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Original Research Article

Relationship between uric acid, blood pressure and anthropometric indices in a healthy Ghanaian adult population

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ABSTRACT

Background: Age- and sex-dependent variations in the relationship between uric acid and blood pressure and anthropometric indices have been reported in some populations. However, this has not been studied in a Ghanaian adult population.
Methods: Body mass index, waist circumference, blood pressure and serum uric acid levels were measured. Categorical differences were analysed with chi-square. Differences between groups were assessed by t-test and one-way analysis of variance. Association between serum uric acid and baseline characteristics of age, body mass index, waist circumference and blood pressure was assessed by Pearson's correlation. Statistical significance was pegged at $p<0.05$.
Results: Prevalence of hyperuricemia was 3.2%. There was no significant difference in prevalence of hypertension between males (28.6%) and females (28.9%). General obesity and central obesity prevalence were significantly higher among females. In males, serum uric acids levels had statistically non-significant positive correlations with age, blood pressure, waist circumference and body mass index. In females, the results showed that among women less than 45 years, serum uric acid had significant positive correlations with only body mass index and waist circumference. However, significant positive correlations were observed between all the baseline parameters and uric acid among women who are 45 years and above.
Conclusions: Increasing serum uric acid levels are significantly associated with higher blood pressure, body mass index and waist circumference. This relationship is stronger in females than in males, with the age group ≥45 years being the main determinant of this relationship.

Keywords: Uric acid, Blood pressure, Body mass index, Waist circumference, Ghanaians, Adults

INTRODUCTION

Uric acid (UA) is the end product of purine degradation.[1] The pool of purines in the body is from a combination of both exogenous and endogenous sources. There are significant variations in the exogenous pool derived predominantly from the diet whiles the endogenous production of uric acid is mainly from live and dying cells from the liver, intestines and other tissues like muscles, adipose tissue, kidneys and the vascular endothelium.[1] UA plays a bi-metabolic role in the pro-oxidant/antioxidant system. UA possesses a free-radical-scavenging property, accounting for over 50% of total antioxidant capacity of the plasma.[2] Under conditions of oxidative stress, however, UA may also act as a pro-oxidant.[3] It was hypothesized in the original description of essential hypertension that uric acid may be an integral factor in the eventual development of essential hypertension.[4] Subsequently, many studies have reported findings suggestive of agreement to the hypothesis.[5-7] Despite these observations, the lack of a direct causal mechanism has led to it being largely ignored in medical practice. Facchini et

al have suggested the plausible mechanistic processes through which insulin action could enhance serum uric acid (SUA) concentration.[8] In several longitudinal studies in different populations, hyperuricemia has been reported as a strong independent risk factor of hypertension in adults, children and even as a predictor of the metabolic syndrome (MS).[9-11] Currently, a growing body of evidence tend to support the role of hyperuricemia as the link between hypertension and MS.[12,13]

Previous studies have also suggested that age-specific differences exist in the relationship between SUA concentration and blood pressure. For example, the relationship between SUA concentration and blood pressure was reported to be absent in a cohort of Chinese adults aged over 90 years.[14] Similarly, it was reported that high SUA concentrations were associated with high blood pressure in Korean participants aged <60 years but not older, whereas this association was observed in only Japanese participants aged ≥40 but not <40 years old.[15,16] In another study involving a cohort of Chinese adults, this relationship was only significant in the age group 41 to 50 years.[17] Additionally, there are established gender differences in uric acid levels and, SUA levels have been reported to be positively associated with obesity in several populations.[18,19] This suggests the possibility of age- and sex-dependent variations in the relationship between SUA and blood pressure and anthropometric indices in different populations.[20] These variations in the relationship between uric acid, blood pressure and anthropometric indices however, has not been previously studied in a Ghanaian population.

The overall aim of the study was to investigate the relationship between serum uric acid level and blood pressure and anthropometric indices in a healthy Ghanaian adult population.

METHODS

Participants

Eligibility criteria

Smoking, Pregnant, lactating mothers, use of antihypertensive or antihyperuricemic drugs, history of gout, cardiac, renal disease, diabetes mellitus, dyslipidaemia or any other chronic condition were used as exclusion criteria.

Study design and protocol

Prospective subjects were invited for a health education seminar and screening after which the purpose and procedures of the study were thoroughly explained to them. A structured questionnaire was then used to select eligible consenting subjects. The cross-sectional study was conducted at the Kintampo municipality, involving a total of 250 individuals who met the eligibility criteria for inclusion in the study.

Measurements

Anthropometric measurements

Height was measured to the nearest 0.1 cm by Seca stadiometer and weight was measured to the nearest 0.1 kg by modern electronic digital weighing machine (Beurer BF 700, Germany) wearing light clothing and no shoes. The body mass index (BMI) was calculated as the weight (in kg) divided by the body height (in m^2). Waist circumference was measured midway between the lowest border of the ribs and iliac crest in the horizontal plane to the nearest 1cm with an inelastic tape. General obesity was defined as BMI ≥30 kg/m^2. Central obesity was defined as ≥94 cm for men and ≥80 cm for women.

Blood pressure

After at least five minutes of rest, two blood pressure measurements were taken with OMRON 907 (OMRON, Hoofdorrp, Netherlands). The mean of the two readings was recorded and used for our analysis. Hypertension was defined as a systolic blood pressure ≥140 mmHg and or diastolic pressure ≥90 mmHg.

Serum uric acid

Serum uric acid was measured with Mindray BS-200E. Hyperuricemia was defined as SUA concentration >416.4 µmol/l in men or >356.9 µmol/l in women.[21]

Data analysis

Data were recorded on an excel sheet and analysed with GraphPad prism version 8.0.2. Continuous variables are presented as mean±standard deviation and simple percentages. Categorical differences were analysed with chi-square. Differences between groups were assessed by t-test and one-way analysis of variance (ANOVA). Association between serum uric acid and baseline characteristics of age, BMI and blood pressure was assessed by Pearson's correlation. Statistical significance was pegged at p value <0.05.

Ethical issues

The institutional review committee approved the study. Participation was solely on voluntary consent. No personal records of the participants were obtained. All procedures were carried out in accordance with the Helsinki declaration.

RESULTS

General characteristics of the study participants

The study population was made up of 84 (33.6%) males and 166 (66.4%) females with no significant age difference. The results showed that the mean serum uric acid level in men was significantly higher than females

whilst BMI and waist circumference were significantly higher in females. However, there were no significant differences in terms of systolic and diastolic blood pressures (Table 1).

Age and sex distribution of baseline characteristics

The results showed that among men, there was no significant difference between the age groupings in terms of uric acid levels, BMI and waist circumference. However, both systolic and diastolic blood pressures were significantly higher in men older than 45 years. The results among women showed that uric acid, blood pressure and anthropometric parameters were all significantly higher among the age group older than 45 years (Table 2).

Prevalence of hyperuricemia, hypertension and obesity in the study population

The distributions of hyperuricemia, hypertension and obesity in the study population showed no significant difference in prevalence of hyperuricemia and hypertension between men and women. However, the prevalence of general obesity and central obesity were significantly higher among women than men (Table 3).

Table 1: General characteristics of the study participants.

Parameter	Males	Females	p value
Number (%)	84 (33.6)	166 (66.4)	
Age (years)	38.0±14.4	37.8±14.2	0.917
Systolic blood pressure (mmHg)	131.5±14.4	128.1±17.3	0.123
Diastolic blood pressure (mmHg)	77.7±11.6	80.4±12.7	0.104
BMI (kg/m^2)	25.3±3.6	26.7±5.4	0.033
Waist circumference (cm)	86.2±7.8	89.9±11.6	0.0009
Serum uric acid (µmol/l)	289.2±75.2	210±61.5	<0.0001

Results are presented as mean±standard deviation

Table 2: Age and sex distribution of baseline characteristics.

Groups	Males			Females		
Parameter	**<45 years**	**≥45 years**	**P value**	**<45 years**	**≥45 years**	**P value**
Uric acid (µmol/l)	290.0±73.1	286.1±81.9	0.832	199.2±50.5	237.1±75.2	0.0002
Systolic BP (mmHg)	128.6±12.1	139.0±16.9	0.002	123.7±14.9	138.1±19.7	<0.0001
Diastolic BP (mmHg)	75.8±11.6	82.5±10.3	0.016	78.1±12.0	85.7±12.6	0.0003
BMI (kg/m^2)	24.5±2.7	25.8±4.2	0.096	25.2±4.9	29.9±5.3	<0.0001
WC (cm)	86.8±7.1	84.7±9.2	0.265	86.5±9.7	97.6±12.1	<0.0001

Results are presented as mean±standard deviation, BP: blood pressure, WC: waist circumference

Table 3: Prevalence of hyperuricemia the study population.

Variable	Males (%)	Females (%)	Odds ratio	95% CI	P value
Hyperuricemia	4 (4.8)	4 (3.5)	1.93	0.55 to 6.74	0.354
Hypertension	24 (28.6)	48 (28.9)	0.98	0.54 to 1.78	0.955
General obesity	4 (4.8)	34 (20.5)	0.19	0.07 to 0.56	0.011
Central obesity	11 (13.1)	136 (81.9)	0.03	0.03 to 0.02	<0.0001

Table 4: Characteristics of subjects according to serum (uric acid stratifications µmol/l).

Parameters	Serum uric acid groups (µmol/l)				
	<139	**139-208**	**209-357**	**>357**	**P value**
Age (years)	32.3±10.9	35.5±12.4	38.5±14.1	45.9±19.1	0.006
Systolic BP (mmHg)	120.7±13.4	124.2±14.0	131.7±17.2	138.4±17.3	<0.0001
Diastolic BP (mmHg)	78.7±13.3	78.0±9.8	80.0±13.2	82.1±13.7	0.511
BMI (kg/m^2)	24.9±3.3	25.1±5.3	26.4±4.6	28.3±5.7	0.027
WC (cm)	83.1±7.2	86.0±10.1	90.2±10.7	92.4±11.4	0.001

Results are presented as mean±standard deviation, BP: blood pressure, BMI: body mass index, WC: waist circumference

Table 5: Correlation between uric acid and baseline parameters in males.

Groups	Age <45 years		Age ≥45 years	
Parameter	**r**	**P value**	**r**	**P value**
Age (yrs)	0.144	0.274	0.069	0.748
Systolic blood pressure	0.246	0.058	0.345	0.099
Diastolic blood pressure	0.232	0.074	0.215	0.313
BMI	0.229	0.079	0.087	0.685
Waist circumference	0.234	0.055	0.396	0.056

Table 6: Correlation between uric acid and baseline parameters in females.

Groups	Age <45 years		Age ≥45 years	
Parameter	**r**	**P value**	**r**	**P value**
Age (yrs)	0.162	0.085	0.478	0.0004
Systolic blood pressure	0.150	0.109	0.389	0.005
Diastolic blood pressure	0.050	0.599	0.325	0.020
BMI	0.189	0.043	0.469	0.0005
Waist circumference	0.267	0.004	0.489	0.0003

Association of baseline characteristics with serum uric acid stratifications

The ANOVA trend results showed that increasing age, systolic blood pressure, BMI, and waist circumference are all significantly associated with increased serum uric acid levels (Table 4).

Correlation between uric acid and baseline parameters

The results showed that in males, serum uric acids levels had statistically non-significant positive correlations with age, blood pressure, BMI and waist circumference. In females, the results showed that among women less than 45 years, serum uric acid had significant positive correlations with only BMI and waist circumference. However, significant positive correlations were observed between all the baseline parameters and uric acid among women who were in the age group of 45 years and above (table 5 and 6).

DISCUSSION

A summary of the major findings in the present study point to the importance of age- and sex-dependent variations in the relationship between serum uric acid and blood pressure and anthropometric indices. This is the first study that investigated the age- and sex-specific variations in the association of anthropometric indices, uric acid and blood pressure in a cohort of healthy Ghanaians. The mean uric acid level in men was significantly higher than females, consistent with many findings in different populations.[19,22,23] The prevalence of hyperuricemia and hypertension in the present study were 3.2% and 28.9% respectively, with no significant difference in male and female distributions. The prevalence distribution of general obesity and central obesity being significantly higher in females was consistent with other works.[24,25] The results showed that increasing age is associated with higher levels of uric acid in the overall study population. However, this association was mainly significant in women older than 45 years but not in men. A similar finding of significant positive correlation of uric acid levels with age among women has also been reported in another study.[22] In the present study, increasing blood pressure was observed to be positively associated with higher uric acid levels. Increasing levels of uric acid levels have been reported to be significantly associated with higher levels of blood pressure and hypertension in different population.[15-17,26] The ANOVA trend results showed that higher BMI and waist circumference were both positively associated with increased serum uric acid levels. These findings have also been reported in previous studies.[15,27-29] Additionally, SUA levels are increased both in individuals with subcutaneous fat obesity and in those with visceral fat obesity.[31] Many reports have suggested that the visceral adipose tissue is pathologically active and may impair the regulation of adipocytokine levels. Dysregulation of adipocyte metabolism is hypothesized to alter uric acid transport in the renal tubules, reducing urinary excretion and urinary sodium excretion leading to hyperuricemia.[8,32-34] Obesity is being hypothesized as a causal mediator of hyperuricemia/elevated SUA-associated hypertension. However, few studies have investigated the relationship between SUA and the risk of hypertension for different obesity criteria. In the study of Han el al obese hyperuricemic individuals were observed to have a significantly increased risk of hypertension as compared to the healthy subjects, and this combined risk was much higher than any of the single risk factors alone.[35] Similar findings have also been reported in other populations.[27,36] Reports have suggested that the strength of the relationship between SUA and hypertension becomes attenuated as the duration of hypertension gets longer.[15] In summary, the results showed that in males, serum uric acids levels had statistically non-significant positive correlations with age, blood pressure, BMI and

waist circumference. In females, the results showed that among women less than 45 years, serum uric acid had significant positive correlations with only BMI and waist circumference. However, significant positive correlations were observed between uric acid and BMI, waist circumference and blood pressure among women who are 45 years and above. This relationship between serum uric acid concentration and blood pressure was reported to be absent in a cohort of Chinese participants aged over 90 years.[14] Similarly, it was reported that high serum uric acid concentrations were associated with high blood pressure in Korean participants (women aged <40 years and men <60 years, whereas this association was only present in Japanese participants aged ≥40 but not <40 years old.[15,16] In another cohort of Chinese adults, the relationship was observed only in the age group 41 to 50 years.[17] However, the main metabolic mechanisms are not well-defined. Though the age- and sex-specific differences in uric acid levels vary in different populations, aside ethnic differences, the main factor appears to be hormonal, with the female hormone (estrogen) being the key metabolic culprit.[20] The physio-metabolic events occurring over the life-span of female development influence hormonal levels, especially the factor of estrogen levels. Sumino et al have reported that estrogens have an impact on the renal tubular handling of uric acid by increasing renal clearance of uric acid and this may possibly explain the underlying difference in uric acid levels between pre- and postmenopausal women.[37] In addition, a recent study has suggested that the association of insulin resistance and SUA levels may be greater in postmenopausal women than premenopausal women.[38] The interplay between these associations however remains to be clearly defined.

Limitations

This study has a few limitations. First, the cross-sectional design precludes any causal relationships between obesity-linked serum uric acid levels and hypertension being hypothesized. Secondly, the study did not directly take into account other potential confounders like lipid profile, fasting blood glucose, kidney function, dietary and alcohol consumption patterns by direct measurements but, rather exclusion was done through history taking.

CONCLUSION

The study revealed significant differences in the relationship between serum uric acid levels and blood pressure and anthropometric indices among the Ghanaian adults population. There is no significant gender difference in the prevalence of hyperuricemia in the population. Increasing serum uric acid levels are significantly associated with higher blood pressure, BMI and waist circumference. This relationship is stronger in females than in males, with the age group ≥45 years being the main determinant of this relationship.

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