Association of Serum Uric Acid with Body Mass Index: A Cross-Sectional Study from Jiangsu Province, China

Honggang WANG, Lizhen WANG, Rui XIE, Weijie DAI, Chengcheng GAO, Peng SHEN, Xiaodan HUANG, Faming ZHANG, Xiaozhong YANG, *Guozhong JI

1. Dept. of Gastroenterology, Huai’an First People’s Hospital, Nanjing Medical University, Huai’an, P. R. China
2. Dept. of Medical Center for Digestive Diseases, the Second Affiliated Hospital of Nanjing Medical University, Nanjing, P.R. China

*Corresponding Author: Email: jgzzl@163.com

(Received 05 July 2014; accepted 10 Sep 2014)

Abstract
Background: Body mass index (BMI) has been demonstrated to be associated with serum uric acid (SUA) level in many developed countries, however, there is still a lack of large sample study in Jiangsu Province, one of the most economically developed regions in China, where fat-rich diet is common.

Methods: Through retrospective analysis in healthy subjects, we determined the association of BMI with hyperuricemia risk. Data of 39,736 participants from January 2011 to June 2013 in China were analyzed for parameters including physical examinations and biochemical blood analysis.

Results: On univariate analysis, SUA was positively correlated with age, SBP, DBP, BMI, FPG, red blood cell count, hemoglobin, white blood cell count, platelet, cholesterol, triglyceride, HDL-cholesterol, LDL-cholesterol, ALT, AST, bilirubin, albumin, BUN and creatinine. SUA was significantly elevated in a linear fashion as BMI increased, and SUA in obesity was significantly higher than underweight. The prevalence of hyperuricemia remained approximately 2.98 times greater among individuals with overweight, and 5.96 times greater among obesity, compared to individuals with underweight.

Conclusion: There is a positive relationship between BMI and SUA among healthy subjects in Jiangsu province, China.

Keywords: Serum uric acid, Body mass index, Association

Introduction

Uric acid is a byproduct of purine metabolism (1, 2) and elevated serum uric acid (SUA) levels have an underlying role in gout (3). Hyperuricemia was defined as SUA concentration > 420 μmol/l in males or 340 μmol/l in female. The prevalence of hyperuricemia is increasing rapidly in China. In the coastal city Tianjin of China, hyperuricemic prevalence was 12.16%, with male significantly higher than female, which was reported in 2011 (4). Increasing evidence has shown that hyperuricemia was also associated with dyslipid-emia (5), increased systemic inflammation (6), insulin resistance (7), diabetes mellitus (8), hypertension (9), chronic kidney disease (10), and cardiovascular disease (11).

Several studies have focused on possible risk factors of hyperuricemia. Gout patients have significantly greater body mass index (BMI) in the Framingham study (12). After two years follow up of 3,153 individuals, Ishizaka reported SUA change was related with for BMI change (13). As the association between obesity and SUA is well
established, BMI is an important modifiable risk factor for hyperuricemia in USA, Japan, and other countries (13, 14). However, according to our knowledge, there is a lack of large sample study in Jiangsu Province, one of the most economically developed regions in China, where fat-rich diet is common. In the present study, we investigated the relationship of BMI and SUA in 39,736 healthy subjects.

**Methods**

This study was approved by the Ethics Committee of Nanjing Medical University. Our study consisted of 39,736 healthy subjects from health checkups at the Health Care Center of the Second Affiliated Hospital of Nanjing Medical University. All subjects completed the physical and blood examinations performed from January 2011 to June 2013.

A physical examination was performed on all subjects by a qualified doctor per established standard methods (15). Weight was obtained with participants wearing light clothing and no shoes. BMI was calculated by dividing body weight (kg) by the square of height (m²). Using diagnostic criteria for obesity in BMI for Asian populations recommended by the WHO, we categorized BMI into four categories: underweight (<18.5 kg/m²), normal weight (18.5-23.0 kg/m²), overweight (23.0-27.5 kg/m²), and obese (≥27.5 kg/m²) (16). Two consecutively readings of systolic blood pressure (SBP) and diastolic blood pressure (DBP) were taken on the right arm using a calibrated mercury sphygmomanometer with the participant in a seated position and arm supported at heart level. The participants rested for at least 5 minutes before blood pressure measurement. The mean of these two measures was used in the subsequent analysis. After an overnight fast of at least 10 hours and rest for 20 minutes, fasting blood samples (without venous stasis) were drawn from an antecubital vein. Measurement of fasting plasma glucose (FPG), red blood cell count, hemoglobin, white blood cell count, platelet, total cholesterol, triglyceride, HDL-cholesterol, LDL-cholesterol, alanine aminotransferase (ALT), aspartate aminotransferase (AST), bilirubin, albumin, urea nitrogen (BUN), creatinine and SUA were done in the laboratory. All procedures were conducted by trained technicians followed standardized protocols. Hyperuricemia was defined as serum uric acid concentration > 420 μmol/l in males or 340 μmol/l in female as previously defined (17).

Statistical analyses were performed using SPSS 18.0 software for Windows (SPSS Inc., Chicago, IL). All variables were normal distribution and presented as mean±standard error (SE) for continuous variables. Comparisons among groups were tested by t test or one-way ANOVA. Partial correlation analysis determined the relationship between SUA and related variables. Multivariate logistic regression models examined the association between BMI and concentrations of SUA, after adjusting for age, FPG, red blood cell count, hemoglobin, white blood cell count, platelet, cholesterol, triglyceride, HDL-cholesterol, LDL-cholesterol, ALT, AST, bilirubin, albumin, BUN, creatinine. All statistical tests were two-tailed with type I error set at 0.05, and P values, 0.05 considered statistically significant.

**Results**

On univariate analysis, SUA was positively correlated with age, SBP, DBP, BMI, FPG, red blood cell count, hemoglobin, white blood cell count, platelet, cholesterol, triglyceride, HDL-cholesterol, LDL-cholesterol, ALT, AST, bilirubin, albumin, BUN and creatinine (Table 1). On multiple regression analysis, SUA was positively associated with age, SBP, BMI, FPG, red blood cell count, hemoglobin, white blood cell count, platelet, triglyceride, HDL-cholesterol, LDL-cholesterol, ALT, AST, bilirubin, albumin, BUN and creatinine, while P value for DBP was 0.652 (>0.05), and for cholesterol was 0.847 (>0.05) (Table 2). Table 3 compares individuals with and without hyperuricemia. The two groups were statistically significantly different in majority of the variables evaluated.

Available at:  http://ijph.tums.ac.ir
Table 1: Serum uric acid: univariate analysis (n=39736)

| Characteristics                  | Serum uric acid | r     | P value |
|----------------------------------|----------------|-------|---------|
| Age (yr)                         | 0.038          | <0.001|         |
| SBP (mmHg)                       | 0.250          | <0.001|         |
| DBP (mmHg)                       | 0.244          | <0.001|         |
| BMI (kg/m²)                      | 0.354          | <0.001|         |
| FPG (mmol/L)                     | 0.048          | <0.001|         |
| Red blood cell count (×10¹²/L)   | 0.326          | <0.001|         |
| Hemoglobin (g/L)                 | 0.388          | <0.001|         |
| White blood cell count (×10¹²/L) | 0.196          | <0.001|         |
| Platelet (×10⁹/L)                | -0.017         |       | 0.001   |
| Cholesterol (mmol/L)             | 0.106          | <0.001|         |
| Triglyceride (mmol/L)            | 0.322          | <0.001|         |
| HDL-cholesterol (µmmol/L)        | -0.318         | <0.001|         |
| LDL-cholesterol (µmmol/L)        | 0.112          | <0.001|         |
| ALT (IU/L)                       | 0.294          | <0.001|         |
| AST (IU/L)                       | 0.223          | <0.001|         |
| Bilirubin (µmmol/L)              | 0.140          | <0.001|         |
| Albumin (g/L)                    | 0.153          | <0.001|         |
| BUN (mmol/L)                     | 0.195          | <0.001|         |
| Creatinine (µmmol/L)             | 0.547          | <0.001|         |

Pearson correlation analysis was used between serum uric acid and the other independent variables. r, Pearson correlation coefficient; P value, significance level.

Table 2: Serum uric acid: multivariate analysis (n=39736)

| Independent variables | β    | Serum uric acid | P value |
|-----------------------|------|----------------|---------|
| Age (yr)              | -0.023| -4.54          | <0.001  |
| SBP (mmHg)            | 0.037 | 4.77           | <0.001  |
| DBP (mmHg)            | -0.003| -0.451         | 0.652   |
| BMI (kg/m²)           | 0.132 | 27.2           | <0.001  |
| FPG (mmol/L)          | -0.049| -11.7          | <0.001  |
| Red blood cell count (×10¹²/L) | 0.013 | 2.12          | 0.034   |
| Hemoglobin (g/L)      | 0.045 | 6.78           | <0.001  |
| White blood cell count (×10¹²/L) | 0.041 | 9.55          | <0.001  |
| Platelet (×10⁹/L)     | 0.009 | 2.04           | 0.041   |
| Cholesterol (mmol/L)  | 0.003 | 0.193          | 0.847   |
| Triglyceride (mmol/L) | 0.128 | 17.7           | <0.001  |
| HDL-cholesterol (µmmol/L) | -0.077 | -11.7       | <0.001  |
| LDL-cholesterol (µmmol/L) | 0.041 | 3.56          | <0.001  |
| ALT (IU/L)            | 0.038 | 5.56           | <0.001  |
| AST (IU/L)            | 0.060 | 9.56           | <0.001  |
| Bilirubin (µmmol/L)   | 0.024 | 5.78           | <0.001  |
| Albumin (g/L)         | 0.089 | 21.1           | <0.001  |
| BUN (mmol/L)          | 0.043 | 10.3           | <0.001  |
| Creatinine (µmmol/L)  | 0.404 | 86.3           | <0.001  |

Linear Regression Analysis was used to analysis the relationship between serum uric acid and other independent variables. β, standardized coefficients; t value, t test statistic; P value, significance level.
Table 3: Comparison of baseline characteristics between hyperuricemia subjects and control group (n=39736)

| Characteristics (mean±SE) | Hyperuricemia (n=4523) | Control (n=35213) | t value | P value |
|---------------------------|------------------------|-------------------|---------|--------|
| Age (yr)                  | 52.7±0.26              | 48.3±0.08         | 16.7    | <0.001 |
| SBP (mmHg)                | 131.1±0.25             | 125.1±0.09        | 23.3    | <0.001 |
| DBP (mmHg)                | 81.4±0.19              | 77.7±0.07         | 18.7    | <0.001 |
| BMI (kg/m²)               | 25.6±0.05              | 23.8±0.02         | 32.1    | <0.001 |
| FPG (mmol/L)              | 5.39±0.01              | 5.20±0.01         | 12.8    | <0.001 |
| Red blood cell count (×10¹²/L) | 4.80±0.01         | 4.79±0.01         | 1.13    | 0.259  |
| Hemoglobin (g/L)          | 145.1±0.22             | 145.5±0.08        | -1.37   | 0.170  |
| White blood cell count (×10¹²/L) | 6.73±0.02         | 6.35±0.01         | 14.8    | <0.001 |
| Platelet (×10¹²/L)        | 205.7±0.76             | 202.8±0.27        | 3.61    | <0.001 |
| Cholesterol (mmol/L)      | 5.26±0.01              | 4.95±0.01         | 20.9    | <0.001 |
| Triglyceride (mmol/L)     | 1.86±0.02              | 1.34±0.01         | 28.5    | <0.001 |
| HDL-cholesterol (μmmol/L) | 1.24±0.01              | 1.33±0.01         | -20.1   | <0.001 |
| LDL-cholesterol (μmmol/L) | 3.06±0.01              | 2.90±0.01         | 13.1    | <0.001 |
| ALT (IU/L)                | 27.6±0.28              | 22.6±0.08         | 17.6    | <0.001 |
| AST (IU/L)                | 23.8±0.13              | 21.2±0.04         | 19.1    | <0.001 |
| Bilirubin (μmmol/L)       | 12.4±0.08              | 12.2±0.03         | 2.49    | 0.013  |
| Albumin (g/L)             | 48.0±0.05              | 47.5±0.02         | 10.6    | <0.001 |
| BUN (mmol/L)              | 5.72±0.02              | 5.31±0.01         | 18.1    | <0.001 |
| Creatinine (μmmol/L)      | 81.2±0.25              | 74.4±0.08         | 25.6    | <0.001 |

Data were expressed as the mean±SE. t test was taken to compare factors associated with hyperuricemia between the two groups in study population.

Table 4: Baseline characteristics according to BMI (kg/m²) (n=39736)

| Characteristics (mean±SE) | Obese (≥27.5) (n=5542) | Overweight (23–27.5) (n=18744) | Normal (18.5–23.0) (n=14108) | Underweight (<18.5) (n=35213) | P value |
|---------------------------|-------------------------|---------------------------------|-------------------------------|-------------------------------|--------|
| Age (yr)                  | 50.1±0.20               | 50.6±0.11                       | 46.5±0.13                     | 42.1±0.47                     | <0.001 |
| SBP (mmHg)                | 136.7±0.21              | 128.7±0.11                      | 119.1±0.12                    | 111.5±0.37                    | <0.001 |
| DBP (mmHg)                | 85.9±0.17               | 80.0±0.09                       | 73.3±0.09                     | 68.9±0.27                     | <0.001 |
| FPG (mmol/L)              | 5.48±0.01               | 5.31±0.007                      | 5.04±0.006                    | 4.90±0.02                     | <0.001 |
| Red blood cell count (×10¹²/L) | 4.96±0.007          | 4.86±0.004                      | 4.67±0.004                    | 4.51±0.01                     | <0.001 |
| Hemoglobin (g/L)          | 150.6±0.19              | 147.7±0.11                      | 141.2±0.13                    | 136.1±0.38                    | <0.001 |
| White blood cell count (×10¹²/L) | 6.94±0.02         | 6.5±0.01                        | 6.08±0.01                     | 5.85±0.04                     | <0.001 |
| Platelet (×10¹²/L)        | 207.8±0.68              | 203.3±0.37                      | 201.6±0.42                    | 196.2±1.32                    | <0.001 |
| Cholesterol (mmol/L)      | 5.14±0.01               | 5.06±0.007                      | 4.86±0.008                    | 4.69±0.02                     | <0.001 |
| Triglyceride (mmol/L)     | 1.87±0.02               | 1.54±0.007                      | 1.07±0.005                    | 0.84±0.01                     | <0.001 |
| HDL-cholesterol (μmmol/L) | 1.16±0.01               | 1.25±0.01                       | 1.44±0.01                     | 1.61±0.01                     | <0.001 |
| LDL-cholesterol (μmmol/L) | 3.09±0.01               | 3.00±0.01                       | 2.78±0.006                    | 2.52±0.02                     | <0.001 |
| ALT (IU/L)                | 32.8±0.26               | 24.8±0.11                       | 18.2±0.09                     | 14.8±0.23                     | <0.001 |
| AST (IU/L)                | 24.5±0.12               | 21.9±0.05                       | 20.0±0.06                     | 19.4±0.18                     | <0.001 |
| Bilirubin (μmmol/L)       | 12.4±0.07               | 12.3±0.04                       | 11.9±0.05                     | 12.2±0.15                     | <0.001 |
| Albumin (g/L)             | 47.4±0.04               | 47.5±0.02                       | 47.6±0.03                     | 48.1±0.09                     | <0.001 |
| BUN (mmol/L)              | 5.53±0.02               | 5.44±0.01                       | 5.22±0.01                     | 5.01±0.04                     | <0.001 |
| Creatinine (μmmol/L)      | 78.9±0.20               | 77.5±0.10                       | 71.4±0.13                     | 67.4±0.37                     | <0.001 |
| SUA (μmmol/L)             | 376.5±1.16              | 344.9±0.59                      | 302.0±0.64                    | 274.8±1.89                    | <0.001 |

Data were expressed as the mean±SE. All data were analyzed by one-way analysis of variance (ANOVA).

We found that BMI was higher in hyperuricemia subjects than control group. To elucidate the association of SUA with BMI, the subjects were divided into 4 groups according to the classification

Available at: http://ijph.tums.ac.ir
of BMI in adults based on WHO (2004) criterion: underweight, normal weight, overweight, and obese. As shown in Table 4, SUA was significantly elevated in a linear fashion as BMI increased, and SUA in subjects with obese was significantly higher than that in subjects with underweight. The prevalence of hyperuricemia remained approximately 2.98 times greater among individuals with overweight (n=18744), and 5.96 times greater among obesity (n=5542), compared to individuals with underweight (n=1342) (Table 5).

Table 5: Effect of BMI on serum uric acid in Chinese subjects by multiple logistic regression (n=39736)

| Diagnostic criteria in BMI | OR (95% CI) | P value |
|----------------------------|-------------|---------|
| Underweight (<18.5) (n=1342) | 1.000 | - |
| Normal (18.5-23.0) (n=14108) | 1.558 (1.193-2.035) | =0.001 |
| Overweight (23-27.5) (n=18744) | 2.980 (2.292-3.874) | <0.001 |
| Obese (≥27.5) (n=5542) | 5.968 (4.571-7.792) | <0.001 |

Multivariate logistic regression analysis was performed to determine the association of BMI and serum uric acid, after adjusting for age, FPG, red blood cell count, hemoglobin, white blood cell count, platelet, cholesterol, triglyceride, HDL-cholesterol, LDL-cholesterol, ALT, AST, bilirubin, albumin, BUN, creatinine. OR, odds ratio; CI, confidence interval

**Discussion**

It has been demonstrated that BMI is strongly associated with prevalent hyperuricemia, which has important public health ramifications given that approximately 34% of Americans are overweight, approximately 20% are obese, and approximately 14% are obese at stages II or greater (18). BMI is thought to be a more valuable prediction marker for the risk of elevated SUA level. For the clinical doctors, BMI is more attractive for it is easy to get. Therefore, doctors are easier to predict the individuals’ risk of hyperuricemia or gout. Previous published paper indicated that weight loss was thought to be an effective non-medical strategy for SUA level reduction in the Japanese population (13). Men losing 10 pounds or more had a 39% lower risk of developing gout (19). The Framingham Heart Study established the dangerous relationship between SUA level elevation and coronary heart disease occurrence, cardiovascular death, and all-cause mortality in females (12). An eight years follow-up study upon 128,569 adults conducted by Pan in Taiwan, China, concluded the hyperuricemia was independently associated with the development of ischemic heart disease not only in the general population but also in those without any metabolic risk factor (20). As known, weight fluctuation can also alter various other metabolic factors such as blood pressure, blood sugar, HDL-cholesterol and obesity (21).

Although several studies have previously demonstrated association between SUA and body weight (14, 22), the relationship between BMI and the risk of hyperuricemia in Jiangsu province, China was not well known. Jiangsu is one of the most economically developed provinces in China, where the number of obesity and hyperuricemia patients is large. Therefore, it is necessary to explore the relationship between BMI and SUA in Jiangsu. This study has demonstrated that SUA was positively correlated with BMI in healthy subjects. Multiple regression analysis showed that BMI was closely related to SUA. When subjects were divided into different groups according to BMI levels, the level of SUA increased in higher BMI groups, especially in obesity subjects. How to explain the correlation? So far, it has not been studied in depth. According to Tsushima’s report (23), uric acid secretion from adipose tissue in obese was increased. Among obese subjects, excessive fat accumulation in obesity could produce and secrete uric acid and is relatively associated with overproduction-type hyperuricemia. This may provide a possible mechanism for the relationship between BMI and SUA. However, our study has several limitations. Firstly, we have no information regarding the extent to which lifestyle
and dietary habit modifications affect our study population. Secondly, our study’s data was from only one hospital in Jiangsu, which might not assess the true prevalence of hyperuricemia. Thirdly, as our study was observational, we could not rule out the possibility unmeasured factors that may contribute to observed associations. Finally, the study design was cross-sectional, and thus might not necessarily represent the role of SUA as the result of high BMI. Further studies are needed to determine the role of BMI in hyperuricemia in multi-center in China and long-term follow-up should be taken.

Conclusion

Our retrospective study indicates that there is a positive relationship between BMI and SUA among healthy subjects in Jiangsu province, China. Obesity may potentially serve as a novel clinical indicator for identifying patients with hyperuricemia.

Ethical considerations

Ethical issues (Including plagiarism, Informed Consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc) have been completely observed by the authors.

Acknowledgments

The authors declare that there is no conflict of interests. This study was partly supported by Medical Technology Development Project of Nanjing, China (No. QYK 11227) for collection and analysis of data.

References

1. Glantzounis GK, Tsimoyiannis EC, Kappas AM, Galaris DA (2005). Uric acid and oxidative stress. Curr Pharm Des, 11(32): 4145-4151.
2. Proctor P (1972). Electron-transfer factors in psychosis and dyskinesia. Physiol Chem Phys, 4(4): 349-360.
3. Terkeltaub RA (2003). Clinical practice. Gout. N Engl J Med, 349(17): 1647-1655.
4. Zhang Q, Lou S, Meng Z, Ren X (2011). Gender and age impacts on the correlations between hyperuricemia and metabolic syndrome in Chinese. Clin Rheumatol, 30: 777-787.
5. Lin SD, Tsai DH, Hsu SR (2006). Association between serum uric acid level and components of the metabolic syndrome. J Clin Med Assoc, 69(11): 512-516.
6. Kang DH, Park SK, Lee IK, Johnson RJ (2005). Uric acid-induced C-reactive protein expression: implication on cell proliferation and nitric oxide production of human vascular cells. J Am Soc Nephrol, 16(12): 3553-3562.
7. Facchini F, Chen YD, Hollenbeck CB, Reaven GM (1991). Relationship between resistance to insulin-mediated glucose uptake, urinary uric acid clearance, and plasma uric acid concentration. JAMA, 266(21): 3008-3011.
8. Bandaru P, Shankar A (2011). Association between serum uric acid levels and diabetes mellitus. Int J Endocrinol, 2011: 604715.
9. Shankar A, Klein R, Klein BE, Nieto FJ (2006). The association between serum uric acid level and long-term incidence of hypertension: population-based cohort study. J Hum Hypertens, 20(12): 937-945.
10. Cain I, Shankar A, Ducatman AM, Steenland K (2010). The relationship between serum uric acid and chronic kidney disease among Appalachian adults. Nephrol Dial Transplant, 25(11): 3593-3599.
11. Fang J, Alderman MH (2000). Serum uric acid and cardiovascular mortality: the NHANES I Epidemiologic Follow-up Study, 1971-1992. National Health and Nutrition Examination Survey. JAMA, 283(18): 2404-2410.
12. Abbott RD, Brand FN, Kannal WB, Castelli WP (1988). Gout and coronary heart disease: the Framingham Study. J Clin Epidemiol, 41(3): 237-242.
13. Ishizaka N, Ishizaka Y, Toda A, Tani M, Koike K, Yamakado M, Nagai R (2010). Changes in waist circumference and body mass index in relation to changes in serum uric acid in Japanese individuals. J Rheumatol, 37(2): 410-416.
14. Masuo K, Kawaguchi H, Mikami H, Ogihara T, Tuck ML (2003). Serum uric acid and plasma norepinephrine concentrations predict subsequent weight gain and blood pressure elevation. Hypertension, 42(4): 474-480.
15. Pan XR, Yang WY, Li GW, Liu J (1997). Prevalence of diabetes and its risk factors in China, 1994. National Diabetes Prevention and Control Cooperative Group. *Diabetes Care*, 20(11):1664-1669.

16. WHO (2004). Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet*, 363(9403), 157-163.

17. Lockitch G, Halstead AC, Albersheim S, MacCallum C, Quigley G (1988). Age- and sex-specific pediatric reference intervals for biochemistry analytes as measured with the Ektachem-700 analyzer. *Clin Chem*, 34(8):1622-1625.

18. Flegal KM, Carroll MD, Ogden CL, Curtin LR (2010). Prevalence and trends in obesity among US adults, 1999-2008. *JAMA*, 303(3):235-241.

19. Choi HK, Atkinson K, Karlson EW, Curhan G (2005). Obesity, weight change, hypertension, diuretic use, and risk of gout in men: the health professionals follow-up study. *Arch Intern Med*, 165(7):742-748.

20. Chuang SY, Chen JH, Yeh WT, Wu CC, Pan WH (2011). Hyperuricemia and increased risk of ischemic heart disease in a large Chinese cohort. *Int J Cardiol*, 154(3):316-321.

21. Zhang H, Tamakoshi K, Yatsuya H, Murata C, Wada K, Otsuka R, Nagasawa N, Ishikawa M, Sugura K, Matsushita K, Hori Y, Kondo T, Toyoshima H (2005). Long-term body weight fluctuation is associated with metabolic syndrome independent of current body mass index among Japanese men. *Cir J*, 69(1): 13-18.

22. Charlotte A, Peter W, Bente B, Kober L, Fosbol EL, Sharma AM, Finer N, Caterson ID, Rode RA, James PT, Torp-Pedersen C (2009). Differential changes in serum uric acid concentrations in sibutramine promoted weight loss in diabetes: results from four weeks of the lead-in period of the SCOUT trial. *Nutr Metab (Lond)*, 6: 42.

23. Tsushima Y, Nishizawa H, Tochinoh Y, Nakatsuji H, Sekimoto R, Nagao H, Shirakura T, Kato K, Imaizumi K, Takahashi H, Tamura M, Maeda N, Funahashi T, Shimomura I (2013). Uric acid secretion from adipose tissue and its increase in obesity. *J Biol Chem*, 288(38): 27138-27149.