A Comparison of Uric Acid Levels in Black African vs Caucasian Women from South Africa: the POWIRS Study

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Objectives: Elevated levels of uric acid are often associated with cardiometabolic risk factors. The aim of this study was to determine whether uric acid levels differ between African and Caucasian women and whether uric acid is associated with cardiometabolic risk factors within the two ethnic groups.

Methods: Women from African (N=102) and Caucasian (N=115) descent were recruited and their uric acid levels measured. Anthropometric measurements included height (stature), weight, and waist circumference. Correlations between uric acid and cardiometabolic variables within each ethnic group were also determined.

Results: African women had significantly lower levels of uric acid ($P<.01$) and significantly higher levels of blood pressure ($P=.05$) compared to the Caucasian women. There was a significant increase in blood pressure from the lower to higher uric acid tertiles in the African women. Uric acid strongly correlated with waist circumference in both ethnic groups.

Conclusions: Despite their higher blood pressure, the African women had lower uric acid levels, yet they showed a significant increase in blood pressure from a low uric acid tertile to high uric acid tertile, which was not noticeable in the Caucasian women. A possible explanation is a lower waist circumference in African women compared to Caucasian women. (*Ethn Dis*. 2007;17:676–681)

Key Words: Uric Acid, African, Caucasian, Cardiovascular Function, Metabolic Syndrome

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Introduction

Several epidemiologic studies have shown that the African population is a high-risk group for hypertension.[1–3] In the Transition and Health during Urbanization in South Africa study (THUSA) conducted in the North-West Province of South Africa, ≈34.8% of the African population had a systolic blood pressure >140 mm Hg, while 26.9% had a diastolic blood pressure >80 mm Hg.[4]

Elevated levels of uric acid are often associated with hypertension[5] and might be associated with cardiovascular dysfunction as well as some components of the metabolic syndrome. It is still a controversial issue whether elevated uric acid levels should be considered a risk factor leading to cardiovascular dysfunction[6–8] or merely a risk marker associated with existing cardiovascular dysfunction.[9]

Few studies have been conducted to determine whether elevated uric acid levels are a risk factor for the African population in South Africa. The aim of this study was to determine whether uric acid levels differ between African and Caucasian women from South Africa and whether uric acid is associated with cardiometabolic risk factors within the two ethnic groups.

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Materials and Methods

Participants

The POWIRS study (Profiles of Obese Women with the Insulin Resistance Syndrome) was a case control study conducted in the Potchefstroom district of the North-West Province, South Africa. The study included apparently healthy women from African ($n=102$) and Caucasian ($n=115$) descent between the ages of 20 and 55 years. According to the original research question of this study,[10] the women were recruited according to the body mass index categories described in the guidelines of the Report of the World Health Organization Consultation on Obesity (1997).[11] The exclusion criteria were pregnant and lactating women, oral temperatures >37°C. and HIV-positive subjects.

Assistance was available to provide any relevant information in each subject's home language. All subjects were informed about the outcome and procedures of the study beforehand and signed an informed consent form. The study was approved by the ethics committee of the North-West University (Potchefstroom Campus) and complies with the Declarations of Helsinki as revised in 2000.[12]

Cardiovascular Measurements

Subjects were required to remain in a supine position (Fowlers) while blood pressure measurements were taken using

Table 1A. Subject characteristics: Demographic and anthropometric indices

Index	African women (*n*=102)	Caucasian women (*n*=115)	*P* value
Age (years)	31.25 (29.56–32.95)	31.34 (29.64–33.03)	.94
BMI (kg/m^2)	27.98 (26.74–29.23)	28.48 (27.16–29.80)	.60
WC (cm)	81.62 (79.02–84.22)	86.00 (83.24–88.76)	.02
SBP (mm Hg)	129.82 (125.97–33.66)	125.41 (123.25–27.57)	.04
DBP (mm Hg)	77.68 (75.58–79.78)	72.47 (70.81–74.14)	<.01
MAP (mm Hg)	100.03 (97.47–102.59)	93.34 (91.54–95.14)	<.01
TPR (mm Hg.s/mL)	1.10 (1.04–1.15)	.84 (.80–.88)	<.01
C_W (mL/mm Hg)	1.85 (1.79–1.91)	2.29 (2.21–2.36)	<.01
Total protein intake	60.67 (56.87–64.47)	96.68 (90.45–102.91)	<.01

the Finometer device (FMS, Finapres Medical Systems, Amsterdam, Netherlands). The Finometer device was connected to the left arm and left middle finger of the subject, and measurements were recorded continuously for at least seven minutes. After a recording of two minutes, a return-to-flow calibration was performed. This is an adjustment that is performed to adjust the brachial arterial pressure of each specific subject with the finger pressure. Highest precision readings were obtained after this calibration.

The Finometer device computed all cardiovascular variables online and stored the data in result files on a hard disk. The following cardiovascular variables were measured and stored: systolic blood pressure (SBP), diastolic blood pressure (DBP), total peripheral resistance (TPR), and Windkessel compliance (C_W).[13]

The vascular unloading technique of Peňáz, together with the physiological criteria of Wesseling, provided reliable, noninvasive and continuous estimates of blood pressure, which are useable especially in comparative studies.[14,15] This technique is, therefore, an alternative to the invasive intra-arterial measurements without the risks and the ethical questions inherent to invasive measurement. Since the pressure waveform is available continuously, computations provide further information on the dynamics of the cardiovascular system, similar to intra-arterial measurements.[16,17]

Anthropometric Measurements

Anthropometric measurements were taken according to standard methods.[18] Height measurements were taken using a stadiometer (Invicta, IP 1465, UK), and measurements were taken to the nearest 0.1 cm. Body mass measurements were taken up to the nearest 0.1 kg, using a calibrated electronic scale (Precision Health Scale, A&D Company, Japan). The waist circumference was measured at midway level between the inferior rib margin and superior margin of the iliac crest.[19] Measurements were taken in triplicate to obtain a reliable mean value.

Biochemical Analyses

A fasting blood sample was taken from the antebrachial vein using a sterile winged infusion set and syringes. Plasma and serum samples were prepared according to standard methods and stored at -82°C until analyses were performed.

Serum lipids and uric acid were measured on a Vitros DT60 II Chemistry system with Vitros DT slides. Plasminogen activator inhibitor-1 (PAI-1) was measured with an indirect enzymatic method (Spectrolyse pL, Bipool Umeå, Sweden). C-reactive protein was analysed with a high sensitivity C-Reactive Protein Kit from Immage Immunochemistry systems (Beckman Coulter, Inc, Fullerton, USA, Cat. No. 474630). Serum leptin was determined with [^{125}I]IRMA kit (Diagnostic Systems Laboratories, Inc., Cat. No. DSL-23100). Plasma glucose was measured by the hexokinase method. Analysis of insulin levels was performed by enzyme immunoassay (BioSource EUROPE S.A. Belgium). Homeostasis model assessment of insulin resistance (HOMA-IR) was calculated using the formula: HOMA-IR = fasting insulin $\times$ fasting glucose/22.5.[20]

Questionnaire

Dietary protein intake was derived from results obtained by a registered dietician from a validated Quantitative Food Frequency Questionnaire.[10]

Statistical Analysis

Statistical analyses were performed using Statistica version 7.1 (Statsoft, Inc., Tulsa, OK, 2005). Quantitative data are presented as means and 95% confidence intervals. An independent Student's t-test was used for comparison between the African and Caucasian women, and to determine whether any significant differences existed between the two groups (Table 1). A multiple analysis of covariance (MANCOVA) was performed to compare the uric acid levels between the two ethnic groups within each body mass index (BMI) group. Correlations were performed to determine associations between uric acid and the cardiometabolic variables.

A significant interaction term was determined by a 2 $\times$ 2 MANCOVA between uric acid and ethnicity while

Table 1B. Subject characteristics: Biochemical results

	African women (*n*=102)	Caucasian women (*n*=115)	*P* value
Triglycerides (mmol/L)	0.71 (0.63–0.80)	1.28 (1.15–1.26)	<.01
Uric acid (µmol/L)	294.21 (278.20–310.21)	331.91 (319.39–344.44)	<.01
PAI-1 (units/mL)	5.97 (5.05–6.89)	12.89 (11.30–14.49)	<.01
Leptin (ng/mL)	57.59 (51.63–63.55)	51.37 (45.27–57.47)	.15
hsCRP (mg/L)	4.59 (3.17–6.01)	3.27 (2.56–3.98)	.09
Fasting glucose (mmol/L)	5.18 (4.95–5.42)	5.04 (4.96–5.11)	.22
Fasting insulin (pmol/L)	92.94 (84.75–101.13)	92.66 (86.45–98.87)	.96
HOMA-IR indexes	3.08 (2.77–3.39)	3.04 (2.80–3.28)	.82

NOTE. Values are expressed as the mean (confidence interval); BMI, body mass index; WC, waist circumference; SBP, systolic blood pressure; DBP, diastolic blood pressure; TPR, total peripheral resistance; C_W, Windkessel compliance; HDL, high-density lipoprotein cholesterol; PAI-1, plasminogen activator inhibitor 1; hsCRP, high sensitivity C-reactive protein; HOMA-IR, homeostasis model assessment – insulin resistance.

adjusting for age and waist circumference. The experimental groups were subdivided into uric acid tertiles, whereafter an independent t-test was performed using only the first and third tertiles. A forward stepwise multiple regression analysis was performed separately in the African and Caucasian women using uric acid as the dependent variable and the following as independent variables: age, BMI, waist circumference, SBP, DBP, mean arterial pressure, TPR, C_W, high-density lipoprotein, triglycerides, C-reactive protein, fasting glucose, fasting insulin, leptin, and total protein intake. Variables that were not normally distributed were logarithmically transformed. These included waist circumference, age, triglycerides, uric acid, leptin, fasting insulin, HOMA-IR, and C-reactive protein.

RESULTS

The African women had significantly lower mean uric acid levels ($P<.01$) compared to the Caucasian women (Table 1). The groups were divided into lean, overweight, and obese. An independent Student t-test showed a significant difference in waist circumference between the two ethnic groups for both the overweight ($P<.01$) and obese groups ($P=.01$), but not for the lean group ($P=.49$) – data not shown. ANCOVA analysis also showed significantly higher uric acid levels in the Caucasian women for each BMI level (Figure 1). A significant interaction term for ethnicity and uric acid was found with $F(1,217) = 12.08$; $P=.001$.

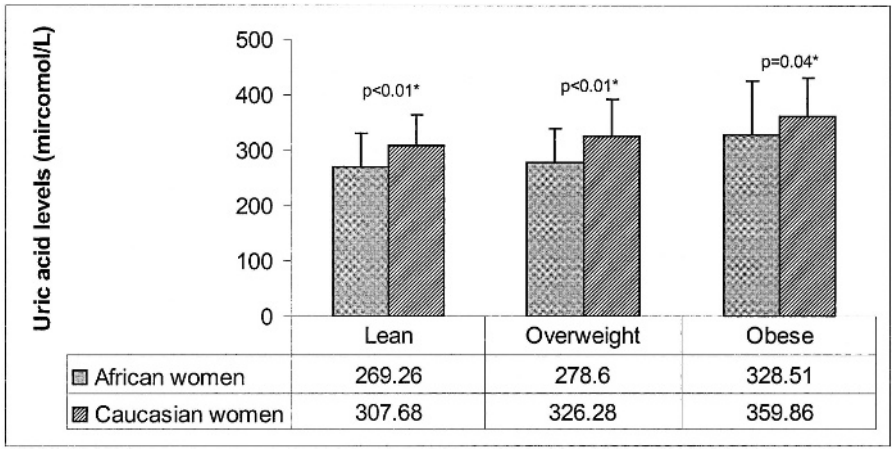

Fig 1. Uric acid levels of African and Caucasian women for the different obesity levels after adjusting for age and waist circumference (values are mean ± standard deviation)

In both ethnic groups uric acid correlated strongly with several variables of the metabolic syndrome (Table 2). Caucasian women showed a strong correlation between PAI-1 and uric acid, which was not noticeable in the African women, whereas only the African women showed a strong correlation between uric acid and triglycerides.

After adjusting for age, BMI, and waist circumference, all significant correlations between uric acid and the variables listed in Table 1 disappeared for both ethnic groups (data not shown), leaving only weakly positive correlations between uric acid and triglycerides ($r = 0.27$) in the African women and between uric acid and PAI-1 ($r = 0.20$) in the Caucasian women.

The two groups were divided into uric acid tertiles, and the first and third tertiles were compared (Table 3). Both groups showed significant increases in obesity level (waist circumference and BMI), as well as leptin and insulin resistance (HOMA-IR and fasting insulin levels) from the first to the third tertile. Blood pressure increased from the lower uric acid levels to the higher uric acid levels, although this was only seen in the African women. The African women also showed a significant increase in triglycerides, whereas only the

Table 2. Correlation coefficients (r) of uric acid

	African women		Caucasian women	
	r-value	*P* value	r-value	*P* value
SBP	.15	.14	.14	.13
DBP	.18	.07	.13	.17
MAP	.15	.12	.17	.07
TPR	−.05	.64	−.22	.02
C_W	.04	.71	.12	.20
BMI	.36	<.01	.34	<.01
WC	.40	<.01	.37	<.01
PAI-1	.09	.38	.38	<.01
HDL	−.06	.58	−.05	.63
Triglycerides	.43	<.01	.29	<.01
hsCRP	.19	.06	.28	<.01
Fasting insulin	.35	<.01	.33	<.01
Fasting glucose	.14	.16	.09	.32
HOMA-IR	.35	<.01	.30	<.01
Leptin	.39	<.01	.32	<.01

SBP, systolic blood pressure; DBP, diastolic blood pressure; MAP, mean arterial pressure; TPR, total peripheral resistance; C_W, Windkessel compliance; BMI, body mass index; WC, waist circumference; PAI-1, plasminogen activator inhibitor-1; HDL, high-density lipoproteins; hsCRP, high sensitivity C-reactive protein; HOMA-IR, homeostasis model assessment-insulin resistance.

Caucasian women showed a significant increase in PAI-1.

Forward stepwise multiple regression analyses were performed (Table 4) in each ethnic group to determine the strongest contributor to uric acid. The multiple regression analysis showed that triglyceride was the strongest contributor for uric acid in the African women, but in the case of the Caucasian women, PAI-1 was the strongest contributor to uric acid.

DISCUSSION

Data from this study correspond with previous findings that African women have higher mean blood pressure than Caucasian women.[1–3] However, despite the African women's higher blood pressure, their uric acid levels were significantly lower compared to the Caucasian women. This is in contrast with American studies that found the African American population to be a high risk group for elevated uric acid levels[21,22] or that the uric acid levels are similar for both the African American and Caucasian population.[23]

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A partial explanation for the lower levels of uric acid in the African women in our study might be their fat distribution. Even though ethnic groups may have the same BMI, their fat distribution might differ, which could result in a different adipokine secretion profile. Uric acid is more commonly associated with abdominal obesity than subcutaneous obesity.[24,25] Our study shows that Caucasian women have a higher mean waist circumference compared to the African women (Table 1), and since waist circumference can be used as a reliable indicator of abdominal obesity,[26,27] it can be speculated that the lower levels of uric acid in the African

Table 3. Differences in variables for the first and third uric acid tertiles

	African women			Caucasian women		
	1st tertile	3rd tertile	*P* value	1st tertile	3rd tertile	*P* value
SBP	124.77	136.28	.03	123.19	127.01	.14
DBP	75.16	81.55	.01	70.90	74.46	.09
MAP	96.74	104.70	.01	91.22	95.11	.09
TPR	1.07	1.11	.61	.88	.81	.13
C_W	1.88	1.83	.60	2.23	2.39	.07
BMI	25.90	31.31	<.01	26.03	31.36	<.01
WC	77.43	89.32	<.01	80.22	93.23	<.01
Triglycerides	.578	.918	<.01	1.199	1.470	.12
HDL	1.223	1.158	.37	1.186	1.205	.79
PAI-1	5.87	6.51	.55	9.91	17.14	<.01
Fasting insulin	84.66	113.27	.01	84.59	108.97	<.01
Fasting glucose	5.062	5.587	.12	5.027	5.064	.68
HOMA-IR	2.79	3.89	.01	2.76	3.59	.01
Leptin	49.76	73.08	<.01	38.03	66.59	<.01

SBP, systolic blood pressure; DBP, diastolic blood pressure, MAP, mean arterial pressure; TPR, total peripheral resistance, C_W, Windkessel compliance; BMI, body mass index, WC, waist circumference; PAI-1, plasminogen activator inhibitor-1; HOMA-IR, homeostasis model assessment – insulin resistance.

Table 4. Forward stepwise multiple regression analysis with uric acid as the dependent variable

Independent Variable	Beta	Partial R^2	Cumulative R^2	*P* value
African women R^2 adjusted = .259				
Triglycerides	.327	.187	.187	<.01
Leptin	.172	.061	.249	.10
Insulin	.193	.018	.267	.06
Age	.144	.014	.281	.13
Fasting glucose	.141	.015	.296	.16
Caucasian women R^2 adjusted = .220				
PAI-1	.256	.145	.145	.03
Triglycerides	.132	.023	.168	.19
Fasting glucose	.236	.017	.185	.03
BMI	.171	.025	.209	.19
Total protein intake	.148	.014	.223	.13
Fasting insulin	.257	.016	.239	.04
TPR	−.243	.018	.25	.04
C_W	−.168	.015	.272	.20
HDL	.114	.010	.282	.24

PA-1, plasminogen activator inhibitor-1; BMI, body mass index; TPR, total peripheral resistance; C_W, Windkessel compliance; HDL, high-density lipoproteins

women can be due to their lower waist circumference (abdominal obesity).

However, this finding is only valid when the total ethnic groups were compared. When the waist circumferences from the three BMI groups were compared between the two ethnic groups, significant differences were noticeable only between the overweight and obese groups and not in the lean group. Despite no difference in waist circumference for the lean group, a significant difference in uric acid levels was still noticeable. Apart from waist circumference, other factors determine circulating uric acid levels.

A possible contingent factor is dietary protein intake. A protein (purine)-rich diet will increase uric acid levels,[28,29] and according to this study, the Caucasian women had a significantly higher protein intake compared to the African women (Table 1). But even after adjusting for protein intake, there were still significant differences in uric acid levels between the two groups.

Another significant finding from this study is that when blood pressures from the first and third uric acid tertiles of each ethnic group were compared (Table 3), only the African women showed significantly higher blood pressure in the high-uric acid tertile. Thus, with an increase in uric acid levels is a concomitant increase in blood pressure in African women.

Other differences of interest between the first and third uric acid tertiles were that both ethnic groups showed that higher uric acid levels are accompanied by higher levels of obesity (BMI and waist circumfererence), leptin, and insulin resistance. Together with the higher blood pressure in the third tertile of the African women, we see that higher uric acid levels are closely associated with higher risk for the metabolic syndrome or type 2 diabetes, especially in the African women. However, we cannot determine from the results of this study the cause-effect relationship.

The data from this study also show a significant increase in PAI-1 levels with an increase in uric acid levels in the Caucasian women (Table 3). A possible explanation might be the antioxidant properties of uric acid,[30] which would result in a protective effect against the atherogenic properties of PAI-1. This finding might explain why no cardiovascular dysfunction was present in the Caucasian women, despite their high levels of both uric acid and PAI-1.

Waist circumference (abdominal obesity) seems to be the strongest obesity marker associated with elevated levels of uric acid. Despite their higher levels of uric acid, the cardiovascular profile of Caucasian women seems not to be affected detrimentally, but the African women showed a less favourable cardiovascular profile.

A limitation of this study is that the estrogen levels and the menstrual phase of the subjects were not determined. Uric acid levels in women are influenced by estrogen and the menopausal phase.[31,32] Estrogen acts as a uricosuric,[23] and it is therefore important that with future studies, the menstrual phase and estrogen levels should be determined.

Because different fat depositions are associated with different adipokine profiles, the fat distribution, expressed in terms of waist circumference, may explain the significantly lower levels of uric acid in African women. Despite their significant lower mean uric acid levels, the African women showed a significant increase in blood pressure with an increase in uric acid levels. Even though uric acid was lower in the African women, it seems to be integrated with other cardiometabolic risk factors.

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REFERENCES

1. Seedat YK. Hypertension in Black South Africans. *J Hum Hypertens*. 1999;13(11): 96–103.
2. Van Rooyen JM, Kruger HS, Huisman HW, Wissing MP, Margetts BM, Venter CS. An epidemiological study of hypertension and its determinants in a population in transition: the THUSA study. *J Hum Hypertens*. 2000; 14(12):779–787.
3. Opie LH, Seedat YK. Hypertension in sub-Saharan African populations. *Circulation*. 2005;112(23):3562–3568.
4. Vorster HH, Venter CS, Wissing MP, Margetts BM. The nutrition and health transition in the North-West Province of South Africa: a review of the THUSA (Transition and Health during Urbanization of South Africa) study. *Public Health Nutr*. 2005;8(5): 480–490.
5. Johnson RJ, Kang D, Feig D, Kiclighn S, Kanellis J, Watanbe S, et al. Is there a pathogenic role for uric acid in hypertension and cardiovascular and renal disease? *Hypertension*. 2003;41(6):1183–1190.
6. Longo-Mbenza B, Luila EL, Mbete P, Vita EK. Is hyperuricemia a risk factor of stroke and coronary heart disease among Africans? *Int J Cardiol*. 1999;71(1):17–22.
7. Chien KL, Hsu HC, Sung FC, Su TC, Chen MF, Lee YT. Hyperuricemia as a risk factor on cardiovascular events in Taiwan: The Chin-Shan community cardiovascular cohort study. *Atherosclerosis*. 2005;183(1):147–155.
8. Hozawa A, Folsom AR, Ibrahim H, Javier Nieto F, Rosamond WD, Shahar E. Serum uric acid and risk of ischemic stroke: the ARIC study. *Atherosclerosis*. 2006;187(2):401–407.
9. Uric acid: a new look at an old risk marker for cardiovascular disease, metabolic syndrome, and type 2 diabetes mellitus: the urate redox shuttle. Available at: http://www.nutritionandmetabolism.com.content/1/1/10. Accessed 7/19/2005.
10. Schutte AE, Kruger HS, Wissing MP, Underhay C, Vorster HH. The emergence of the metabolic syndrome in urban obese African women: The POWIRS study. *S Afr J Sci*. 2005;101(1/2):61–67.
11. World Health Organization. Obesity, preventing and managing the global epidemic. Report of a WHO consultation on obesity, June 3–5, 1997. Geneva.
12. World Medical Association. Declaration of Helsinki: ethical principles for medical research involving human subjects. Available at: http://www.wma.net/e/policy/b3.htm. Accessed 4/12/2006.
13. Wesseling KH, Jansen JR, Settles JJ, Schreuder JJ. Computation of aortic flow from pressure in humans using a nonlinear, three-element model. *J Appl Physiol*. 1993;74(5):2566–2573.
14. Silke B, McAuley D. Accuracy and precision of blood pressure determination with the Finapres: an overview using resampling statistics. *J Hum Hypertens*. 1998;12(6):4093–4096.
15. Schutte AE, Huisman HW, Van Rooyen JM, Malan NT, Schutte R. Validation of the Finometer device for measurement of blood pressure in black women. *J Hum Hypertens*. 2004;18(2):79–84.
16. Imholz BP, Wieling W, Van Montfrants GA, Wesseling KH. Fifteen years of experience with finger arterial pressure monitoring: assessment of the technology. *Cardiovasc Res*. 1998;38(3): 605–616.
17. Langewouters GJ, Settles JJ, Roelandt R, Wesseling KH. Why use Finapres or Portapres rather than intra-arterial or intermitted non-invasive techniques of blood pressure measurement. *J Med Eng Technol*. 1998;22(1):37–43.
18. Norton K, Olds T. *Anthropometrica: a Textbook of Body Measurements for Sports and Health Courses*. Sydney: UNSW Press; 1996.
19. De Ridder JH. Die grondaspekte van kinantropometrie: 'n Handleiding vir studente. 3de Uitgawe.
20. Matthews DR, Hosker JP, Rudenski AS, Naylor DF, Treacher DF, Turner RC. Homeostasis model assessment: insulin resistance and β-cell function from fasting plasma glucose and insulin concentrations in man. *Diabetologia*. 1985;28(7):412–419.
21. Watanabe S, Kang DH, Feng L, et al. Uric acid, hominoid evolution, and the pathogenesis of salt-sensitivity. *Hypertension*. 2002; 40(3):355–360.
22. Hochberg MC, Thomas J, Thomas DJ, Mead L, Levine DM, Klag MJ. Racial differences in the incidence of gout. *Arthritis Rheum*. 1995;38(5):628–632.
23. Alderman MH. Uric acid and cardiovascular risk. *Curr Opin Pharmacol*. 2002;2(2): 126–130.
24. Takahashi S, Yamamoto T, Tsutsumi Z, Moriwaki Y, Yamakita J, Higashino K. Close correlation between visceral fat accumulation and uric acid metabolism in healthy men. *Metabolism*. 1997;46(10):1162–1165.
25. Miyatake N, Kogashiwa M, Wang DH, Kira S, Yamasato T, Fujii M. The relationship between visceral adipose tissue accumulation and biochemical tests in university students. *Acta Med Okayama*. 2005;59(4):129–134.
26. Yusuf S, Hawken S, Ôunpuu S, et al. Obesity and the risk of myocardial infarction in 27,000 participants from 52 countries: a case-case control study. *Lancet*. 2005;366(9497): 1640–1649.
27. Dagenais GR, Yi Q, Mann JF, Bosch J, Pogue J, Yusuf S. Prognostic impact of body weight and abdominal obesity in women and men with cardiovascular disease. *Am Heart J*. 2005;149(1):54–60.
28. Choi HK, Liu S, Curhan G. Intake of purine-rich foods, and dairy products and relationship to serum levels of uric acid: the Third National Health and Nutrition Examination Survey. *Arthritis Rheum*. 2005;52(1):283–289.
29. Fam AG. Gout: excess calories, purines, and alcohol intake and beyond. Response to a urate-lowering diet. *J Rheumatol*. 2005; 32(5):903–905.
30. Spitsin SV, Scott GS, Mikheeva R, et al. Comparison of uric acid and ascorbic acid in protection against EAE. *Free Radic Biol Med*. 2000;33(10):1363–1371.
31. Simon JA, Lin F, Vittinghoff E, Bittner V, for the Heart and Estrogen-Progestin Replacement Study (HERS) Research Group. The relation of postmenopausal hormone therapy to serum uric acid and the risk of cardiovascular heart disease events: the Heart and Estrogen-Progestin Replacement Study (HERS). *Ann Epidemiol*. 2006;16(x):138–145.
32. Wingrove CS, Walton C, Stevenson JC. The effect of menopause on serum uric acid levels in non-obese healthy women. *Metabolism*. 1998;47(4):435–438.

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