The Prevalence of Hyperuricemia in a Population of the Coastal City of Qingdao, China

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ABSTRACT. ***Objective.*** Hyperuricemia and gout have shown an increase worldwide. Data are lacking for the prevalence of hyperuricemia and gout and their correlates in China. We studied the occurrence of these conditions in Chinese adults in the city of Qingdao.

Methods. A population-based cross-sectional survey for hyperuricemia and gout was performed among 2438 adults (1535 women, 903 men; aged 20–74 yrs) in 2002. Fasting serum uric acid (UA) and lipid profiles were determined, as well as height, weight, and blood pressure. Hyperuricemia was defined as serum UA levels > 420 μmol/l in men and > 360 μmol/l in women. Diagnosis of gout was self-reported. Complete biochemical and questionnaire data were available for analysis from 1303 women and 720 men.

Results. The age-standardized prevalence was 25.3% for hyperuricemia and 0.36% for gout in adults aged 20 to 74 years. Hyperuricemia was more prevalent in men than in women (32.1% vs 21.8%; $p < 0.001$). Age-adjusted mean serum UA level was 389.3 μmol/l in men and 315.7 μmol/l in women. Serum UA increased with age in women only (p for trend < 0.001). Body mass index and serum triglycerides had the strongest associations with serum UA in both genders, followed by alcohol drinking and diastolic blood pressure in men, and systolic blood pressure and total cholesterol in women.

Conclusion. The prevalence of hyperuricemia in the urban adult population in Qingdao city is high, while the frequency of gout is lower. Obesity, hypertension, and dyslipidemia are the major factors associated with hyperuricemia in this study. (J Rheumatol 2006;33:1346–50)

Key Indexing Terms:
SERUM URIC ACID HYPERURICEMIA GOUT PREVALENCE CHINESE

Serum uric acid (UA) has been shown to be related to risk of hypertension, cardiovascular disease, and type 2 diabetes in clinical and epidemiological studies, in addition to gout, which is a specific disease caused by high UA[1-4]. During the past 4 decades, the prevalence of hyperuricemia has been increasing in both developed and developing countries[5-10]. In the US National Health Interview Survey (NHIS) in 1996, the overall prevalence of self-reported gout was 4.6% for men and 2.0% for women in adults aged 45 years or older[1]. Results from the Nutrition and Health Survey in Taiwan (1993-96) revealed a prevalence of hyperuricemia of 26.1% for men and 17.0% for women in Han Chinese[11]. The prevalence of hyperuricemia and gout in Taiwanese Aborigines (who live mainly in high mountain areas) was 41.4% and 11.7%, respectively, whereas corresponding figures were only 11.0% and 3.0% in the remaining "ethnic Taiwanese," most of whom came from southern Mainland China some 400 years ago and some of whom arrived from the central and northern areas of Mainland China 50 years ago[12,13]. In Seychelles, the prevalence of hyperuricemia in adults aged 25–64 years was 35.2% for men and 8.7% for women in 1994[10].

It has been reported that the prevalence of hyperuricemia and gout have been increasing recently in large Chinese cities, even though it was once considered a very rare disease in China[14-16]. The prevalence of hyperuricemia in 1980 was 1.4% in men and 1.3% in women, while no gout was found in adults in Beijing, Shanghai, or Guangzhou[14]; the corresponding figures were 15.4% and 11.0% in urban adults in Beijing in 1987-88[15]. In 1998, the prevalence of hyperuricemia was 14.2% in men and 7.1% in women, and 0.34% for gout in both genders in Shanghai[16]. The prevalence of hyperuricemia and gout was 5.8% and 0.05%, respectively, in men in a survey done during 1995-96 in Shandong province[17]. To date, there

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Supported by the Bureau of Science and Technology, Qingdao (2001KNS-E-5); LifeScan, Inc., Johnson & Johnson Company, China; the Academy of Finland (46558); and the Paulo Foundation, Future Forum Grant 2004, Finland.

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Accepted for publication February 26, 2006.

is no study on the prevalence of hyperuricemia and gout in Qingdao. Qingdao is one of the largest harbor cities in China, with a high consumption of seafood and beer. Seafood and beer contain plenty of purine and have been reported to be risk factors for hyperuricemia.

We investigated the prevalence of hyperuricemia and gout and the risk factors associated with hyperuricemia in the Han Chinese population in an urban community in Qingdao.

MATERIALS AND METHODS

Study population. People aged 20–74 years who had lived in Qingdao for at least 5 years were included in the survey. Street blocks were randomly drawn from Zhanshan community to serve as clusters for the survey. From each selected block, families were randomly selected, and a total of 2777 eligible subjects were invited to take part in the survey. Of them, 2438 (1535 women and 903 men) participated, with an overall response rate of 87.8%. Among them, 135 subjects did not have valid data on the key measurements and were thus excluded, leaving 2303 subjects in the current data analysis.

Survey procedure. The survey was conducted during the months of April to June, 2002. The survey team consisted of nurses and specialists in internal medicine, who were trained for one week before the fieldwork. Nurses distributed survey questionnaires to all participants during a house visit. The questionnaire contained questions on demographic, dietary, drinking, and smoking information, and personal and family history of diabetes, gout, and hyperuricemia. A participant was classified as an alcohol drinker if he/she was currently drinking beer, wine, or liquors during the last half-year. Subjects' height and weight were measured wearing light clothing and without shoes. Body mass index (BMI) was calculated by dividing the weight (kg) by the height (m) squared. Waist girth at the midpoint between the lower margin of rib and the iliac crest and hip circumference at the maximal horizontal girth between the waist and thigh were measured. The measurements were made to the nearest 0.5 cm. Two consecutive measurements were performed, and if the variation was greater than 2.0 cm between the 2 readings, a third measurement was taken. The two most consistent readings were used in the analysis. Waist to hip ratio was calculated by waist circumference divided by hip circumference. Three consecutive blood pressure readings, at least 5 min apart, were taken from the right arm of seated subjects and the average of the 3 readings was used in data analysis.

Individuals were instructed to fast for at least 10 hours before blood was drawn. Blood samples were collected at Zhanshan community health clinic. Fasting blood specimens were collected for measurement of serum UA, serum total cholesterol, triglycerides, high density lipoprotein cholesterol (HDL-C), and glucose. After a fasting blood sample was drawn, each participant was asked to drink 75 g glucose dissolved in 300 ml water[18] between 7:00 and 9:30 AM. Venous blood samples were collected from the antecubital vein into a vacuum tube containing sodium fluoride before and 120 min after the ingestion of 75 g glucose. The specimens were put into ice-cooled containers and transported immediately to the clinical laboratory of the Qingdao Endocrinology and Diabetes Hospital. Plasma glucose was determined by glucose oxidase method within 3 h after the blood sample was collected. Serum was frozen at –20° and serum UA was measured by the uricase method within a month in the same clinical laboratory.

Hyperuricemia was defined as serum UA > 420 μmol/l for men and > 360 μmol/l for women according to guidelines[4]. The diagnosis of gout was based on self-reported information that was confirmed by reading the patient's diagnosis record. Hypertension was defined as systolic blood pressure ≥ 140 and/or diastolic blood pressure ≥ 90 mm Hg and/or being on antihypertensive therapy. The World Health Organization 1999 criteria for diabetes was used to classify subjects into groups, including diabetes mellitus, impaired glucose regulation, and normal glucose tolerance[18].

Statistical methods. The standard world population for 10-year intervals was adopted to calculate age-standardized prevalence of hyperuricemia and self-reported gout[19]. Analysis of covariance was used for comparison of the difference in continuous variables between subgroups. Chi-square test was employed to estimate the difference in categorical variables. In statistical analyses, the logarithmic transformation was made for triglycerides, fasting plasma glucose (FPG), and 2 h plasma glucose (2hPG), because of their skewed distributions. The relationship between serum UA and several other variables was evaluated separately for men and women using the multiple linear regression analysis. The independent variables included in the regression model were age, BMI, triglycerides, total cholesterol, FPG, systolic and diastolic blood pressure, and current alcohol drinking (coded as yes/no). P value < 0.05 (2-tailed) was considered statistically significant. All analyses were performed using SPSS for Windows version 12.0.

RESULTS

Age-adjusted mean serum UA, triglycerides, waist circumference, and waist to hip ratio were statistically significantly higher in men than in women (Table 1, Figure 1). Age-adjusted means of BMI, waist circumference, systolic blood pressure, diastolic blood pressure, and triglycerides were higher, and HDL-C was lower in the hyperuricemic group than in the non-hyperuricemic group in both genders (Table 1). Current alcohol drinking, smoking, and higher education level were common in men. Age, BMI, FPG, and 2hPG did not differ between sexes. Serum UA increased with age only in women (p for trend < 0.001; Figure 1); this variable was higher (328.0 ± 2.5 μmol/l vs 301.6 ± 2.9 μmol/l; p <0.001) in postmenopausal versus premenopausal women.

The age-standardized prevalence of hyperuricemia was 25.3% (95% CI 23.5%–27.2%) in the adult population aged 20–74 years. It was higher in men than in women below age 55 years, but there was no sex difference above 55 years (Table 2). Postmenopausal women had a much higher prevalence of hyperuricemia than premenopausal women (29.1% vs 15.4%; p < 0.001). When using different cutoff values for UA levels for women before (> 360 μmol/l) and after (> 420 μmol/l) menopause, the crude prevalence of hyperuricemia would be 15.4% and 6.8% in pre- and postmenopausal women; this erases the age difference in women. There were 11 patients with gout, 6 of whom had normal UA levels. The mean UA in these 11 patients with gout was higher than that in subjects without gout (416.1 μmol/l vs 341.6 μmol/l; p = 0.004). The age-standardized prevalence of gout was 0.63% (95% CI 0.05–1.21) in men, 0.23% (95% CI 0.0–0.49) in women, and 0.36% (95% CI 0.10–0.62) in the entire study population.

In multivariate regression analysis, BMI, triglycerides, and alcohol drinking were significantly and positively associated with increase in serum UA concentration in men, and explained 15.0% of the variation in serum UA. In women, BMI, triglycerides, total cholesterol, and systolic blood pressure were positively, and FPG negatively, associated with serum UA levels, which explained 11.0% of serum UA variation. Systolic and diastolic blood pressure and hypertension were tested separately in different models, and were found to have significant direct correlation with UA (Table 3).

DISCUSSION

The study revealed a higher prevalence of hyperuricemia in

Table 1. Characteristics of the study population in Zhanshan Community, Qingdao. Data are age-adjusted mean (95% confidence interval), unless otherwise indicated.

	Male		Female	
	Non-Hyperuricemic	Hyperuricemic	Non-Hyperuricemic	Hyperuricemic
Number	505	215	1009	294
Age, yrs	53 (52–54)	52 (50–53)	51 (50–52)	54 (53–56)
Body mass index, kg/m^2	25.8 (25.5–26.1)	27.8 (27.3–28.2)	25.7 (25.5–25.9)	27.4 (27.0–27.8)
Waist circumference, cm	88.2 (87.4–89.0)	93.7 (92.5–94.9)	83.0 (82.4–83.5)	85.8 (84.7–86.8)
Hip circumference, cm	98.5 (97.9–99.0)	101.7 (100.8–102.6)	98.3 (97.9–98.7)	100.9 (100.1–101.7)
Waist to hip ratio	0.89 (0.89–0.90)	0.92 (0.91–0.93)	0.84 (0.84–0.85)	0.85 (0.84–0.86)
Protein intake, g per day	228 (215–242)	213 (195–233)	208 (199–216)	204 (189–221)
Systolic blood pressure, mm Hg	127 (125–128)	132 (129–134)	127 (126–128)	134 (132–136)
Diastolic blood pressure, mm Hg	83 (82–84)	87 (85–88)	81 (80–82)	84 (83–86)
Education ≥ 9 yrs, %	88.9	90.7	79.6†	75.9††
History of diabetes, % positive	3.0	0.5	2.2	2.3
Current smoking, %	37.0	37.7	1.1†	1.4††
Current alcohol drinking, %	38.4	44.7*	1.30†	2.40††
Serum uric acid, μmol/l	346 (341–350)	493 (486–499)	288 (284–291)	412 (406–418)
Serum total cholesterol, mmol/l	5.52 (5.43–5.62)	5.65 (5.50–5.80)	5.61 (5.54–5.67)	6.00 (5.88–6.13)
High density lipoprotein cholesterol, mmol/l	1.48 (1.46–1.51)	1.51 (1.47–1.54)	1.50 (1.49–1.52)	1.57 (1.54–1.60)
Triglycerides, mmol/l	1.33 (1.27–1.39)	1.83 (1.71–1.96)	1.19 (1.15–1.22)	1.52 (1.44–1.61)
Fasting plasma glucose, mmol/l	5.45 (5.35–5.55)	5.61 (5.45–5.77)	5.52 (5.46–5.60)	5.42 (5.28–5.56)
2-h plasma glucose, mmol/l	5.96 (5.75–6.18)	5.93 (5.61–6.25)	6.00 (5.85–6.17)	6.25 (5.97–6.56)

$p < 0.05$. † difference between genders in non-hyperuricemic groups; †† difference between genders in hyperuricemic groups; * difference in men with and without hyperuricemia.

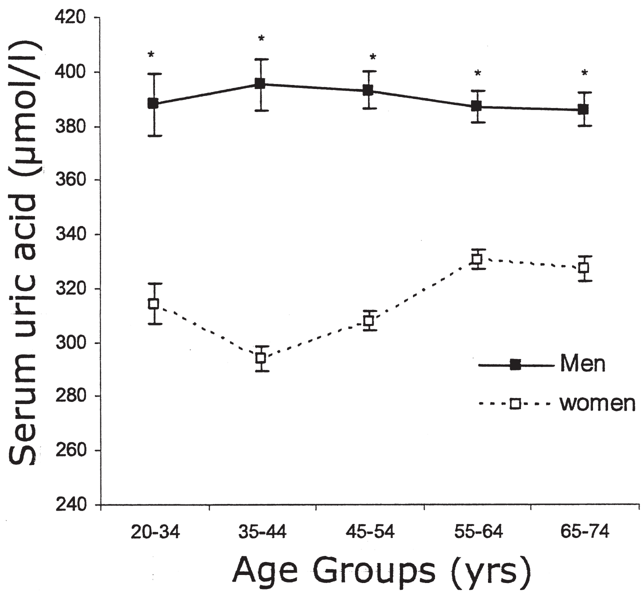

Figure 1. Age and gender-specific mean serum uric acid levels and their standard error (bar). *p < 0.001 for the difference between men and women.

Qingdao as compared to those reported previously in mainland China, but the prevalence in this study was lower than most reports from studies in Taiwan, and much lower than in Taiwanese Aborigines[20] (Table 4). It has been well known that Taiwanese Aborigines have high UA levels, which is explained by their higher BMI and relatively higher amounts of alcohol consumption than non-aborigines, in addition to genetic factors[11]. In past decades obesity and dyslipidemia have been reported to increase in mainland China[22], which may explain to a large extent the higher prevalence of hyperuricemia in our survey as compared with surveys in the 1990s. In addition, seafood is a major part of the food component in Qingdao. This may also contribute to the high levels of uric acid observed in Qingdao.

In our study the associations of BMI and triglycerides with serum UA were highly significant in both sexes. Serum UA levels are likely to be determined by both genetic and environmental factors[23]. It is well documented that the serum UA level is determined by the balance between its production and urinary excretion[24]. The potential mechanisms relating hyperuricemia to fasting hypertriglyceridemia are unknown. It has been speculated to be due to an increase in NADPH requirement for *de novo* fatty acid synthesis in obese men. With increased NADPH, UA production is enhanced, and this might increase the serum UA level[25]. We also demonstrated that serum UA significantly correlated with hypertension. The relationship of serum UA with blood pressure has been reported in many clinical and epidemiological studies[3,4,10,15]. Age appears to be related to hyperuricemia in women in our study, which is consistent with a study in Beijing[15]. In other Asian studies, age was also reported as a risk factor for hyperuricemia in women, but in men hyperuricemia has been found to decrease with age[11,26]. The mechanisms relating hyperuricemia to aging remain unclear, but estrogen may play a role[27]. Alcohol drinking was associated with hyperuricemia only in men in our study. This may be because women seldom drink alcohol in China.

Table 2. Prevalence, as a percentage of hyperuricemia* in Qingdao by age and sex.

	N		Prevalence (95% CI)		
Age, yrs	Men	All	Men	Women	All
20–34	64	187	34.4 (22.8–46.0)	25.2 (17.5–32.9)	28.3 (21.8–34.8)
35–44	113	316	34.5 (25.7–43.3)	10.8 (6.5–15.1)†	19.3 (14.9–23.7)
45–54	192	605	30.7 (24.2–37.2)	17.9 (14.2–21.6)†	22.0 (18.7–25.3)
55–64	208	568	27.4 (21.3–33.5)	31.1 (26.3–35.9)	29.8 (26.0–33.6)
65–74	143	347	26.6 (19.4–33.8)	27.5 (21.4–33.6)	27.1 (22.4–31.8)
All, crude	720	2023	29.9 (26.6–33.2)	22.6 (20.4–25.0)	25.2 (23.3–27.1)
Age-standardized	—	—	32.1 (28.7–35.5)	21.8 (19.6–24.1)	25.3 (23.5–27.2)

* Uric acid ≥ 420.0 μmol/l for men and ≥ 360.0 μmol/l for women. † $p < 0.001$ for the difference between men and women.

Table 3. Standardized linear regression coefficient for serum uric acid concentration (μmol/l) corresponding to a 1 standard deviation increase in covariates.

Covariate (SD for men, women, and all subjects)	Men, n = 720	Women, n = 1303	All, n = 2303
Age, yrs (12.1, 12.0, 12.0)	–0.01	–0.014	–0.04
Body mass index, kg/m^2 (3.4, 3.9, 3.7)	0.23††	0.17††	0.17††
Triglycerides, mmol/l (1.5, 0.9, 1.2)	0.23††	0.15††	0.18††
Total cholesterol, mmol/l (1.2, 1.1, 1.2)	0.00	0.12††	0.05*
Systolic blood pressure, mm Hg (19.2, 21.4, 20.6)	0.05	0.12††	0.08†
Diastolic blood pressure, mm Hg (11.3, 11.5, 11.5)	0.10†	0.06*	0.07†
Hypertension, 1 = yes, 0 = no	0.08*	0.10†	0.08††
Fasting plasma glucose, mmol/l (1.7, 1.8, 1.7)	–0.06	–0.06*	–0.05†
Alcohol drinking, 1 = yes, 0 = no	0.10†	0.00	0.07†
Sex, 1 = men, 0 = women	—	—	0.35††
Adjusted R^2 for model 1	0.15	0.11	0.27
Adjusted R^2 for model 2	0.15	0.10	0.27
Adjusted R^2 for model 3	0.14	0.11	0.27

* $p < 0.05$, † $p < 0.01$, †† $p < 0.001$. Systolic blood pressure, diastolic blood pressure, and hypertension were tested separately in models 1, 2, and 3.

Table 4. Prevalence of hyperuricemia in Chinese populations.

Survey Year	Reference	Geographic location	Age, yrs	No. of Men/Women	Prevalence, % Men	Prevalence, % Women
1980	Fang[14]	Beijing, Shanghai, and Guangzhou	≥ 20	267/235	1.4	1.3
1987–88	Li[15]	Beijing urban area	40–58	1062/951	15.4	11.0
		Beijing rural area	40–58	558/949	11.3	8.4
1990	Chou[12]	Taiwan Aborigines	≥ 18	145/197	53.8	30.7
1991–92	Lin[21]	Taiwan Kin-Hu, Kinmen	≥ 30	1515/1670	25.8	15.0
1993–96	Chang[11]	Taiwan	≥ 19	1348/1498	26.1*	17.0*
	Chang[11]				42.1	27.4
1993–96	Chang[11]	Taiwan, metropolitan cities	≥ 19	204/201	48.0	20.7
	Chang[11]	Taiwan, mountainous area	≥ 19	206/233	82.0	64.3
1995–96	Jiang[17]	Shandong province, littoral area, not including Qingdao	≥ 20	—	5.8	0.05
1998	Chen[16]	Shanghai	≥ 15	913/1124	14.2	7.1

* Hyperuricemia defined as uric acid ≥ 458 μmol/l for men and ≥ 393 μmol/l for women; the rest using uric acid ≥ 420 μmol/l for men and ≥ 360 μmol/l.

Of all the families included in the data analysis, 95% had 3 or fewer family members, and 80% consisted of couples only. The selection bias of larger families is not a major concern. In Qingdao, people are accustomed to consuming seafood, which is a characteristic of all citizens, not restricted to certain families only. Seafood has been reported to be one of the risk factors for hyperuricemia, and high consumption may have contributed to the high prevalence of hyperuricemia in Qingdao. During the survey, we randomly selected a sample of 65 hyperuricemic subjects, instructing them to eat foods containing low purine for one week. After one week the second serum UA concentration was measured. The second UA level was significantly lower than their first measurements (mean of paired difference was 71 μmol/l; $p < 0.001$; unpublished data). Shellfish, one kind of high purine-enriched food, is extremely popular in Qingdao city, and among many kinds of shellfish, clams are the most frequently consumed. Clams as well as other shellfish might be the major dietary factor contributing to the high prevalence of hyperuricemia. One important factor that could affect the levels of uric acid is plasma creatinine levels[23]. Unfortunately, we did not collect detailed dietary information or measure plasma creatinine levels, therefore we could not take these important factors into account.

In summary, hyperuricemia is highly prevalent in the urban adult population in Qingdao, China. Obesity, dyslipidemia, and hypertension are important risk factors associated with the high prevalence of hyperuricemia.

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