ASIAN JOURNAL OF PHARMACEUTICAL AND CLINICAL RESEARCH

INNOVARE ACADEMIC SCIENCES
Knowledge to Innovation

Vol 11, Issue 9, 2018

Online - 2455-3891
Print - 0974-2441

Research Article

ASSESSMENT OF SERUM AND URINE URIC ACID LEVEL IN RELATION WITH ANTHROPOMETRIC INDICES IN OVERWEIGHT AND OBESE UNIVERSITY UNDERGRADUATE STUDENTS

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Received: 20 June 2018, Revised and Accepted: 27 July 2018

ABSTRACT

Objectives: Elevated uric acid level is related to a variety of adverse metabolic conditions including gout, obesity, and risk factor for cardiovascular diseases. This prospective study designed to assess the serum and urine uric acid level in relation with anthropometric indices in overweight and obese undergraduate students at NAU, Nnewi, Nigeria.

Methods: A total of 302 undergraduate students aged between 18 and 40 years were randomly recruited for the present study. They were grouped based on their body mass index (BMI) as overweight, obese, and control participants. 132 participants were males, of which 21 were obese, 34 were overweight while 77 were normal (control) males. 170 participants were females, of which 56 were obese, 62 were overweight while the remaining 52 were normal (control) females. Fasting blood and 24 h urine sample were aseptically collected from all the participants for determination of serum and urine uric acid.

Results: The study observed significantly higher serum uric acid level in obese and overweight males than female and control counterparts (p=0.000, respectively). Urine uric acid level was significantly higher in obese males and females than in their overweight and control counterparts (p=0.000). This shows increase production and accumulation of monosodium urate with decreased uric acid excretion which may result in hyperuricemia and hyperuricosuria which may result in gout. Serum and urine uric acid levels were significantly higher among age range (26–32) and (33–40) years compared with those among age range (18–25) ($p<0.05$) signifying that uric acid level increases with age. Serum and urine uric acid were significantly positively correlated with BMI, waist circumference, and waist hip ratio ($p<0.05$).

Conclusions: High serum uric acid is a prerequisite for gout and also associated with the metabolic syndrome and risk factors for cardiovascular disease. Proper awareness of the implication of hyperuricemia among undergraduate students is necessary.

Keywords: Uric acid, Anthropometric indices, Overweight, Obesity, Undergraduate students.

 DOI: http://dx.doi.org/10.22159/ajpcr.2018.v11i9.27995

INTRODUCTION

Uric acid is originated from enzymatic degradation and metabolic conversion of exogenous or endogenous purines in the liver and intestine. It is excreted in urine through the kidney as the by-product of amino acid (purines) metabolism in humans [1]. Uric acid is a weak acid with a high dissociation constant and can exist in plasma as the monovalent sodium salt in the form of monosodium urate [2]. Some studies have indicated that variation in serum uric acid is genetic and could be affected by several genes [3-5]. When the saturation threshold of uric acid in body fluids (serum or urine) is exceeded, hyperuricemia or hyperuricosuria, respectively, occurs. The average urate pool in healthy adults is estimated to be 1200 mg with a mean turnover rate of 700 mg/day. Hyperuricemia was established as serum uric acid level >450 μmol/L for males and >390 μmol/L for females while hyperuricosuria was defined as urine uric acid level >1000 mg/24 h assuming for normal diets and <600 mg/24 h assuming low purine diets [6-8]. Excessive production and accumulation of monosodium urate with a reduction in the urinary excretion lead to high level of uric acid in body fluids. This results in the formation and continual deposition of the crystals in and around the joints and tissues thereby causing severe pains and inflammation in the joints and subsequently leads to impaired health [9-11]. Elevation of uric acid is associated with a variety of metabolic diseases including inflammatory gout, hypertension and cardiovascular death, renal disease, atherosclerosis, and ischemic heart disease [12-19]. Several modifiable risk factors have been linked with hyperuricemia; these include starvation, body mass index (BMI), obesity, waist circumference (WC), high purine, and fructose-rich diets [20,21]. Serum uric acid may be grossly elevated in starvation due to accelerated tissue turnover and reduced renal excretion of uric acid [22]. Impaired kidney function leads to impaired uric acid excretion in the urine [23].

Uric acid level in body fluid can vary with height, body weight, kidney function, and alcohol intake in healthy men [24]. Reports have associated elevated serum uric acid levels with BMI and WC [2,19,25]. However, Sivakumar *et al.* reported that serum uric acid was not significantly correlated with BMI [2]. BMI is an index of weight and height which is used in classifying overweight and obesity in the adult population and individuals. Overweight and obesity are defined as abnormal or excessive fat accumulation due to excess calorie intake; several authors have reported a significant positive association between elevated serum uric acid levels, overweight, and obesity [18,26-28]. Obese individuals, due to excess calorie intake, get impaired kidney excretion leading to the hyperuricemia [29]. The pathogenic factors responsible for the elevated uric acid level in obesity have been implicated to lecithin concentration

and decreased urinary excretion of its metabolites [30,31]. However, the mechanism behind impaired urate excretion in obese individuals and its improvement during weight reduction remains to be determined.

The average urate pool in healthy adults is estimated to be 1200 mg with a mean turnover rate of 700 mg/day. It has been indicated that the level of serum uric acid is lower in women than in men [29,32,33]. However, a study has shown that obesity-related hyperuricemia can be treated with only appropriate diet therapy without drugs in most cases [34]. The present study, therefore, sets to assess the serum and urine uric acid levels in relation with anthropometric indices among overweight and obese university undergraduate students at Nnamdi Azikiwe University Nnewi Campus Nigeria.

METHODS

Study design

This is a cross-sectional prospective study designed to assess the serum and urine uric acid levels in relation with anthropometric indices among overweight and obese undergraduate students at Nnamdi Azikiwe University, College of Health Sciences, Nnewi Campus, Anambra State, Nigeria.

Study population

The study population consisted of 302 apparently healthy male and female students. They were randomly recruited and grouped based on their BMI as obese >30 kgm^2, overweight 25–29.9 kgm^2, and control <25 kg^2 [35]. The study was conducted between March and May, 2017.132 participants were males, of which 21 were obese, 34 were overweight while 77 were normal (control) males. 170 participants were females of which 56 were obese, 62 were overweight while the remaining 52 were normal (control) females.

Inclusion criteria

Apparently healthy adult male and female undergraduate students aged between 18 and 40 years were recruited for the study.

Exclusion criteria

Students with any known disease conditions, for example, liver and kidney disease diabetics or those taking alcohol, medications that may affect the level of uric acid in serum and urine, for example, diuretic. Pregnant women and lactating mothers were excluded.

Sample collection

5 ml of blood was collected by venepuncture from the subjects following overnight fasting on the morning of completing urine collection and dispensed into a plain container for centrifugation at 5000 rpm for 5 min. Serum was extracted for the estimation of serum uric acid. The samples were refrigerated at −20°C until analyzed. 24 h urine specimen was collected aseptically from all the participants without dietary regulation except for alcohol and medications.

Ethical consideration

Ethical clearance for the study was obtained from the Ethics committee of Nnamdi Azikiwe University Teaching Hospital, Nnewi, as well as Faculty of Health Science and Technology, College of Health Sciences, Nnamdi Azikiwe University, Nnewi Campus Nigeria. The informed consent was obtained from the subjects, and their participation was voluntary.

Sample processing and storage

The blood sample was withdrawn from the antecubital vein by means of sterile plastic syringes into a plain container and was allowed to clot. Later, the tubes were centrifuged for 10 min for proper separation of the serum. After centrifugation, the serum samples were separated and used stored frozen at −20°C until the analysis of serum uric acid. 24 h urine sample was collected with the universal container and was stored frozen until analysis urine uric acid.

Sample analysis

Estimation of uric acid;

The serum uric acid and urine uric acid levels were measured by the uricase method [36].

Principle

$$\text{Uric acid} + O_2 + 2H_2 \xrightarrow{\text{uricase}} \text{Allantoin} + CO_2 + H_2O_2$$

$$2H_2O_2 + \text{4-Aminoantipyrine} + \text{DHBS} \xrightarrow{\text{peroxidase}} \text{chromogen} + 4\,H_20$$

Uric acid is converted by uricase into allantoin and hydrogen peroxides. The hydrogen peroxide initiates the coupling of 4-aminoantipyrine to 3,5-dichloro-2-hydroxybenzene sulfonic acid to form the chromogen which is measured at 520 nm and which is proportional to the amount of hydrogen peroxide generated from uric acid.

Anthropometric measurement

The BMI was calculated by dividing the weight (kg) by height square (m^2) [37].

WC was measured twice in millimeters, using the smallest circumference between the lower ribs and iliac crests. WC <80 cm for females and <90 cm for males were defined as the reference values [38]. Hip circumference was measured using the greatest circumference between the iliac crest at the level of the umbilicus and thigh at the level of maximal protrusion of the gluteal muscles at the widest circumference. Waist-hip ratio (WHR) was calculated as the ratio of WC to hip circumference.

The average of the two measurements for each variable was then used in the analyses. Body fat composition was estimated by bioelectrical impedance technology (Valhalla Scientific, San Diego, CA).

Statistical analysis

Data generated from the study were subjected to statistical analysis using the Statistical Package for the Social Sciences version 20.0. The result was expressed as a mean±standard deviation; the statistical difference between groups was done using analysis of variance (ANOVA) with *post hoc* (least standard deviation). Pearson's correlation analysis was used for association between variables. The differences were considered significant at $p<0.05$.

RESULTS

The mean BMI was significantly higher in obese males and females (30.92±4.90 and 29.18±4.10) when compared with overweight (26.71±4.80 and 25.08±3.50) and control (22.89±2.91 and 22.10±3.09), and significantly higher in overweight than control participants (P=0.000, respectively). Similarly, the WC was significantly higher in obese males and females (105 61±12.10 and 94.77±4.32) when compared with their overweight (95.12±10.04 and 86.46±9.01) and control (76.99±4.11 and 72.69±2.90) counterparts (p=0.000, respectively). The mean value of WHR was also significantly higher in obese males and females (0.99±0.84 and 0.89±0.07) compared with their corresponding overweight (0.90±0.51 and 0.81±0.06) and control (0.78±0.34 and 0.75±0.04) participants (p=0.000, respectively) (Table 1).

Levels of serum uric acid levels and urine uric acid in obese overweight and control male and female participants

When the mean serum uric acid and urine uric acid levels were compared among all the participants, the mean serum uric acid level in obese and overweight males (382.83±87.64 and 356.63±85.40) was significantly higher when compared with obese female (277.78±78.90), overweight female (220.80±68.30), control male (289.72± 66.96), and control female (193.70±56.83) participants (p=0.000, respectively).

Similarly, the mean urine uric acid level in obese males and females (1059.74±399.91 and 1035.22±395.64) was significantly higher when compared with overweight female (914.20±351.52), control male (886.94±349) and female (877.62±291.74) participants (p=0.000).

Table 1: Demographic characteristics of all the study participants

Anthropometric parameters	Overweight (males, n=34, females, n=62)	Obese (males, n=21, females, n=56)	Control (males, n=77, females, n=52)	p value
Age (years) males	22.99±1.29	22.08±2.44	22.70±1.06	0.165
Age (years) Females	21.47±2.40	21.81±1.94	21.67±3.01	0.131
BMI (kg/m^2) males	26.71±4.80	30.92±4.9	22.89±2.91	0.000
BMI (kg/m^2) females	25.08±3.50	29.18±4.1	22.10±3.09	0.000
WC (cm) males	95.12±10.04	105 61±12.10	76.99±4.11	0.000
WC (cm) females	86.46±9.01	94.77±4.32	72.69±2.90	0.000
WHR males	0.90±0.51	0.99±0.84	0.78±0.34	0.000
WHR females	0.81±0.06	0.89±0.07	0.75±0.04	0.000

p<0.05=Significant. Data were expressed as mean±SD. SD: Standard deviation, WHR: Waist-hip ratio, BMI: Body mass index, WC: Waist circumference

The mean serum uric acid level in obese male and female (382.83±87.64 and 277.78±78.97) was significantly higher when compared with their control counterparts (289.72±66.96 and 193.76±56.83) (p=0.000, respectively). Similar observation was made in the mean serum uric acid level between overweight male (356.63±85.40) control male and female (289.72±66.96 and 193.76±56.83) participants (p=0.000, respectively).

The mean urine uric acid level in obese males and females (1059.74±399.91 and 1035.22±395.64) was significantly higher when compared their corresponding control (886.94±349 and 877.62±291.74) participants (p=0.000, respectively). Similar observation was made in overweight males (984.60±352.10) when compared with control male and female (886.94±349 and 877.62±291.74) participants (p=0.001, 0.020, and 0.000, respectively). There was a significantly higher mean level of serum uric acid in control male (289.72±66.96) when compared with the female counterpart (193.76±56.83) (p=0.000) (Table 2).

Levels of serum uric acid and urine uric acid according to age ranges

The mean serum uric acid level was significantly higher among the age range 26–32 and 33–40 years (289.00±72.33 and 299.10±83.66) when compared with participants among the age range 18–25 years (238.10±72.69) (p=0.003).

Similarly, the mean urine uric acid level was significantly higher among age range 26–32 years (922.50±324.20) and 33–40 years (999.40±444.80) when compared with participants within the age range of 18–25 years (805.90±82.12) (p=0.000 and 0.003). Furthermore, the urine uric acid level was significantly higher among the age range 33–40 (999.40±444.80) when compared with those within 26–32 (922.50±324.20) years (p=0.040) (Table 3).

Correlation of serum uric acid and urine uric acid with the anthropometric parameters

Serum uric acid was significantly positively correlated with age, BMI, WC, and WHR, (r=0.289, 0.313, 0.431, 0.326, and 0.265, p=0.014, 0.032, 0.011, 0.029, and 0.041, respectively). Similarly urine uric acid was significantly positively correlated with age, BMI, and WC, (r=0.211, 0.351, and 0.549, p=0.008, 0.021, and 0.000, respectively) (Table 4).

DISCUSSION

Participants in this study were classified based on their BMI into obese (>30), overweight (25.0–29.9 kg/m^2), and normal control subjects (18.5–24.9 kg/m^2) according to the WHO classification of body mass index [35]. The present study observed significantly higher serum uric acid in obese and overweight males when compared with their female counterparts and controls. This is consistent with the other reports [19, 39,40]. This is an indication of increase formation and deposition of monosodium urate crystals in and around joints suggesting the future risk of development of gout [10] as well as other adverse conditions associated with hyperuricemia [12-18]. Increased serum uric acid levels in these participants may also be due to reduced renal clearance and excessive secretion and production of uric acid by the adipose tissue through xanthine oxidoreductase. Several researchers have also observed elevated levels of serum and urine uric acid level in both men and women [41-43]. In women, the sexual dimorphism in serum uric acid level was thought to be related to higher renal clearance of urate, possibly due to their higher plasma estrogen levels [41,44,45]. However, our study observes that obese male and female participants had significantly higher serum uric acid than the control female. This is similar to the report of Oyama *et al*. [46]. Our study also observed significantly higher serum and urine uric acid levels in males when compared with females. This shows that variation on the uric acid level is sex-dependent. Increase serum uric acid in apparently healthy males than females have been previously reported [5,41,47]. There have been reports of overwhelming increases in the prevalence of gout disease globally [42,48,49]. Gout has been previously linked with some metabolic disorders including coronary heart disease and cardiovascular death in females [50,51] while the risk factors for gout include obesity, metabolic Syndrome WHR, renal disease, and use of medications [52-56]. However, variation in body weight can modify the various risk factors for metabolic syndrome [57]. Previous reports have reported an increased prevalence of obesity in female undergraduate students [58,59]. Obesity is characterized by excess body fat, and this excess body fat induces a variety of cardiovascular disease risk factors such as insulin resistance, hypertension, dyslipidemia, and endothelial dysfunction [60].

In the present study, participants were grouped into age ranges 18–25 years, 26–32 years, and 33–40 years. Comparison of the serum and urine uric acid levels among participants within age range 26–32 and 33–40 years were significantly higher when compared with age range 18–25 years and significantly higher in age range 33–40 than 26–32 years. This study revealed that uric acid level tends to increase with age. This is consistent with previous reports [41,61].

The present study showed that SUA and UUA were positively correlated with age, BMI, WC, and WHR. These findings are in line with previous reports [5,62,63]. The WC and WHR are measures of visceral adiposity and body fat accumulation [64]. The study has shown that excess free fatty acid production as a result of increased in visceral fat might indirectly affect uric acid production through common pathways involving nicotinamide adenine dinucleotide phosphate [65]. Increased visceral fat might contribute to decreased uric acid excretion this can result to metabolic syndrome as well as other cardiovascular risk factors [66,67]. It has been indicated that WC is stronger biomarker for obesity than BMI. Elevated WC and BMI are associated with increased insulin resistance, and this decreases the kidney excretion of uric acid thereby increasing its concentration [2]. The elevated and significant positive correlation between uric acid and WC was also attributed to increase concentration of leptin with reduced urinary excretion [31,68] thereby leading to increased uric acid concentration in obese individuals.

CONCLUSION

The study concludes that there was significantly higher serum uric acid level in obese and overweight male than their female counterparts and controls. The mean urine uric acid level was also significantly higher in obese male and females than in their overweight and

Table 2: Levels of serum uric acid levels and urine uric acid in obese and non-obese male and female participants

Group	Serum uric acid (µmol/L)	Urine uric acid (µmol/L)
Obese male (A) n=21	382.83±87.64	1059.74±399.41
Obese Female (B) n=56	277.78±78.97	1035.22±395.64
Overweight male (C) n=34	356.63±85.40	984.60±352.10
Overweight female (D) n=62	220.80±68.30	914.20±351.52
Control male (E) n=77	289.72±66.96	886.94±349.36
Control female (F) n=52	193.76±56.83	877.62±291.74
F value	13.63	7.62
P value	0.000	0.000
A versus B	0.000	0.000
A versus C	0.327	0.118
A versus D	0.001	0.011
A versus E	0.000	0.000
A versus F	0.000	0.000
B versus C	0.000	0.251
B versus D	0.211	0.039
B versus E	0.754	0.000
B versus F	0.000	0.000
C versus D	0.000	0.870
C versus E	0.001	0.020
C versus F	0.000	0.000
D versus E	0.554	0.601
D versus F	0.344	0.499
E versus F	0.000	0.899

p<0.05=Significant. Data were expressed as mean±SD. SD: Standard deviation

Table 3: Levels of serum uric acid and urine uric acid according to age ranges

Age range	Serum uric acid (µmol/L)	Urine uric acid (µmol/L)
18–25 (years)(G) n=219	238.10±57.69	805.90±82.12
26–32 (years) (H) n=66	289.00±72.33	922.5±324.20
33–40 (years) (I) n=5	299.10±83.66	999.40±444.80
F value	4.400	5.824
p value	0.003	0.000
G versus H	0.033	0.000
G versus I	0.001	0.003
H versus I	0.811	0.040

p<0.05=Significant. Data were expressed as mean±SD. SD: Standard deviation

Table 4: Correlation of serum uric acid, urine uric acid with BMI, WC, and WHR in the study participants

Parameters	N	r value	p value
Serum uric acid versus age	302	0.289	0.014
Urine uric acid versus age	302	0.211	0.008
Serum uric acid versus BMI	302	0.313	0.032
Urine uric acid versus BMI	302	0.351	0.021
Serum uric acid versus WC	302	0.431	0.011
Urine uric acid versus WC	302	0.549	0.000
Serum uric acid versus WHR	302	0.265	0.041
Urine uric acid versus WHR versus acid	302	0.045	0.659
Serum uric acid versus urine uric acid	302	−0.149	0.139

WHR: Waist-hip ratio, BMI: Body mass index, WC: Waist circumference

control counterparts. This shows that the participants might be predisposing to hyperuricemia and hyperuricosuria which could lead to gout and subsequently results in other adverse conditions such as atherosclerosis, metabolic syndrome, as well as cardiovascular diseases. Serum and urine uric acid levels were significantly higher among the age range 26–40 years. The serum and urine uric acid levels were significantly positively correlated with age, BMI, WC, and WHR. This shows that elevated uric acid level is age- and sex-dependent. Proper awareness of the prevalence of hyperuricemia is necessary. Importance of good dietary regimens and physical exercise is highly advocated for weight reduction among university undergraduates in the study area to minimize the risk of gout.

ACKNOWLEDGMENTS

The authors wish to acknowledge all the undergraduate students of College of Health Sciences, Nnamdi Azikiwe University, Nnewi Campus, who willingly gave their informed consent to participate in the present study.

AUTHORS' CONTRIBUTIONS

1. Conceptualization and study design - Nkiruka Rose Ukibe, Solomon Nwabueze Ukibe.
2. Data collection, sample analysis and performing the experiment - Nkiruka Rose Ukibe, Emmanuel Ikechukwu Onwubuya, Ofia Anya Kalu, Obinwanne Chikamnario Osuagwu
3. Preparation of manuscript - Nkiruka Rose Ukibe, Solomon Nwabueze Ukibe,
4. Statistical Analysis - Ofia Anya Kalu, Emmanuel Ikechukwu
5. Proofreading the manuscript-Solomon Nwabueze Ukibe, Emmanuel Ikechukwu
6. All authors read and approved the final manuscript.

CONFLICTS OF INTEREST

All authors have none to declare.

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