hyperuricaemia in this study.

INTRODUCTION

Hyperuricaemia, defined as elevated uric acid level in blood, is a metabolic disorder commonly recognised to be closely related to gout and chronic kidney disease.[1] Over the last decade, more and more studies have found that hyperuricaemia is also associated with other metabolic diseases, such as obesity, hypertension, dyslipidaemia and non-alcoholic fatty liver disease (NAFLD).[2–6] Some studies also suggested hyperuricaemia as an independent risk factor for metabolic syndrome and NAFLD.[7 8] Moreover, the prevalence of hyperuricaemia varies across populations and regions. In the USA, approximately 21.4% of adults met the criteria for hyperuricaemia in the first decade of the 21st century, which was 3.2% higher than the proportion reported by National Health and Nutrition Examination Survey (NHANES) 1988–1994.[9] According to a recent meta-analysis, the pooled prevalence of hyperuricaemia was 13.3% in China.[10] A study from Wuhan, China suggested that the prevalence of hyperuricaemia in men rose from 26.1% in 2010 to 34.4% in 2019, and the prevalence of hyperuricaemia in women rose from 5.8% in 2010 to 10.1% in 2019.[11] It is reported that the prevalence of hyperuricaemia was 18.4% and the incidence of hyperuricaemia was 68.58 cases per 1000 person-years of follow-up in Eastern China.[12] The findings above may call for more attention on the health problem of hyperuricaemia from a metabolic perspective, yet entailing further verification across populations.

Many metabolism-related indicators are independent risk factors for hyperuricaemia. Serum levels of triglyceride, total cholesterol, apolipoprotein-B and low-density lipoprotein cholesterol (LDL-C), and the ratio of triglyceride to high-density lipoprotein cholesterol (HDL-C) have been reported to be positively correlated with the serum uric acid level, while the serum HDL-C level inversely.[13] Juraschek *et al* found a fourfold or higher prevalence of hyperuricaemia in individuals who had blood pressure uncontrolled and were exposed to other risk factors of cardiovascular diseases (CVDs).[14]

It is generally believed that obesity is closely associated with metabolism-related diseases, and it increases the risk of developing diabetes, NAFLD and hyperuricaemia. Recently, more and more studies have shifted their attention to metabolic disorders in the non-obese population. Some studies showed that the non-obese population could also present a high prevalence of NAFLD. For example, as we previously reported, the prevalence of NAFLD in a non-obese Chinese population was 7.3%.[15] A study from Japan warned that more than 60% of Japanese subjects with diabetes are non-obese.[16] The findings suggest that it be important to assess metabolic abnormalities in non-obese individuals. So far, there has still been a paucity of studies on hyperuricaemia in the non-obese population.

In this study, we conducted a retrospective cross-sectional analysis on a non-obese Chinese population to evaluate the prevalence of hyperuricaemia and determine its associated factors.

METHODS

Study population

The study population of this cross-sectional study was adults who took their health check-ups at the First Affiliated Hospital, Zhejiang University School of Medicine from 1 January to 31 December 2019. Following the hospital's standard health check-up protocol, all participants received medical history collection, anthropometric measurement, blood examination and abdominal ultrasound examination. For research purpose, we collected these data from their check-up reports and excluded participants meeting the following criteria: (1) those with body mass index (BMI) ≥24 kg/m^2; (2) those with incomplete anthropometric and biochemical data; (3) those with a history of malignancy and (4) those under urate-lowering treatment. A total of 10 908 participants were enrolled in this study, 4120 of whom had a BMI greater than 24 kg/m^2, 684 had incomplete data, 114 had a history of malignancy and 259 took urate-lowering drugs. Finally, this study qualified 5731 participants (including 2349 men and 3382 women) (online supplemental figure S1).

Clinical evaluations

For all the participants undergoing the health check-up, anthropometric parameters including standing height, body weight and waist circumference were measured. Blood pressure was gauged following a standard protocol. For height and weight, participants should be in light clothes with shoes taken off. BMI (kg/m^2) was calculated as the body weight (kg) divided by the standing height (m) squared. Fasting serum samples were obtained for biochemical analysis with a Hitachi 7600 clinical analyser (Hitachi, Tokyo, Japan) in accordance with standard methods. Questions about alcohol intake included frequency of alcohol consumption (per week) and usual amount per day. Questions about smoking history included daily smoking count and years of smoking.

Diagnostic criteria and definitions

BMI was adopted to define obesity. Non-obese was defined as BMI <24 kg/m^2, and obesity is defined as BMI ≥24 kg/m^2. Excessive drinking was defined as alcohol consumption >210 g/week for men or >70 g/week for women. Hyperuricaemia could be diagnosed with the serum uric acid level >420 µmol/L for men or >360 µmol/L for women.[8 17 18] The factor eGFR (estimated glomerular filtration rate) was calculated using the modified MDRD formula, $eGFR = 175 \times Scr^{-1.234} \times (Age)^{-0.179} \times 0.79$ (if women).[19]

In the health check-up, all individuals underwent abdominal ultrasound examination, which was performed by trained ultrasonographists with a Toshiba Nemio 20 ultrasound system (Toshiba, Tokyo, Japan). The criteria for ultrasonic diagnosis of fatty liver were based on those suggested by the Chinese Liver Disease Association.[20]

Metabolic syndrome was defined according to the modified National Cholesterol Education Program Adult Treatment Panel III report.[21] Participants diagnosed with metabolic syndrome must have three or more of the following factors: (1) central obesity, defined as waist circumference >102 cm for men or >88 cm for women; (2) raised serum triglyceride level, defined as triglyceride ≥1.7 mmol/L or specific treatment for this lipid abnormality; (3) reduced HDL-C, defined as HDL-C <1.03 mmol/L for men or <1.29 mmol/L for women; (4) elevated blood pressure, defined as systolic blood pressure ≥130 mm Hg or diastolic blood pressure ≥85 mm Hg, or treatment of previously diagnosed hypertension; and (5) raised fasting blood sugar, defined as fasting blood sugar ≥6.1 mmol/L, or previously diagnosed type 2 diabetes. Metabolically unhealthy participants were defined as those who met the criteria of metabolic syndrome.

Statistical analyses

The statistical analyses were performed using SPSS V.18.0. Continuous variables were presented as mean and 95% CI and compared by Student's t-test or Mann-Whitney U test as appropriate. Categorical variables were compared using the χ^2 test. A stepwise logistic regression approach was introduced to explore the association of hyperuricaemia with anthropometric or biochemical parameters (probability to enter=0.05 and probability to remove=0.10). It was considered that $p<0.05$ (two-tailed test) was statistically significant.

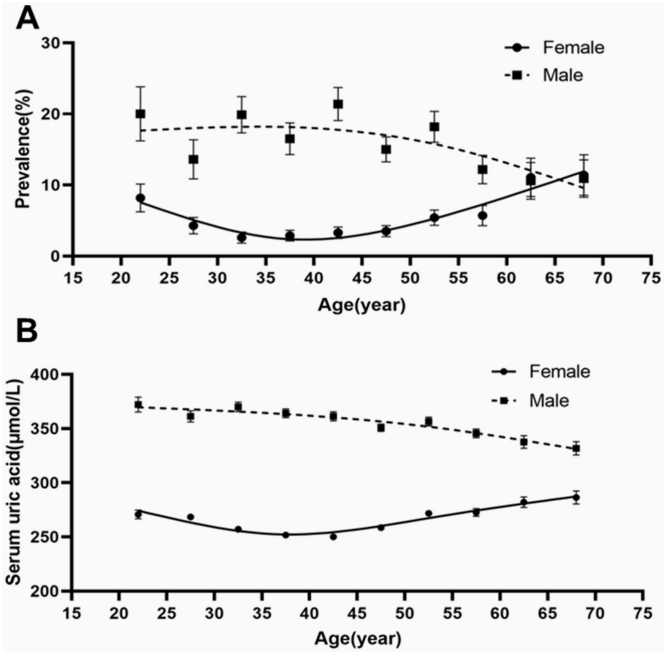

Figure 1 Prevalence of hyperuricaemia (A) and serum uric acid (B) in participants. Data were expressedas mean with 95% CI (error bars).

Patient and public involvement

Patients or the public were not involved in the design, conduct, report or dissemination of our research.

RESULTS

Prevalence of hyperuricaemia in the non-obese population

A total of 5731 non-obese participants (2349 men and 3382 women) with a mean age of 44.6±12.0 years were included in this study. The overall prevalence of hyperuricaemia was 9.4% (16.3% in men and 4.6% in women). In non-obese men, the prevalence of hyperuricaemia was stable before the age of 50 years, and gradually decreased after 50 years. Conversely, in non-obese women, the prevalence of hyperuricaemia decreased with age before the age of 50 years, and gradually increased after 50 years. An interesting finding was that the prevalence of hyperuricaemia in women was even higher than that in men after the age of 65 years figure 1 .

We compared the clinical characteristics of participants with or without hyperuricaemia in both genders (table 1). We found that participants with hyperuricaemia showed greater BMI (22.33 (22.19–22.47) vs 21.87 (21.80–21.94) kg/m^2, p<0.001 in men; 21.64 (21.36–21.92) vs 20.94 (20.88–21.00) kg/m^2, p<0.001 in women) and waist circumference (83.1 (82.6–83.6) vs 81.3 (81.1–81.5) cm, p<0.001 in men; 76.6 (75.5–77.7) vs 74.0 (73.8–74.2) cm, p<0.001 in women), higher diastolic blood pressure (77.2 (76.1–78.3) vs 75.6 (75.1–76.1) mm Hg, p=0.006 in men; 73.9 (72.1–75.7) vs 69.2 (68.8–69.6) mm Hg, p<0.001 in women), and worse lipid profiles than those without hyperuricaemia. Participants with hyperuricaemia also had higher serum levels of alanine aminotransferase (ALT) (26.5 (24.7–28.4) vs 21.4 (20.6–22.3) U/L, p<0.001 in men; 23.2 (18.4–28.0) vs 15.2 (14.9–15.6) U/L, p=0.001 in women), aspartate aminotransferase (AST) (22.5 (21.6–23.5) vs 20.6 (20.1–21.0) U/L, p=0.001 in men; 23.1 (20.5–25.7) vs 18.4 (18.1–18.6) U/L, p=0.001 in women), gamma-glutamyl transpeptidase (41.6 (37.7–45.6) vs 30.1 (29.1–32.9) U/L, p<0.001 in men; 22.9 (19.5–26.3) vs 16.8 (16.2–17.5) U/L, p<0.001 in women), blood urea nitrogen (BUN) (5.37 (5.21–5.53) vs 5.12 (5.07–5.17) mmol/L, p=0.003 in men; 5.07 (4.84–5.30) vs 4.55 (4.51–4.59) mmol/L, p<0.001 in women), and creatinine (86.5 (84.6–88.4) vs 81.2 (80.6–81.8) μmol/L, p<0.001 in men; 63.8 (62.2–65.4) vs 59.5 (59.2–59.8) μmol/L, p<0.001 in women) than participants with normouraemia.

Association of hyperuricaemia with metabolic disorders in the non-obese population

We classified all the non-obese participants into metabolically healthy normal-weight (MHNW) group and metabolically unhealthy normal-weight (MUHNW) group, according to their metabolic status. We found that MUHNW participants had a significantly higher prevalence of hyperuricaemia than MHNW participants. In detail, the prevalence of hyperuricaemia increased from 15.6% in MHNW participants to 26.7% in MUHNW participants in men (p<0.001). Similarly, the prevalence of hyperuricaemia increased from 4.1% in MHNW participants to 16.3% in MUHNW participants in women (p<0.001) (figure 2).

We also analysed the prevalence of metabolic disorders in non-obese individuals with or without hyperuricaemia. We found that the prevalence of metabolic syndrome was significantly higher in participants with hyperuricaemia (male 10.2%, female 16%) than in participants with normouraemia (male 5.4%, female 4%; p<0.001 in both genders). We also found that the prevalence of fatty liver disease was significantly higher in participants with hyperuricaemia (male 30.4%, female 20.5%) than in participants with normouraemia (male 13.8%, female 6.4%; p<0.001 in both genders). Male participants with hyperuricaemia had a higher prevalence of raised triglyceride level and reduced HDL-C than participants with normouraemia. Female participants with hyperuricaemia had a higher prevalence of raised triglyceride level, reduced HDL-C, elevated blood pressure and raised fasting blood sugar than participants with normouraemia (table 2). However, the prevalence of diabetes was not different between the two groups (table 2).

Factors associated with hyperuricaemia among the non-obese population

We adopted a stepwise logistic regression approach to analyse the factors associated with hyperuricaemia. The multivariable model showed that greater waist circumference values (1.057 (1.030 to 1.084) (the data were expressed as OR (95% CI), the same below) in men and 1.038 (1.006 to 1.071) in women), elevated BUN levels (1.114 (1.014 to 1.223) in men and 1.308 (1.137 to 1.505)

Table 1 Clinical characteristics of the study population

Variables	Male			Female		
	Without hyperuricaemia (n=1967)	With hyperuricaemia (n=382)	P value	Without hyperuricaemia (n=3226)	With hyperuricaemia (n=156)	P value
Age (year)	46.5 (46.0 to 47.1)	44.5 (43.3 to 45.7)	0.004	43.4 (43.0 to 43.8)	46.6 (44.3 to 49.0)	0.009
WC (cm)	81.3 (81.1 to 81.5)	83.1 (82.6 to 83.6)	<0.001	74.0 (73.8 to 74.2)	76.6 (75.5 to 77.7)	<0.001
BMI (kg/m^2)	21.87 (21.80 to 21.94)	22.33 (22.19 to 22.47)	<0.001	20.94 (20.88 to 21.00)	21.64 (21.36 to 21.92)	<0.001
SBP (mm Hg)	122.8 (122.1 to 123.5)	124.1 (122.4 to 125.8)	0.159	115.0 (114.4 to 115.6)	122.2 (119.0 to 125.4)	<0.001
DBP (mm Hg)	75.6 (75.1 to 76.1)	77.2 (76.1 to 78.3)	0.009	69.2 (68.8 to 69.6)	73.9 (72.1 to 75.7)	<0.001
ALT (U/L)	21.4 (20.6 to 22.3)	26.5 (24.7 to 28.4)	<0.001	15.2 (14.9 to 15.6)	23.2 (18.4 to 28.0)	0.001
AST (U/L)	20.6 (20.1 to 21.0)	22.5 (21.6 to 23.5)	0.001	18.4 (18.1 to 18.6)	23.1 (20.5 to 25.7)	0.001
GGT (U/L)	30.1 (29.1 to 32.9)	41.6 (37.7 to 45.6)	<0.001	16.8 (16.2 to 17.5)	22.9 (19.5 to 26.3)	<0.001
Creatinine (μmol/L)	81.2 (80.6 to 81.8)	86.5 (84.6 to 88.4)	<0.001	59.5 (59.2 to 59.8)	63.8 (62.2 to 65.4)	<0.001
BUN (mmol/L)	5.12 (5.07 to 5.17)	5.37 (5.21 to 5.53)	0.003	4.55 (4.51 to 4.59)	5.07 (4.84 to 5.30)	<0.001
eGFR	101.1 (100.4 to 101.8)	95.3 (93.5 to 97.1)	<0.001	188.7 (188.0 to 189.4)	109 (105.4 to 112.6)	<0.001
TG (mmol/L)	1.38 (1.34 to 1.42)	1.88 (1.76 to 2.00)	<0.001	1.05 (1.03 to 1.07)	1.60 (1.28 to 1.92)	0.001
TC (mmol/L)	4.49 (4.45 to 4.53)	4.71 (4.62 to 4.80)	<0.001	4.52 (4.49 to 4.55)	4.76 (4.62 to 4.90)	0.001
HDL-C (mmol/L)	1.21 (1.20 to 1.22)	1.14 (1.11 to 1.17)	<0.001	1.44 (1.43 to 1.45)	1.36 (1.30 to 1.42)	0.003
LDL-C (mmol/L)	2.62 (2.59 to 2.65)	2.72 (2.65 to 2.79)	0.012	2.53 (2.51 to 2.55)	2.65 (2.53 to 2.77)	0.026
VLDL-C (mmol/L)	0.65 (0.64 to 0.66)	0.84 (0.80 to 0.88)	<0.001	0.55 (0.54 to 0.56)	0.73 (0.65 to 0.81)	<0.001
FBS (mmol/L)	5.02 (4.97 to 5.07)	5.01 (4.93 to 5.09)	0.815	4.81 (4.79 to 4.83)	5.07 (4.93 to 5.21)	<0.001
Excessive drinking (%)	14.0 (12.5 to 15.5)	19.4 (15.4 to 23.4)	0.007	1.4 (1.0 to 1.8)	3.8 (0.8 to 6.8)	0.016
Smoking history (%)	39.0 (36.8 to 41.2)	42.9 (37.9 to 47.9)	0.15	1.4 (1.0 to 1.8)	1.3 (0 to 3.1)	0.906
SUA (μmol/L)	333.8 (331.6 to 336.0)	467.9 (463.2 to 472.6)	<0.001	260.0 (258.5 to 261.5)	397.1 (390.8 to 403.4)	<0.001

Data are expressed as mean (95% CI).
ALT, alanine aminotransferase; AST, aspartate aminotransferase; BMI, body mass index; BUN, blood urea nitrogen; DBP, diastolic blood pressure; eGFR, estimated glomerular filtration rate; FBS, fasting blood sugar; GGT, gamma-glutamyl transpeptidase; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; SBP, systolic blood pressure; SUA, serum uric acid; TG, triglyceride; TC, total cholesterol; VLDL-C, very low-density lipoprotein cholesterol; WC, waist circumference.

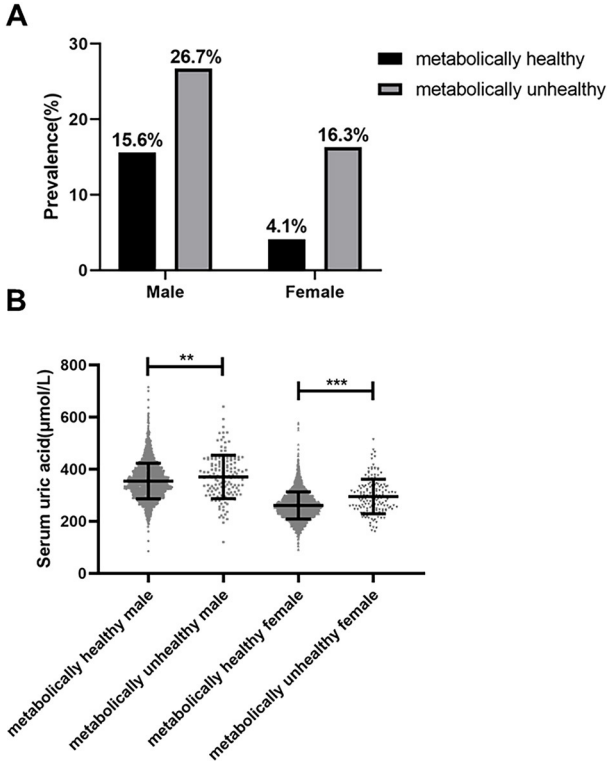

Figure 2 Prevalence of hyperuricaemia (A) and serum uric acid (B) in metabolically healthy or metabolically unhealthy participants. Data were expressed as mean±SD. **P<0.01, ***p<0.001.

in women), excessive drinking (1.501 (1.097 to 2.055) in men and 3.562 (1.408 to 9.011) in women) and presence of fatty liver (1.959 (1.472 to 2.607) in men and 1.900 (1.164 to 3.102) in women) were associated with an increased prevalence of hyperuricaemia in both genders. Greater age (0.961 (0.950 to 0.972) in men and 0.958 (0.939 to 0.977) in women) and elevated eGFR levels (0.973 (0.965 to 0.980) in men and 0.976 (0.966 to 0.985) in women) were associated with a decreased prevalence of hyperuricaemia in both genders. Elevated serum levels of AST (1.014 (1.004 to 1.024)) and total cholesterol (2.717 (1.921 to 3.843)) were associated with an increased prevalence of hyperuricaemia in men. Elevated serum levels of HDL-C (0.378 (0.240 to 0.594)) and LDL-C (0.386 (0.256 to 0.583)) were associated with a decreased prevalence of hyperuricaemia in men. Elevated diastolic blood pressure (1.033 (1.016 to 1.050)), higher ALT (1.023 (1.013 to 1.033)) and triglyceride (1.423 (1.199 to 1.690)) levels were associated with an increased prevalence of hyperuricaemia in women (table 3).

DISCUSSION

This study investigated the prevalence and factors associated with hyperuricaemia in a non-obese Chinese population. We found that the prevalence of hyperuricaemia was 9.4% in the non-obese adults, with 16.3% in men and 4.6% in women. Age, waist circumference, eGFR, BUN, excessive drinking and presence of fatty liver were associated with hyperuricaemia in both genders.

The prevalence of hyperuricaemia in non-obese individuals was 9.4%, lower than that previously reported in the general population in East Asia,[10 22] which included both non-obese and obese individuals as a whole, rather than separately. We found that in the non-obese individuals, the overall prevalence of hyperuricaemia was higher in men than in women. However, the prevalence of hyperuricaemia increased greatly in women older than 50 years, which could be corroborated by other studies.[23 24] A

Table 2 Prevalence of metabolic disease according to hyperuricaemia

	Male			Female		
	Without hyperuricaemia	With hyperuricaemia	P value	Without hyperuricaemia	With hyperuricaemia	P value
Metabolic syndrome	5.4%	10.2%	<0.001	4%	16%	<0.001
Metabolic syndrome components						
Waist circumference (>102 cm in men, >88 cm in women)	0%	0%	/	1.4%	3.2%	0.06
Fasting blood glucose (≥6.1 mmol/L)	6.4%	6.5%	0.890	2%	10.9%	<0.001
Triglyceride (≥1.7 mmol/L)	21.9%	45%	<0.001	10.8%	26.3%	<0.001
HDL-C (<1.04 mmol/L in men, <1.30 mmol/L in women)	28.9%	37.7%	0.001	35.2%	48.1%	0.001
Blood pressure (≥130/85 mm Hg)	33.7%	38%	0.105	19.3%	35.9%	<0.001
Diabetes mellitus	3.4%	2.9%	0.599	1%	2.6%	0.062
NAFLD	13.8%	30.4%	<0.001	6.4%	20.5%	<0.001

HDL-C, high-density lipoprotein cholesterol; NAFLD, non-alcoholic fatty liver disease.

Table 3 Multivariable analysis for factors associated with hyperuricaemia

Variables	Male		Female	
	OR (95% CI)	P value	OR (95% CI)	P value
Age (year)	0.961 (0.950 to 0.972)	<0.001	0.958 (0.939 to 0.977)	<0.001
WC (cm)	1.057 (1.030 to 1.084)	<0.001	1.038 (1.006 to 1.071)	0.020
DBP (mm Hg)	/		1.033 (1.016 to 1.050)	<0.001
ALT (U/L)	/		1.023 (1.013 to 1.033)	<0.001
AST (U/L)	1.014 (1.004 to 1.024)	0.005	/	
eGFR (µmol/L)	0.973 (0.965 to 0.980)	<0.001	0.976 (0.966 to 0.985)	<0.001
BUN (mmol/L)	1.114 (1.014 to 1.223)	0.025	1.308 (1.137 to 1.505)	<0.001
TG (mmol/L)	/		1.423 (1.199 to 1.690)	<0.001
TC (mmol/L)	2.717 (1.921 to 3.843)	<0.001	/	
HDL-C (mmol/L)	0.378 (0.240 to 0.594)	<0.001	/	
LDL-C (mmol/L)	0.386 (0.256 to 0.583)	<0.001	/	
Excessive drinking	1.501 (1.097 to 2.055)	0.011	3.562 (1.408 to 9.011)	0.007
NAFLD	1.959 (1.472 to 2.607)	<0.001	1.900 (1.164 to 3.102)	0.010

ALT, alanine aminotransferase; AST, aspartate aminotransferase; BUN, blood urea nitrogen; DBP, diastolic blood pressure; eGFR, estimated glomerular filtration rate; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; NAFLD, non-alcoholic fatty liver disease; TC, total cholesterol; TG, triglyceride; WC, waist circumference.

possible explanation could be the effects of sex hormones on renal urate transport. Oestrogen affects serum uric acid level through renal clearance, secretion and reabsorption. Serum urate level is generally lower in young adult women than in their male counterparts, while the onset of menopause has been reported to correlate with an increased serum urate level.[25]

At the same time, we found that the prevalence of hyperuricaemia gradually decreased with age in male non-obese patients, which was inconsistent with previous studies.[26 27] One possible reason was that we have excluded patients undergoing urate-lowering treatment in our study. Nowadays, as the prevalence of gout increases significantly with age, the number of patients taking urate-lowering treatment is also on the rise as age grows, which may lead to a selection bias in our research.[28 29]

Some studies have reported the interaction between hyperuricaemia and NAFLD. We previously reported that hyperuricaemia is independently associated with the risk of NAFLD.[6] Our previous prospective study also found that NAFLD was strongly associated with an increased risk of incident hyperuricaemia.[8] In this study, we identified fatty liver as a factor associated with hyperuricaemia in the non-obese population. Our results suggested that the interaction between hyperuricaemia and metabolic disorders should also be paid attention to in the non-obese population, to prevent further progression to deteriorated metabolic status.

MUHNW, generally defined as normal weight with metabolic syndrome, has raised considerable scientific interest.[30] Individuals with a metabolically unhealthy profile were associated with several health issues and higher healthcare and loss-of-productivity costs.[31] The risk of CVD in MUHNW individuals was 1.5–3-fold higher than that in MHNW individuals, and higher than the relative risk in those with metabolically healthy obesity (MHO).[32] It is not rare to find that MUHNW individuals have a worse prognosis of diabetes than MHO individuals.[33] In this study, we found that the prevalence of hyperuricaemia increased significantly in MUHNW participants compared with that in MHNW participants. This phenomenon was more obvious in women, which implied that we could pay more attention to serum uric acid level in MUHNW individuals. As they are more likely to suffer from hyperuricaemia, early intervention in uric acid level may benefit these patients by protecting them from developing further metabolic disorders.[34]

We next assessed the comorbidity of other metabolic disorders in non-obese patients with hyperuricaemia. We found that the prevalence of metabolic syndrome and of fatty liver disease in non-obese participants with hyperuricaemia was higher than those in normouraemic controls. This indicated that hyperuricaemia in the non-obese population could also be accompanied by multiple metabolic disorders. Studies have reported hyperuricaemia as a cause of metabolic syndrome.[7] Our previous studies also found that hyperuricaemia could promote the occurrence and development of NAFLD, and urate-lowering treatment could alleviate NAFLD.[8] Therefore, non-obese individuals with hyperuricaemia may also need active intervention in uric acid level to reduce the risk of comorbid metabolic disorders.[35]

Several limitations are acknowledged for this study. First, due to the single-centre design and the limited sample size, the results of this study may not apply to the entire adult Chinese population. Further multicentre

cohort studies are needed. Second, in our study, patients currently undergoing urate-lowering treatment were excluded, which might cause a selection bias in the prevalence of hyperuricaemia. In our research, some factors related to uric acid were not included, such as gout, renal disease, treatment with diuretics, etc. Third, several studies have demonstrated that fructose-enriched foods and drinks lead to increased serum uric acid levels,[36] indicating the role of dietary intake in the development of hyperuricaemia. Dietary information, however, was not unavailable in the check-up reports and thus was not discussed in this study. Meanwhile, this study defined the non-obese participants by BMI without including waist circumference or waist-to-hip ratio. Some central obese patients could be mixed in the non-obese participants.

In conclusion, our retrospective cross-sectional study showed that the prevalence of hyperuricaemia was 9.4% in the non-obese Chinese population. The prevalence of hyperuricaemia increased significantly in MUHNW participants compared with MHNW participants. Hyperuricaemia in non-obese people could also be accompanied by multiple metabolic disorders. Therefore, we suggest that clinicians pay attention to serum uric acid level in non-obese patients.

Contributors CX and HZ conceived and designed the experiment. JW, YC and SC collected the clinical information. JW, XW and HZ analysed the data. JW and YC wrote the paper. CX was responsible for the overall content as the guarantor. All authors reviewed the manuscript.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not required.

Ethics approval During the health check-up, all participants were informed of the potential use of their check-up data for future research and that subject information would be anonymised at collection prior to research analysis. All methods were performed in accordance with the approved guidelines. The study was approved by the Clinical Research Ethics Committee of the First Affiliated Hospital, Zhejiang University School of Medicine (No.2021015). Written consent was not required because of the retrospective observational design of the study.

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