Original Article

The Association of Metabolic Parameters with Gout in Thai Adults

Kitsarawut Khuancharee, PhD[1], Sivaporn Wannaiampikul, PhD[2], Passagorn Sangsawangchot, MD[3], Chantra Tanunyutthawongse, MD[2]

[1] Department of Preventive and Social Medicine, Faculty of Medicine, Srinakharinwirot University, Nakhon Nayok, Thailand
[2] Department of Biochemistry, Faculty of Medicine, Srinakharinwirot University, Bangkok, Thailand
[3] Department of Internal Medicine, Faculty of Medicine, Srinakharinwirot University, Nakhon Nayok, Thailand

Background: Despite the close relationships between metabolic parameters and gout, there is no data concerning this relation in the Thai adult population.

Objective: The aim of the present study was to determine the association between metabolic parameters and gout.

Materials and Methods: We conducted a 1:2 case-control study that included 90 gout patients as the case and 180 non-gout patients as the control group. Gout was defined as Rome criteria and confirmed by a rheumatologist. Diagnosis of metabolic syndrome was based on ATP III criteria. Multivariate unconditional logistic regression analysis was used to analyze the data and presented in terms of adjusted odds ratio (aOR) and 95% confidence interval (95% CI).

Results: Our results revealed that gout was significantly associated with age increase every 10 years, men, high fasting blood glucose (FBG), and high blood pressure (BP). The aOR and 95% CI were 1.64 (1.29 to 2.07), 14.51 (6.17 to 34.27), 2.16 (1.08 to 4.46), and 2.01 (1.88 to 4.62), respectively. In addition, obesity with metabolic syndrome participants had an increased risk of gout (aOR = 2.78, 95% CI = 1.16 to 6.67).

Conclusion: The present study indicates a significant association between gout and older age, men, high fasting blood glucose, and high blood pressure among Thai adults. Furthermore, a greater body mass index with metabolic syndrome increases the risk of gout. Subjects with these risk factors should be provided with appropriate management and treatment options.

Keywords: Gout; Thai adults; Metabolic parameters

J Med Assoc Thai 2021;104(Suppl.3): S23-30
Website: http://www.jmatonline.com

Gout is one of the most common arthritis and is an independent risk factor for cardiovascular disease[1]. The prevalence of metabolic syndrome (MetS) and hyperuricemia/gout has steadily increased. Many previous studies demonstrated that gout is more prevalent in men than in women and with increasing age in various populations. The recent reports of the prevalence and incidence of gout worldwide ranges from <1% to 6.8%[1-7] and an incidence of 0.58 to 2.89 per 1,000 person-years[8]. Thailand is one of the countries with the low prevalence of gout, but highest prevalence of hyperuricemia worldwide[9-11]. In addition, the prevalence of MetS persistently increased in various populations[12-17]. In the United States population, the prevalence was 19.5% among those aged 20 to 39 years and increased to 48.6% among those aged at least 60 years[18]. Similarly, in the Indian population over 18 years old, Krishnamoorthy Y et al[19] demonstrated that the prevalence of MetS gradually increased from 13% (18 to 29 years group) to 50% (50 to 59 years). In Chinese population, the prevalence increased during 40 to 70 years, while declined in populations aged over 70 years[20]. In Thailand, the overall prevalence of MetS among adults was 32.6% to 36.49%[21,22]. The results of previous study also found that women (19.5% in men and 26.8% in women) and people living in urban areas (23.1% in urban areas vs. 17.9% in rural areas) had higher prevalence of MstS[22]. Several clinical investigations showed a higher prevalence of metabolic syndrome in patients with gout compared to the general population[23-26]. These results showed parallel increasing prevalence of both metabolic syndrome and gout. Current published evidence shows that gout occurrence has been known to be strongly associated with genetic variants[27,28], medications (diuretics, thiazide, and low dose aspirin)[29,30], and dietary factors such as red meat[29,31], seafood[32], sugar-sweetened beverages[29,33], and alcohol consumption[29,34]. In addition, the individual metabolic abnormalities of the metabolic syndrome including obesity[29,30,35], hypertension[29,30,34,36], diabetes[29,37,38], and

Correspondence to:

Tanunyutthawongse C.

Department of Biochemistry, Faculty of Medicine, Srinakharinwirot University, 114 Sukhumvit 23, Wattana, Bangkok 10110, Thailand.

Phone: +66-89-6102050

Email: morchantra@gmail.com

How to cite this article:

Khuancharee K, Wannaiampikul S, Sangsawangchot P, Tanunyutthawongse C. The Association of Metabolic Parameters with Gout in Thai Adults. J Med Assoc Thai 2021;104 (Suppl.3): S23-30.

doi.org/10.35755/jmedassocthai.2021.S03.00011

dyslipidemia[39-41] increase the uric acid concentration. The findings have been suggested that gout is linked with metabolic syndrome and/or metabolic parameters. Thus, recent published evidence has been extremely successful at establishing significant associations between gout and individual components of the metabolic syndrome, but this association is not fully elucidated in Thai adults. Therefore, the aim of this study was to investigate the independent association between gout and metabolic factors.

Materials and Methods

Study population

An unmatched (1:2) case-control study, a total of 270 subjects (90 gout patients and 180 controls) were included and selected from people over aged 20 years. The gout patients were clinically diagnosed as primary gout based on the Rome criteria[42] and confirmed by rheumatologist. We excluded the 16 gout patients with uncompleted biochemical information. The inclusion criteria of control subjects are each of the following: 1) no evidence of gout and/or no signs and symptoms with gout[43]. Participants were excluded from the study as follows: 1) had cardiovascular disease due to acute heart disease, kidney disease or kidney dysfunction; 2) all cancer patients; 3) had stress and anxiety; 4) using drugs and substances which can induce hyperuricemia (HUA) such as diuretics or low-dose aspirin or anti-depression drugs or drugs used for organ transplantation and/or vitamin C supplementation. This study was approved by the ethics committee of Srinakharinwirot University, Thailand (SWUEC/E-148/2560).

Sample size calculation

The results of previous study reported that the 14.82% of obesity in patients with gout[35] and obesity (body mass index ≥30.00 kg/m^2) increased (2.90-fold) the risk of gout[30]. A sample size of 81 subjects would be needed per group for the 1:2 ratio in the unmatched case-control study, and there is 80% power to consider an important difference between the two groups at two-sided alpha of 0.05. Thus, a total sample size of 270 subjects were 90 per gout patients and 180 per non-gout.

Anthropometric measurement

Anthropometric data such as individual height, weight and blood pressure were obtained using the standard procedure. Height was measured to the nearest 0.1 cm and weight was measured to the nearest 0.1 kg. Blood pressure (Systolic blood pressure; SBP) and diastolic blood pressure; DBP) was measured using an automatic sphygmomanometer, in a seated position after each subject had rested for at least 5 to 10 minutes. The body mass index (BMI) was calculated as the weight (kg) divided by the body height squared and treated as a continuous variable. We categorized using the World Health Organization classification system[44]. Furthermore, we defined MetS based on the National Cholesterol Education Program (NCEP) Adult Treatment Panel III (ATP III) criteria[45].

Laboratory measurements

All subjects participated in health check-up and examinations, including blood sampling at the HRH Princess MahaChakri Sirindhorn Medical Center (MSMC) and SWU-clinic, Srinakharinwirot University (SWU). The blood sample was collected from each participant after an 8 to 12-hour overnight fast. Serum samples were used to determine serum uric acid (SUA) and lipid profiles such as serum triglyceride (TG) levels, total cholesterol (TC), high- and low-density lipoprotein cholesterol (HDL-C and LDL-C). Plasma samples were used to determine fasting plasma glucose (FPG). All biochemical data (FPG, TC, TG, HDL-C and LDL-C and SUA) were measured by the automatic biochemical analyzer (Abbott CI 8200, United State) at the laboratory of the MSMC. All laboratory biochemical results were reported in mg/dl.

Statistical analysis

Descriptive data are presented as mean and standard deviation (SD) for continuous variables, and as numbers and percentages for categorical variables. Multivariate unconditional logistic regression analysis was performed to estimate the association of gout with MetS, its various components, and general obesity. We calculated the adjusted odds ratio (aOR) and 95% confidence interval (95% CI). Subgroup analyses were conducted after categorizing the subjects according to age and presence of MetS with or without general obesity. The statistical tests were two-sided, and a p-value less than 5% were considered statistically significant. All statistical analyses were performed with STATA version 14 (Stata, College Station, TX).

Results

The baseline characteristics of the participants are presented in Table 1. Among a total of 270 participants (90 gout patients and 180 non-gout), the ages of gout patients were older than non-gout Thai population. The highest proportion of gout was found in men, married status, and comorbidity with diabetes, hypertension, and dyslipidemia. The mean age at diagnosis of gout was 51.95±14.73 years. Participants with gout had a higher SBP, DBP, TG, FPG and SUA levels than non-gout subjects, whereas TC, HDL-C, and LDL-C had lower levels compared to those without gout.

Table 2 presents the results of simple and multivariable unconditional logistic regression analyses, performed to quantify the strength of the association between the metabolic parameters and gout. In the simple model, an age increases every 10 years, men, BMI 25.00 to 29.99 kg/m^2, high fasting glucose or diabetic medication, hypertriglyceridemia, and high BP or hypertension medication were significantly associated with increasing the risk of gout in the overall Thai adults, whereas a reduced HDL-C is a preventive factor with gout. In the age- and sex-adjusted model, the adjusted odds ratio (aOR) for having gout were approximately 2-fold among subjects with high fasting glucose or diabetic medication and 2-fold among those with high BP or

Table 1. Demographic, laboratory, and anthropometric characteristics of participants

Variables	Gout (n=90)	Non gout (n=180)
Age (years)*	61.92±13.36	48.56±15.01
Gender, n (%)		
Men	82 (91.11)	66 (36.67)
Women	8 (8.89)	114 (63.33)
Marital status, n (%)		
Single	10 (11.11)	68 (37.78)
Married	77 (85.56)	111 (61.67)
Widowed	2 (2.22)	1 (0.56)
Separated	1 (1.11)	0
Comorbidity with DM/HTN/DLP, n (%)	48 (53.33)	25 (13.89)
Onset of gout (years)*	51.95±14.73	-
Urate lowering medications, n (%)	90 (100.00)	0
Body mass index (BMI) (kg/m^2)*	25.75±4.56	25.05±4.84
BMI ≥23, n (%)	69 (76.67)	110 (61.11)
BMI ≥25, n (%)	55 (61.11)	82 (45.56)
Metabolic parameters*		
Systolic blood pressure (mmHg)	139.88±18.29	127.01±15.98
Diastolic blood pressure (mmHg)	79.79±13.74	77.46±10.68
Total cholesterol (mg/dL)	188.64±54.51	208.72±36.10
Triglycerides (mg/dL)	162.58±121.30	128.46±66.12
High density lipoprotein cholesterol (mg/dL)	49.63±21.79	59.04±14.35
Fasting plasma glucose (mg/dL)	111.34±32.26	98.96±29.51
Low density lipoprotein cholesterol (mg/dL)*	99.96±43.48	127.58±34.24
Serum uric acid levels (mg/dL)*	6.35±2.42	5.94±1.32

* Data was presented as mean±standard deviation
DM = diabetes mellitus; HTN = hypertension; DLP = dyslipidemia

hypertension medication. However, we observed aged-based differences (older adults with age at gout onset in 51 years and younger adults with age <51 years) (Table 3). High fasting glucose or diabetic medication and high BP or hypertension medication factors were demonstrated as significant risk factors for gout in older adults. Meanwhile, hypertriglyceridemia was associated with gout only in younger adults after adjustments. Table 4 shows the adjusted OR and 95% CI for having gout, according to the presence of MetS and/or general obesity in subgroups. In the overall Thai adult population, subjects with MetS were at a 2.38-fold higher risk of developing gout in Thai adults. In addition, both general obesity and MetS showed nearly a 3-fold increased risk for gout compared to adults without both conditions.

Discussion

In this case-control study, we confirmed that high fasting blood glucose, which one of the main metabolic components, determined gout regardless of other metabolic components in Thai adults, especially older adults. The previous study showed that plasma glucose is freely filtered at the glomerulus, similar to circulating uric acid, with almost all of it reabsorbed in the proximal tubule[46]. Since both glucose and uric acid were reabsorbed in the proximal tubule, therefore glucose may influence renal uric acid excretion by regulation of uric acid reabsorption[47]. Furthermore, glucose transporter protein-9 (GLUT9), expressed in human kidney proximal tubules, is a distinct member of the glucose transporters (GLUT) family, which has a high capacity for transporting urate and increases the speed of uric acid reabsorption by glucose transport in humans[48]. Some previous studies clarified that the SLC2A9 variant of GLUT9 could exchange extracellular glucose for intracellular uric acid, suggesting that glucose might influence the function of GLUT9[49]. Therefore, we hypothesized that an increase of glucose in the tubular fluid of reabsorptive transport on GLUT9 may also influence uric acid reabsorption. Our results also indicated that high blood pressure was at a 2-fold higher risk of developing gout in Thai adults.

Table 2. The association between metabolic parameters and gout

Factors	OR	95% CI	aOR	95% CI
Age increases every 10 year	1.87	1.53 to 2.28*	1.64	1.29 to 2.07*
Age increases every 5 year	1.36	1.24 to 1.51	1.30	1.14 to 1.48*
Men	17.70	8.06 to 38.88*	14.54	6.17 to 34.27*
Body mass index (kg/m^2)				
25.00 to 29.99	1.88	1.07 to 3.30*	1.33	0.61 to 2.83
≥30.00	1.87	0.89 to 3.92	1.63	0.58 to 4.55
High fasting glucose	4.71	2.74 to 8.09*	2.16	1.08 to 4.46*
Hypertriglyceridemia	2.74	1.61 to 4.64*	1.35	0.65 to 2.78
Low high-density lipoprotein cholesterol	0.28	0.13 to 0.62*	0.37	0.14 to 1.00
High Blood Pressure	6.06	3.14 to 11.67*	2.01	1.88 to 4.62*

* The p-value less than 0.05 is considered statistically significant
High blood pressure = blood pressure ≥130/85 mmHg or hypertension medication; Hypertriglyceridemia = triglyceride ≥150 mg/dl; low high-density lipoprotein cholesterol (HDL-C) = HDL-C <40 mg/d in men and <50 mg/d in women; High fasting glucose = glucose ≥100 mg/dl or diabetic medication; Area under receiver operating characteristic (ROC) curve = 88.67%; OR = crude odds ratio; aOR = adjusted for age and sex

Table 3. The odds ratios for the presence of gout according to age at gout onset

Factors	OR	95% CI	aOR	95% CI
Older: Age >51 year (n=152)				
Body mass index (kg/m^2)				
25 to 29.99	1.61	0.80 to 3.23	1.26	0.54 to 2.95
≥30	2.02	0.77 to 5.34	1.24	0.38 to 4.05
High fasting glucose	2.62	1.34 to 5.11*	2.04	1.86 to 4.75*
Hypertriglyceridemia	1.22	0.63 to 2.35	1.01	0.42 to 2.43
Low high-density lipoprotein cholesterol	0.33	0.12 to 0.90*	0.40	0.12 to 1.34
High Blood Pressure	3.82	1.65 to 8.85*	2.25	1.83 to 6.09*
Younger: age ≤51 year (n=118)				
Body mass index (kg/m^2)				
25 to 29.99	2.89	0.87 to 9.60	1.24	0.26 to 5.81
≥30	2.24	0.48 to 10.46	0.67	0.11 to 4.19
High fasting glucose	4.11	1.28 to 13.20*	1.72	0.43 to 6.86
Hypertriglyceridemia	7.55	2.25 to 25.34*	4.42	1.08 to 18.03*
Low high-density lipoprotein cholesterol	0.27	0.06 to 1.22	0.53	0.09 to 3.02
High Blood Pressure	5.05	1.52 to 16.79*	2.37	0.51 to 11.04

* The p-value less than 0.05 is considered statistically significant
High blood pressure = blood pressure ≥130/85 mmHg or hypertension medication; Hypertriglyceridemia = triglyceride ≥150 mg/dl; Low high-density lipoprotein cholesterol (HDL-C) = HDL-C <40 mg/d in men and <50 mg/d in women; High fasting glucose = glucose ≥100 mg/dl or diabetic medication; In subgroup analysis, Area under receiver operating characteristic (ROC) curve = 81.75% in older group and 81.65% in younger group; OR = crude odds ratio; aOR = adjusted for sex

Our results were able to extend the previous findings that hypertension was associated with gout from the population-based Atherosclerosis Risk in Communities (ARIC) study that was limited to participants of the This analysis was limited to participants who were Caucasian or African American. The magnitude of the association, approximately a 2-fold increase in risk, was similar to these previous studies[50]. However, hypertension was not

Table 4. The odds ratios for the presence of gout according to presence of metabolic syndrome and obesity

Factors	OR	95% CI	aOR	95% CI
Metabolic syndrome (MetS)	4.36	2.52 to 7.53	2.38	1.20 to 4.72*
GO (-) MetS (-)	1.00		1.00	
GO (-) MetS (+)	3.69	1.65 to 8.26	1.26	0.45 to 3.52
GO (+) MetS (-)	1.23	0.52 to 2.92	0.82	0.29 to 2.30
GO (+) MetS (+)	5.42	2.68 to 10.94	2.78	1.16 to 6.67*

* The p-value less than 0.05 is considered statistically significant
GO = General obesity (defined by BMI ≥25 kg/m^2); Area under receiver operating characteristic (ROC) curve = 87.47%; OR = crude odds ratio; aOR = adjusted for age and sex

associated with gout in men population[51]. Hypertension is the cause of glomerular arteriolar damage and glomerulosclerosis, which leads to renal insufficiency and hyperuricemia. However, the directionality of hypertension and hyperuricemia is currently debated, and it is possible that the relationship is bi directional[36]. Therefore, we are agreed with a previous study remark that hypertension is one component of metabolic syndrome, which has been associated with the development of gout[52].

Our present study has shown that hypertriglyceridemia was associated with gout in young adults, but not older adults. This could be due to the number of cases of gout in older remained low. However, this present study was consistent with a study in Bangladeshi and Taiwanese adults[40,55]. The previous study demonstrating the possible mechanism that enhanced triglyceride lipolysis in adipose tissue is speculated to potentiate gout. An engagement of fatty acids with Toll-like receptor 2 that drives interleukin-1β production via the ASC/caspase 1 pathway has been demonstrated in monosodium urate monohydrate crystal (MSU) crystal-induced gout[56]. Therefore, we hypothesized that comorbidities may contribute to the high risk of gout development in young adults. However, our study shows that no significant association between different metabolic components with low high-density lipoprotein cholesterol, overweight and obesity. Inconsistent with our finding, some previous studies have also shown the association of gout with hypertriglyceridemia, low HDL-C, obesity in the noninstitutionalized United States civilian population[25], and a positive association was also found between increase serum uric acid and overweight/obesity[53,54], and low HDL-C[39,40] in different population.

We were the first to find substantial association between metabolic syndromes, approximately 2-fold, on gout in Thai adults. A previous large cross-sectional study showed that the prevalence of the metabolic syndrome in people with gout was 62.8% compared with 25.4% in people without gout[25]. That is, MetS can be used as an important predictive factor for gout. However, we cannot be possible to determine a causal relationship between gout and MetS. Because, this study could not eliminate the potential effects of underlying diseases, and dietary habits for these diseases among participants on the present findings. Thus, it is possible that residual confounding by these factors may also affect the MetS and gout link. Further population-based prospective studies are needed to clarify a cause-effect relationship between gout and MetS. Furthermore, not only elevated MetS were associated with an increased risk of gout, but both general obesity and MetS showed nearly a 3-fold increased risk for gout compared to adults without conditions. We assumed that general obesity and MetS may intensify several pathophysiological mechanisms that are associated with the gout risk and may have synergistic interactions with causing gout. The mechanisms of association between obesity-MetS need to explore in the nearly future.

The current study has some limitations, which should be considered. Firstly, our findings are based on a rural community of Thai adults with gout. Future large independent studies are warranted to further validate our results. Secondly, our current study suggested that men were significantly associated with increasing the risk of gout, due to the large sample size and the relatively even proportion of men and women remained low (8 cases). Women may have more delay in diagnosis with gout since the disease is male-dominant. However, the results from a meta-analysis revealed[57] that risk factors for developing gout did not typically differ between genders. Therefore, further investigation and more research into the risk factors for gout in women are required in a matched case-control study. In addition, we were not able to collect more detailed information as this study did not provide information about environmental factors such as alcohol consumption, smoking, dietary consumption as well as adiposity throughout the life course such as waist circumference (WC), waist to hip ratio (WHR), or waist to height ratio (WHtR) that could affect gout. Therefore, we should be investigated in future studies. Finally, environmental factors-metabolic parameters interaction might also play a significant role in gout risk, which represents a limitation of our study. Despite the limitations, this study result would be useful with respect to public health, because we demonstrated associations between gout with both MetS parameters and

general obesity in a Thai adult population-representative survey database.

Conclusion

In conclusion, our study confirmed that age increase every 10 years, sex (men), and components of MetS such as high fasting blood glucose and high blood pressure had significantly increased risk of gout. The participants with general obesity with MetS emerged as having one of the most significant risk factors for developing gout in Thai adults. Furthermore, older adults with both high fasting blood glucose and high blood pressure carried strikingly higher risks of gout compared to those without both conditions, whereas young adults with hypertriglyceridemia are higher increased. Accordingly, more attention should be paid to the increased risk of gout for these population.

What is already known on this topic?

Major significant risk factors for gout include high fasting blood glucose and high blood pressure.

A combination of obesity and MetS contribute to the development of gout.

Hypertriglyceridemia have been identified as risk factors for gout in the middle-aged.

Both high fasting blood glucose and high blood pressure factors are important risk factors for gout in older population.

What this study adds?

Future research into interactions between environmental factors (alcohol consumption, smoking, and dietary consumption) would expand our understanding of the epidemiology and pathophysiology of gout. Further studies with larger sample sizes are needed on adiposity throughout the life course, waist-to-hip ratio, and weight changes in relation to gout as there were few studies in the Thai population. In addition, environmental factors-metabolic parameters interaction, including interaction between co-morbidities, might also play a significant role in gout risk, which represents a limitation of our study.

Acknowledgements

We thank the department of Biochemistry and department of Internal Medicine, Faculty of medicine, Srinakharinwirot University for their cooperation and their kind support. This study was supported by Government Budget Grant (Contract No. 006/2562).

Potential conflicts of interest

The authors declared no conflict of interests.

References

1. Annemans L, Spaepen E, Gaskin M, Bonnemaire M, Malier V, Gilbert T, et al. Gout in the UK and Germany: prevalence, comorbidities and management in general practice 2000-2005. Ann Rheum Dis 2008;67:960-6.
2. Kuo CF, Grainge MJ, Zhang W, Doherty M. Global epidemiology of gout: prevalence, incidence and risk factors. Nat Rev Rheumatol 2015;11:649-62.
3. Liu R, Han C, Wu D, Xia X, Gu J, Guan H, et al. Prevalence of hyperuricemia and gout in mainland China from 2000 to 2014: a systematic review and meta-analysis. Biomed Res Int 2015;2015:762820.
4. Bardin T, Bouee S, Clerson P, Chales G, Flipo RM, Liote F, et al. Prevalence of gout in the adult population of France. Arthritis Care Res (Hoboken) 2016;68:261-6.
5. Rodriguez-Amado J, Pelaez-Ballestas I, Sanin LH, Esquivel-Valerio JA, Burgos-Vargas R, Perez-Barbosa L, et al. Epidemiology of rheumatic diseases. A community-based study in urban and rural populations in the state of Nuevo Leon, Mexico. J Rheumatol Suppl 2011; 86:9-14.
6. Singh G, Lingala B, Mithal A. Gout and hyperuricaemia in the USA: prevalence and trends. Rheumatology (Oxford) 2019;58:2177-80.
7. Kuo CF, Grainge MJ, See LC, Yu KH, Luo SF, Zhang W, et al. Epidemiology and management of gout in Taiwan: a nationwide population study. Arthritis Res Ther 2015;17:13.
8. Dehlin M, Jacobsson L, Roddy E. Global epidemiology of gout: prevalence, incidence, treatment patterns and risk factors. Nat Rev Rheumatol 2020;16:380-90.
9. Lohsoonthorn V, Dhanamun B, Williams MA. Prevalence of hyperuricemia and its relationship with metabolic syndrome in Thai adults receiving annual health exams. Arch Med Res 2006;37:883-9.
10. Wannaiampikul S, Sangsawangchot P, Tanunyutthawongse C. High prevalence of hyperuricemia and lack of association with rs2280205 and rs6820230 alleles of the SLC2A9 gene in urban Bangkok, Thailand. Genet Mol Res. 2020;19:GMR18511.
11. Uaratanawong S, Suraamornkul S, Angkeaw S, Uaratanawong R. Prevalence of hyperuricemia in Bangkok population. Clin Rheumatol 2011;30:887-93.
12. Patel S, Nanda R, Mohapatra E. Prevalence of metabolic syndrome and its association with various risk factors. Int J Recent Sci Res 2017;08:16256-60.
13. Osei-Yeboah J, Owiredu WK, Norgbe GK, Yao Lokpo S, Gyamfi J, Alote Allotey E, et al. The prevalence of metabolic syndrome and its components among people with type 2 diabetes in the Ho Municipality, Ghana: a cross-sectional study. Int J Chronic Dis 2017;2017: 8765804.
14. Jahangiry L, Khosravi-Far L, Sarbakhsh P, Kousha A, EntezarMahdi R, Ponnet K. Prevalence of metabolic syndrome and its determinants among Iranian adults: evidence of IraPEN survey on a bi-ethnic population. Sci Rep 2019;9:7937.
15. Syed MA, Al Nuaimi AS, Latif Zainel AJA, HA AQ. Prevalence of metabolic syndrome in primary health settings in Qatar: a cross sectional study. BMC Public Health 2020;20:611.
16. Sigit FS, Tahapary DL, Trompet S, Sartono E, Willems

van Dijk K, Rosendaal FR, et al. The prevalence of metabolic syndrome and its association with body fat distribution in middle-aged individuals from Indonesia and the Netherlands: a cross-sectional analysis of two population-based studies. Diabetol Metab Syndr 2020;12:2.
17. Dalvand S, Niksima SH, Meshkani R, Ghanei Gheshlagh R, Sadegh-Nejadi S, Kooti W, et al. Prevalence of metabolic syndrome among Iranian population: a systematic review and meta-analysis. Iran J Public Health 2017;46:456-67.
18. Hirode G, Wong RJ. Trends in the prevalence of metabolic syndrome in the United States, 2011-2016. JAMA 2020;323:2526-8.
19. Krishnamoorthy Y, Rajaa S, Murali S, Rehman T, Sahoo J, Kar SS. Prevalence of metabolic syndrome among adult population in India: A systematic review and meta-analysis. PLoS One 2020;15:e0240971.
20. Ge H, Yang Z, Li X, Liu D, Li Y, Pan Y, et al. The prevalence and associated factors of metabolic syndrome in Chinese aging population. Sci Rep 2020;10:20034.
21. Yuenyongchaiwat K, Pipatsitipong D, Sangprasert P. The prevalence and risk factors of metabolic syndrome a suburban community in Pathum Thani province, Thailand. Songklanakarin J Sci Technol 2017;39:787-92.
22. Aekplakorn W, Chongsuvivatwong V, Tatsanavivat P, Suriyawongpaisal P. Prevalence of metabolic syndrome defined by the International Diabetes Federation and National Cholesterol Education Program criteria among Thai adults. Asia Pac J Public Health 2011;23:792-800.
23. Jung JH, Song GG, Ji JD, Lee YH, Kim JH, Seo YH, et al. Metabolic syndrome: prevalence and risk factors in Korean gout patients. Korean J Intern Med 2018;33:815-22.
24. Yoo HG, Lee SI, Chae HJ, Park SJ, Lee YC, Yoo WH. Prevalence of insulin resistance and metabolic syndrome in patients with gouty arthritis. Rheumatol Int 2011;31:485-91.
25. Choi HK, Ford ES, Li C, Curhan G. Prevalence of the metabolic syndrome in patients with gout: the Third National Health and Nutrition Examination Survey. Arthritis Rheum 2007;57:109-15.
26. Rho YH, Choi SJ, Lee YH, Ji JD, Choi KM, Baik SH, et al. The prevalence of metabolic syndrome in patients with gout: a multicenter study. J Korean Med Sci 2005;20:1029-33.
27. Lukkunaprasit T, Rattanasiri S, Turongkaravee S, Suvannang N, Ingsathit A, Attia J, et al. The association between genetic polymorphisms in ABCG2 and SLC2A9 and urate: an updated systematic review and meta-analysis. BMC Med Genet 2020;21:210.
28. Chen CJ, Tseng CC, Yen JH, Chang JG, Chou WC, Chu HW, et al. ABCG2 contributes to the development of gout and hyperuricemia in a genome-wide association study. Sci Rep 2018;8:3137.
29. Singh JA, Reddy SG, Kundukulam J. Risk factors for gout and prevention: a systematic review of the literature. Curr Opin Rheumatol 2011;23:192-202.
30. Evans PL, Prior JA, Belcher J, Mallen CD, Hay CA, Roddy E. Obesity, hypertension and diuretic use as risk factors for incident gout: a systematic review and meta-analysis of cohort studies. Arthritis Res Ther 2018;20:136.
31. Roddy E, Choi HK. Epidemiology of gout. Rheum Dis Clin North Am 2014;40:155-75.
32. Choi HK, Atkinson K, Karlson EW, Willett W, Curhan G. Purine-rich foods, dairy and protein intake, and the risk of gout in men. N Engl J Med 2004;350:1093-103.
33. Choi HK, Curhan G. Soft drinks, fructose consumption, and the risk of gout in men: prospective cohort study. BMJ 2008;336:309-12.
34. Bhole V, de Vera M, Rahman MM, Krishnan E, Choi H. Epidemiology of gout in women: Fifty-two-year followup of a prospective cohort. Arthritis Rheum 2010; 62:1069-76.
35. Cea Soriano L, Rothenbacher D, Choi HK, Garcia Rodriguez LA. Contemporary epidemiology of gout in the UK general population. Arthritis Res Ther 2011;13: R39.
36. Pan A, Teng GG, Yuan JM, Koh WP. Bidirectional association between self-reported hypertension and gout: The Singapore Chinese Health Study. PLoS One 2015;10:e0141749.
37. Anagnostopoulos I, Zinzaras E, Alexiou I, Papathanasiou AA, Davas E, Koutroumpas A, et al. The prevalence of rheumatic diseases in central Greece: a population survey. BMC Musculoskelet Disord 2010;11:98.
38. Pan A, Teng GG, Yuan JM, Koh WP. Bidirectional association between diabetes and gout: the Singapore Chinese Health Study. Sci Rep 2016;6:25766.
39. Peng TC, Wang CC, Kao TW, Chan JY, Yang YH, Chang YW, et al. Relationship between hyperuricemia and lipid profiles in US adults. Biomed Res Int 2015;2015: 127596.
40. Ali N, Rahman S, Islam S, Haque T, Molla NH, Sumon AH, et al. The relationship between serum uric acid and lipid profile in Bangladeshi adults. BMC Cardiovasc Disord 2019;19:42.
41. Son M, Seo J, Yang S. Association between dyslipidemia and serum uric acid levels in Korean adults: Korea National Health and Nutrition Examination Survey 2016-2017. PLoS One 2020;15:e0228684.
42. Taylor WJ, Fransen J, Dalbeth N, Neogi T, Schumacher HR, Brown M, et al. Performance of classification criteria for gout in early and established disease. Ann Rheum Dis 2016;75:178-82.
43. Grassi W, De Angelis R. Clinical features of gout. Reumatismo 2012;63:238-45.
44. WHO Expert Consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet 2004;363:157-63.
45. Huang PL. A comprehensive definition for metabolic

syndrome. Dis Model Mech 2009;2:231-7.
46. Mather A, Pollock C. Glucose handling by the kidney. Kidney Int Suppl 2011;(120):S1-6.
47. Nan H, Dong Y, Gao W, Tuomilehto J, Qiao Q. Diabetes associated with a low serum uric acid level in a general Chinese population. Diabetes Res Clin Pract 2007;76:68-74.
48. Augustin R, Carayannopoulos MO, Dowd LO, Phay JE, Moley JF, Moley KH. Identification and characterization of human glucose transporter-like protein-9 (GLUT9): alternative splicing alters trafficking. J Biol Chem 2004;279:16229-36.
49. Caulfield MJ, Munroe PB, O'Neill D, Witkowska K, Charchar FJ, Doblado M, et al. SLC2A9 is a high-capacity urate transporter in humans. PLoS Med 2008;5:e197.
50. McAdams-DeMarco MA, Maynard JW, Baer AN, Coresh J. Hypertension and the risk of incident gout in a population-based study: the atherosclerosis risk in communities cohort. J Clin Hypertens (Greenwich) 2012;14:675-9.
51. Campion EW, Glynn RJ, DeLabry LO. Asymptomatic hyperuricemia. Risks and consequences in the Normative Aging Study. Am J Med 1987;82:421-6.
52. Chen SY, Chen CL, Shen ML. Manifestations of metabolic syndrome associated with male gout in different age strata. Clin Rheumatol 2007;26:1453-7.
53. Ali N, Perveen R, Rahman S, Mahmood S, Rahman S, Islam S, et al. Prevalence of hyperuricemia and the relationship between serum uric acid and obesity: A study on Bangladeshi adults. PLoS One 2018;13: e0206850.
54. Chen MY, Zhao CC, Li TT, Zhu Y, Yu TP, Bao YQ, et al. Serum uric acid levels are associated with obesity but not cardio-cerebrovascular events in Chinese inpatients with type 2 diabetes. Sci Rep 2017;7:40009.
55. Chen JH, Pan WH, Hsu CC, Yeh WT, Chuang SY, Chen PY, et al. Impact of obesity and hypertriglyceridemia on gout development with or without hyperuricemia: a prospective study. Arthritis Care Res (Hoboken) 2013;65:133-40.
56. Joosten LA, Netea MG, Mylona E, Koenders MI, Malireddi RK, Oosting M, et al. Engagement of fatty acids with Toll-like receptor 2 drives interleukin-1β production via the ASC/caspase 1 pathway in monosodium urate monohydrate crystal-induced gouty arthritis. Arthritis Rheum 2010;62:3237-48.
57. Evans PL, Prior JA, Belcher J, Hay CA, Mallen CD, Roddy E. Gender-specific risk factors for gout: a systematic review of cohort studies. Adv Rheumatol 2019;59:24.