Association of Uric Acid Levels with Arterial Stiffness in Korean Women and Non-smoking Men

Jae Woong Sull1,†, Eun Na Koh2, Sung Kweon Cho3, Hyung-Joon Bae4 and Sun Ha Jee5

1Department of Biomedical Laboratory Science, College of Health Sciences, Eulji University, Seongnam 13135, Korea
2Exercise Medicine Center for Diabetes and Cancer Patients, Yonsei University, Seoul 03722, Korea
3Department of Pharmacology, Yonsei University College of Medicine, Seoul 03722, Korea
4Department of Clinical Laboratory Science, Daejeon Institute of Science and Technology, Daejeon 35408, Korea
5Institute for Health Promotion & Department of Epidemiology and Health Promotion, Graduate School of Public Health, Yonsei University, Seoul 03722, Korea

Measuring the pulse wave velocity (PWV) is a non-invasive method for evaluating the stiffness of the vessel wall. While previous studies investigated the association of uric acid level with arterial stiffness, most did not consider smoking status and obesity as covariates. The objective of this study was to investigate the relationship between uric acid levels and arterial stiffness, considering smoking status and obesity. We studied 3390 subjects (1940 males and 1450 females). Abnormal PWV was also defined as the highest quartile of values in the subjects. Data were analyzed using Pearson correlation, t-test, and multiple regression analysis. Approximately 41.9% of men and 3.7% of women were current smokers. Prevalence of hypertension was 11.4% in men and 7.0% in women. In women, hyperuricemia was associated with abnormal PWV (OR 1.58; 95% CI 1.03–2.43). Hyperuricemia was also associated with abnormal PWV (OR 2.37; 95% CI 1.01–5.59) in non- or light male smokers with normal blood pressure. This study suggests that uric acid is associated with arterial stiffness in women and non-smoking men.

Key Words: Pulse wave velocity, Uric acid, Obesity, Smoking

INTRODUCTION

Elevated serum uric acid levels are associated with a variety of adverse health outcomes, including gout, hypertension, diabetes mellitus, and cardiovascular diseases (Richette et al., 2010). Arterial stiffness represents vascular damage and indicates the degree of atherosclerosis (Cohn, 1999). Measuring pulse wave velocity (PWV) is a noninvasive technique to assess atherosclerosis related to arterial stiffness. Previous studies have reported that the association of uric acid level with arterial stiffness remains controversial (Chen et al., 2010; Lim et al., 2010; Tsoufis et al., 2011; Fang et al., 2014; Saijo et al., 2005; Bae et al., 2013; Mulè et al, 2014). Most of these studies did not consider smoking status and obesity as covariates. Some studies reported a significant negative correlation between serum uric acid level and the smoking status (Haj Mouhamed et al., 2011; Slater et al., 1985). Obesity factor which can be assessed by waist circumference (WC) is also positively associated with the occurrence of cardiovascular events and diastolic dysfunction (Czernichow et al., 2005). Thus, the purpose of this study...
was to investigate the association of uric acid levels with peripheral PWV, considering smoking status and obesity.

SUBJECTS AND METHODS

Study population

The study population consisted of 6,551 subjects who participated in the Korean Metabolic Syndrome Research Initiative and had routine health examinations at the Health Promotion Centers of university hospitals from January 2006 to December 2006. The objective and contents of this project were explained to the participants who volunteered to undergo the health examinations. The volunteer subjects were recruited only after informed consent was obtained (Yoon et al., 2008). A total of 3,390 subjects (1,940 males and 1,450 females) underwent PWV measurements. The Institutional Review Board of Human Research at Yonsei University approved this study (no. 4-2011-0277).

Data collection

Each participant was interviewed by using a structured questionnaire to collect the history of cigarette smoking (never smoked, ex-smoker, or current smoker) and alcohol consumption (non-drinker or drinker of any amount of alcohol), as well as other demographic characteristics such as age and sex. Pack-years were calculated by multiplying smoking duration with daily tobacco consumption (e.g. the number of cigarette per day). Waist circumference (WC) was measured midway between the lower rib and the iliac crest. Weight and height were measured while the participants were wearing light clothing. Body mass index (BMI) was calculated as weight (kg) divided by the square of height (m²). Blood pressure was measured of the participants in the sitting by a registered nurse or a blood pressure technician using a standard mercury sphygmomanometer or automatic manometer. Both systolic blood pressures (SBP) and diastolic blood pressures (DBP) were measured after a 15-min at rest.

Measurement of biomarkers

Serum for the clinical chemistry assays was separated from peripheral venous blood samples. The serum was obtained from each participant after a 12 hr fast and stored at -70°C for 2 hr. Biomarkers of metabolic syndrome including fasting blood glucose (FBG), triglycerides, and uric acid levels were measured. Data quality control was performed in accordance with the procedures of the Korean Association of Laboratory Quality Control. Peripheral PWV was measured using a PP-1000 pulse wave analyzer (Hanbyul Meditech Co., Jeonju, Korea), as described previously (Zeng et al., 2008; Lee et al., 2009). Regional PWV values in the aorta and leg were calculated automatically 10 sec after the data were collected. Peripheral PWV data were collected from the femoral-dorsalis pedis artery distance.

Statistical analysis

The independent t-test was used to analyze the differences among the participants' characteristics. A Pearson's correlation analysis was also performed to evaluate the relationship between the PWV and various clinical factors. Multiple linear regression models were used to assess the association between uric acid level and peripheral PWV. Multiple logistic regression models were also used to assess the association between hyperuricemia and abnormal peripheral PWV. Hyperuricemia was defined as the highest quartile of values, which was defined as a serum uric acid (SUA) level ≥6.9 mg/dL in men and ≥4.8 mg/dL in women. Abnormal PWV was also defined as the highest quartile of values in subjects. We analyzed the data according to gender because the uric acid levels and the prevalence of smoking were significantly different between men and women. We divided the subjects into two groups (according to median values) of WC (<75 cm and ≥75 cm) in women to control potential confounding by WC because central obesity is associated with cardiovascular disease (Czernichow et al., 2005; Park et al., 2010). We also divided the study subjects according to smoking status in men. All analyses were conducted using SAS ver. 9.2 software (SAS Institute, Cary, NC, USA). All tests were two-sided, and significance was accepted at P < 0.05.

RESULTS

The majority of individuals examined were middle-aged subjects (Table 1). In general, male subjects had higher WC, BMI, FBG, TC, homeostasis model assessment of insulin.
resistance (HOMA-IR), and peripheral PWV levels, but lower high density lipoprotein (HDL)-cholesterol levels than those in female subjects. In male subjects, mean levels of leg PWV were 9.81, 9.73, 9.78, and 9.81, respectively for smokers, non-smokers, normouricemic (<6.9 mg/dL), and hyperuricemic (≥6.9 mg/dL). In female subjects, mean levels of leg PWV were 9.05 and 9.29, respectively for normouricemic (<4.8 mg/dL) and hyperuricemic (≥4.8 mg/dL). Approximately, 41.9% of men and 3.7% of women were current smokers. Prevalence of hypertension was 11.4% in men and 7.0% in women.

Peripheral PWV was significantly associated with SBP in men and women (P<0.0001), respectively, after adjusting for age, lipid level, and BMI (Table 2). Peripheral PWV was also marginally significantly associated with uric acid levels in women (P=0.060), but it was not associated with uric acid levels in men (P=0.393). However, when the analyses were performed only in non-smokers and light smokers, peripheral PWV was significantly associated with uric acid levels in men (P=0.022). The data were further stratified by the median WC level in women. The relationship between peripheral PWV and uric acid was significant in women with WC <75 cm (P=0.031), but this relationship was not significant in the other groups (Table 2 and Fig. 1).

Table 3 shows logistic regression results in men and women. In women, hyperuricemia was associated with abnormal PWV (OR 1.58; 95% CI 1.03–2.43), but hyperuricemia was not associated with abnormal PWV in men (OR 1.13; 95% CI 0.88–1.45). However, in men with normal blood pressure, association of hyperuricemia with abnor-

---

| Table 1. General characteristics of participants (N=3390) |
|------------|-------------|-------------|---------------|
|            | Men (N=1940) | Women (N=1450) | P-value      |
| N          | Mean ± SD   | Mean ± SD   |               |
| Age, years | 44.6±8.5    | 43.3±8.9    | <0.0001      |
| WC, cm     | 86.1±7.3    | 76.1±7.9    | <0.0001      |
| BMI, kg/m² | 24.6±2.7    | 22.7±3.0    | <0.0001      |
| Adiponectin, μg/mL | 6.1±3.6 | 9.8±5.6    | <0.0001      |
| FBG, mg/dL | 99.7±18.9   | 92.3±12.9   | <0.0001      |
| SBP, mmHg  | 126.0±12.3  | 118.0±13.5  | <0.0001      |
| DBP, mmHg  | 75.6±9.6    | 71.3±9.6    | <0.0001      |
| HDL cholesterol, mg/dL | 49.6±10.8 | 58.8±12.5  | <0.0001      |
| LDL cholesterol, mg/dL | 111.5±28.1 | 102.6±27.9 | <0.0001      |
| Triglyceride, mg/dL | 133.5±93.9 | 79.3±44.4  | <0.0001      |
| URIC ACID, mg/dL | 6.1±1.2 | 4.3±0.9    | <0.0001      |
| AORTA PWV, m/s | 7.8±1.0 | 7.3±1.1    | <0.0001      |
| LEG PWV, m/s | 9.8±1.0 | 9.1±1.0    | <0.0001      |
| %       | Ex smokers  |            | <0.0001      |
| Smoking status |        |            |               |
| Light smokers (<20/day) | 31.0 | 1.3        |               |
| Heavy smokers (≥20/day) | 24.7  | 0.6        |               |
| Hypertension |            |            | <0.0001      |
| Prehypertension | 62.2 | 37.4       |               |
| Hypertension | 11.4       | 7.0        |               |

P-values refer to differences between groups as determined by t-test and χ² test for continuous and categorical variables, respectively. FBG: fasting plasma glucose, BMI: body mass index, WC: waist circumference, SBP: systolic blood pressure, DBP: diastolic blood pressure, HDL: high density lipoprotein, LDL: low density lipoprotein.
mal PWV was marginally significant (OR 1.71; 95% CI 0.96–3.06), and hyperuricemia was associated with abnormal PWV (OR 2.37; 95% CI 1.01–5.59) in male non-smokers or light smokers with normal blood pressure.

**DISCUSSION**

Relationships between arterial stiffness and uric acid have been widely analyzed over the past several years, with conflicting results (Chen et al., 2010; Lim et al., 2010; Fang et al., 2014; Saijo et al., 2005; Bae et al., 2013). Fang et al. (2014) reported that uric acid levels were associated with the risk of arterial stiffness using peripheral PWV. Several other studies have also reported the association of uric acid with arterial stiffness (Saijo et al., 2005; Bae et al., 2013). However, in several studies, uric acid levels were not associated with arterial stiffness in women (Chen et al., 2010; Lim et al., 2010). Another study in Korea reported that serum uric acid was associated with arterial stiffness in postmenopausal women (Park et al., 2012). Our results also demonstrate that hyperuricemia was associated with abnormal peripheral PWV in Korean women. The relationship between peripheral PWV and uric acid was stronger in lean women than in obese women. We also used aorta PWV,

### Table 2: Multiple linear regression analysis of Leg PWV

| Variables | Men (N=1940) | Non or light male smokers (0–19/day) (N=853) | Women (N=1450) | Women with WC <75 cm (N=682) |
|-----------|-------------|---------------------------------------------|----------------|-----------------------------|
|           | Regression coefficients | $P$ value | Regression coefficients | $P$ value | Regression coefficients | $P$ value | Regression coefficients | $P$ value |
| Age       | 0.022       | <0.0001 | 0.023 | <0.0001 | 0.025 | <0.0001 | 0.019 | 0.0003 |
| BMI       | -0.079      | <0.0001 | -0.079 | 0.0015 | -0.085 | <0.0001 | -0.087 | 0.0021 |
| Waist     | 0.009       | 0.1128 | 0.009 | 0.3349 | 0.015 | 0.012 | 0.014 | 0.263 |
| SBP       | 0.021       | <0.0001 | 0.020 | <0.0001 | 0.021 | <0.0001 | 0.021 | <0.0001 |
| FBG       | 0.002       | 0.083 | 0.002 | 0.271 | -0.001 | 0.651 | -0.003 | 0.347 |
| LDL-C     | -0.001      | 0.485 | -0.001 | 0.780 | -0.001 | 0.162 | -0.002 | 0.219 |
| HDL-C     | 0.002       | 0.852 | 0.001 | 0.974 | -0.002 | 0.433 | 0.001 | 0.918 |
| TG        | 0.0002      | 0.705 | -0.001 | 0.680 | 0.001 | 0.031 | -0.001 | 0.945 |
| Uric acid | 0.016       | 0.393 | 0.067 | 0.022 | 0.054 | 0.060 | 0.098 | 0.031 |

WC: Waist Circumference

**Fig. 1.** Mean levels of leg PWV in the quartile levels of PWV subgroup with nonsmoking or light smoking in men, and women with WC <75 cm (WC: waist circumference, PWV: pulse wave velocity)
but it was not associated with uric acid levels in men and women. The relationship between aorta PWV and uric acid was not associated in women with WC <75 cm ($P = 0.0865$) (Data not shown). Peripheral PWV was associated with uric acid levels in women, but it was not associated with uric acid levels in men. In a recent study in Taiwan, they reported that high serum uric acid was associated with greater risk of arterial stiffness in healthy women, but the relationship was not significant in men (Fang et al., 2014). In another study, the relationship between arterial stiffness and uric acid was much stronger in women than in men (Kuo et al., 2010). One of the possible reasons for the discrepancy in results between men and women is the clear difference in smoking status between men and women. When the analyses were performed only in non-smokers and light smokers in the present study, peripheral PWV was associated with uric acid levels in men. In this study, we analyzed that the current smokers were divided into two groups (mild and heavy). Several other studies also reported a significant negative correlation between serum uric acid level and the smoking status including the average number of cigarettes smoked per day and the smoking duration (Haj Mouhamed et al., 2011; Slater et al., 1985). In the present study, we also used pack-years as a chronic parameter. However, when the analyses were performed only in non-smokers and smokers with less than 20 pack years, peripheral PWV was not associated with uric acid in men ($P=0.1414$) (Data not shown).

The association of hyperuricemia with abnormal PWV was also marginally significant in men with normal blood pressure. In a study, arterial stiffness was increased in healthy Korean men (Shin et al., 2012). In the present study, hyperuricemia was defined as the highest quartile of values ($\geq 6.9$ mg/dL in men and 4.8 mg/dL in women). Several other studies also used the quartiles of serum uric acid (Lim et al., 2010; Fang et al., 2014; Shin et al., 2012; Ishizaka et al., 2007; Fang et al., 2000). A Japanese study reported that serum uric acid is associated with baPWV, and thus increased arterial stiffness (Ishizaka et al., 2007). In a cardiovascular disease study, compared with the lowest quartile of uric acid level, death rates for ischemic heart disease were significantly higher in quartile 4 for both men and women (Fang et al., 2000). Another recent study also reported that the highest quartile of serum uric acid ($315.3 \sim 585.0$ μmol/L) was positively associated with increased baPWV in women (Fang et al., 2014).

The mechanism underlying the relationship between uric acid and arterial stiffness remains unclear. However, it was shown that endothelial dysfunction was associated with hyperuricemia (Erdogan et al., 2005). High-normal uric acid levels may promote the development and progression of arterial stiffness by producing superoxide and oxidative stress via the xanthine oxidase pathway (Messerli et al.,

| Subjects | Uric acid levels | Normal (<10.323 m/s) | Abnormal (≥10.323 m/s) |
|----------|-----------------|----------------------|------------------------|
|          | $N$ (%)         | $N$ (%)              | $OR (95\% CI)$         | $P$-value |
| Men      | Normal          | 1084 (74.6)          | 360 (74.1)             | 1.00 (reference) |
|          | Abnormal (≥6.9 mg/dL) | 370 (25.2)          | 126 (25.9)             | 1.13 (0.88~1.45)  | 0.3577 |
| Men with normal blood pressure | Normal | 337 (79.9) | 68 (75.6) | 1.00 (reference) |
|          | Abnormal (≥6.9 mg/dL) | 85 (20.1)          | 22 (24.4)              | 1.71 (0.96~3.06)  | 0.0696 |
| Nonsmoking or light smoking men with normal blood pressure | Normal | 153 (81.4) | 28 (71.8) | 1.00 (reference) |
|          | Abnormal (≥6.9 mg/dL) | 85 (20.1)          | 22 (24.4)              | 1.71 (0.96~3.06)  | 0.0696 |
| Women    | Normal          | 845 (77.2)          | 243 (68.5)             | 1.00 (reference) |
|          | Abnormal (≥4.8 mg/dL) | 250 (22.8)         | 112 (31.6)             | 1.58 (1.03~2.43)  | 0.0374 |

*Adjusted for age, systolic blood pressure, smoking status, fasting blood glucose levels, and body mass index
CI, confidence interval
*An abnormal peripheral PWV level in women was ≥9.718 m/s

Table 3. Odds ratios (OR) of the abnormal peripheral PWV levels for abnormal uric acid levels in the population (n=3,390)
Uric acid is also a stimulator of the vascular rennin-angiotensin system, which leads to the production of angiotensin II and vascular smooth muscle cell proliferation (Saito et al., 1978; Corry et al., 2008). Several experimental studies have demonstrated that xanthine oxidase inhibition with allopurinol improves endothelial function in patients with chronic heart failure, heavy smoking, and the metabolic syndrome (Doehner et al., 2002; Guthikonda et al., 2003; Yiginer et al., 2008).

This study had several limitations. We could not identify the mechanisms or determine the direction of causality for the relationship between uric acid and arterial stiffness due to the cross-sectional design. A single PWV assessment may be susceptible to short-term variations, which would lead to bias toward the null. Because of a practical reason that smokers accounted for only 3.7% of women and female heavy smokers were scarce, we could not examine the relationship between uric acid level and arterial stiffness according to smoking status. In conclusion, our results suggest that uric acid levels are associated with peripheral PWV in Korean women. Uric acid was also associated with peripheral PWV in non-smoking or light smoking men. Further studies should be performed in other populations to confirm this result, considering smoking status.

**ACKNOWLEDGMENTS**

This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (2015-R1D1A1A01059651) and the Korea medical institute (KMI).

**CONFLICT OF INTEREST**

The authors declare that they have no conflict of interest.

**REFERENCES**

Bae JS, Shin DH, Park PS, Choi BY, Kim MK, Shin MH, Lee YH, Chun BY, Kim SK. The impact of serum uric acid level on arterial stiffness and carotid atherosclerosis: The Korean Multi-Rural Communities Cohort study. Atherosclerosis. 2013. 231: 145-151.
Chen X, Li Y, Sheng CS, Huang QF, Zheng Y, Wang JG. Association of serum uric acid with aortic stiffness and pressure in a Chinese workplace setting. American Journal of Hypertension. 2010. 23: 387-392.
Cohn JN. Vascular wall function as a risk marker for cardiovascular disease. Journal of Hypertension. 1999. 17: S41-S44.
Corry DB, Eslami P, Yamamoto K, Nyby MD, Makino H, Tuck ML. Uric acid stimulates vascular smooth muscle cell proliferation and oxidative stress via the vascular renin-angiotensin system. Journal of Hypertension. 2008; 26: 269-275.
Czernichow S, Bertrais S, Oppert JM, Galan P, Blacher J, Ducimetière P, Hercberg S, Zureik M. Body composition and fat repartition in relation to structure and function of large arteries in middle-aged adults (the SU.VI.MAX study). International Journal of Obesity. 2005. 29: 826-832.
Doehner W, Schoene N, Rauchhaus M, Leyva-Leon F, Pavitt DV, Reaveley DA, Schuler G, Coats AJ, Anker SD, Hambrecht R. Effects of xanthine oxidase inhibition with allopurinol on endothelial function and peripheral blood flow in hyperuricemic patients with chronic heart failure: results from 2 placebo-controlled studies. Circulation. 2002. 105: 2619-2624.
Erdogan D, Gullu H, Caliskan M, Yildirim E, Bilgi M, Ulus T, Sezgin N, Muderrisoglu H. Relationship of serum uric acid to measures of endothelial function and atherosclerosis in healthy adults. International Journal of Clinical Practice. 2005. 59: 1276-1282.
Fang J, Alderman MH. Serum uric acid and cardiovascular mortality the NHANES I epidemiologic follow-up study, 1971-1992. National Health and Nutrition Examination Survey. JAMA. 2000. 283: 2404-2410.
Fang JI, Wu JS, Yang YC, Wang RH, Lu FH, Chang CJ. High uric acid level associated with increased arterial stiffness in apparently healthy women. Atherosclerosis. 2014. 236: 389-393.
Guthikonda S, Sinkey C, Barenz T, Haynes WG. Xanthine oxidase inhibition reverses endothelial dysfunction in heavy smokers. Circulation. 2003. 107: 416-421.
Haj Mouhamed D, Ezzaher A, Neffati F, Douki W, Gaha L, Najjar MF. Effect of cigarette smoking on plasma uric acid concentrations. Environmental Health and Preventive Medicine. 2011. 16: 307-312.
Ishizaka N, Ishizaka Y, Toda E, Hashimoto H, Nagai R, Yamakado M. Higher serum uric acid is associated with increased arterial stiffness in Japanese individuals. Atherosclerosis. 2007. 192: 131-137.
Kuo CF, Yu KH, Luo SF, Ko YS, Wen MS, Lin YS, Hung KC, Chen CC, Lin CM, Hwang JS, Tseng WY, Chen HW, Shen - 206 -
YM, See LC. Role of uric acid in the link between arterial stiffness and cardiac hypertrophy: a cross-sectional study. Rheumatology. 2010. 49: 1189-1196.

Lee NB, Park CG. Reproducibility of regional pulse wave velocity in healthy subjects. The Korean Journal of Internal Medicine. 2009. 24: 19-23.

Lim JH, Kim YK, Kim YS, Na SH, Rhee MY, Lee MM. Relationship between serum uric acid levels, metabolic syndrome, and arterial stiffness in Korean. Korean Circulation Journal. 2010. 40: 314-320.

Messerli FH, Frohlich ED, Dreslinski GR, Suarez DH, Arismunno GG. Serum uric acid in essential hypertension: an indicator of renal vascular involvement. Annals of Internal Medicine. 1980. 93: 817-821.

Mulè G, Riccobene R, Castiglia A, D'Ignoto F, Ajello E, Geraci G, Guarino L, Nardi E, Vaccaro F, Cerasola G, Cottone S. Relationships between mild hyperuricaemia and aortic stiffness in untreated hypertensive patients. Nutrition, Metabolism & Cardiovascular Diseases. 2014. 24: 744-750.

Park JS, Kang S, Ahn CW, Cha BS, Kim KR, Lee HC. Relationships between serum uric acid, adiponectin and arterial stiffness in postmenopausal women. Maturitas. 2012. 73: 344-348.

Park JS, Nam JS, Cho MH, Yoo JS, Ahn CW, Jee SH, Lee HS, Cha BS, Kim KR, Lee HC. Insulin resistance independently influences arterial stiffness in normoglycemic normotensive postmenopausal women. Menopause. 2010. 17: 779-784.

Richette P, Bardin T. Gout. Lancet. 2010. 375: 318-328.

Saijo Y, Utsugi M, Yoshioka E, Horikawa N, Sato T, Gong YY, Kishi R. Relationships of C-reactive protein, uric acid, and glomerular filtration rate to arterial stiffness in Japanese subjects. Journal of Human Hypertension. 2005. 19: 907-913.

Saito I, Saruta T, Kondo K, Nakamura R, Oguro T, Yamagami K, Ozawa Y, Kato E. Serum uric acid and the renin-angiotensin system in hypertension. Journal of the American Geriatrics Society. 1978. 26: 241-247.

Shin JY, Lee HR, Shim JY. Significance of high-normal serum uric acid level as a risk factor for arterial stiffness in healthy Korean men. Vascular Medicine. 2012. 17: 37-43.

Slater PE, Kaufmann NA, Friedlander Y, Stein Y. Effects of smoking and physical activity on serum uric acid in a Jerusalem population sample. Annals of Human Biology. 1985. 12: 179-184.

Tsiofis C, Kyvelou S, Dimitriadis K, Syrseloudis D, Sideris S, Skiadas I, Katsi V, Stefanadi E, Lalos S, Mihas C, Poulakis M, Stefanadis C. The diverse associations of uric acid with low-grade inflammation, adiponectin and arterial stiffness in never-treated hypertensives. Journal of Human Hypertension. 2011. 25: 554-559.

Yiginer O, Ozcelik F, Inanc T, Aparci M, Ozmen N, Cingozbay BY, Kardesoglu E, Suleymanoglu S, Sener G, Cebeci BS. Allopurinol improves endothelial function and reduces oxidant-inflammatory enzyme of myeloperoxidase in metabolic syndrome. Clinical Research in Cardiology. 2008. 97: 334-340.

Yoon SJ, Lee HS, Lee SW, Yun JE, Kim SY, Cho E, Lee SJ, Lee EJ, Lee HY, Park J, Kim HS and Jee SH. The association between adiponectin and diabetes in the Korean population. Metabolism. 2008. 57: 853-857.

Zeng Q, Sun XN, Fan L, Ye P. Correlation of body composition with cardiac function and arterial compliance. Clinical and Experimental Pharmacology and Physiology. 2008. 35: 78-82.

https://doi.org/10.15616/BSL.2017.23.3.201

Cite this article as: Sull JW, Koh EN, Cho SK, Bae HJ, Lee SH. Association of Uric Acid Levels with Arterial Stiffness in Korean Women and Non-smoking Men. Biomedical Science Letters. 2017. 23: 201-207.