Association between Serum Uric Acid Level and Metabolic Syndrome in Nuclear Power Plant Workers

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1. Introduction

Metabolic syndrome (MetS) is estimated to be the cause of cardiovascular disease, cerebrovascular disease and type 2 diabetes mellitus (DM), and is increasing worldwide [1]. The cause of MetS is known as insulin resistance (IR) and obesity, but the exact mechanism is unknown. Uric acid (UA) is the final product in purine metabolism and is associated with oxidative stress [2]. There have been studies on the increased level of serum UA in shift workers (SW), and it is said that circadian rhythm change induces sleep deprivation and stress, thereby increasing the level of serum UA [3]. IR is associated with MetS because it reduces the excretion of serum UA, and increased level of serum UA causes high blood pressure (BP), high triglyceride (TG) and low high- density lipoprotein cholesterol (HDL-C) [4]. There are many studies on the relationship between hyperuricemia (HU) and MetS, but studies targeting SW are rare. We analyzed the relationship between serum UA level, MetS and Metabolic components in SW by comparing them with daytime workers (DW).

2. Methods and Results

2.1 Participants

Physical measurement, blood test and survey were conducted on 9,195 nuclear power plant workers (NPPW) who underwent regular health check-up from March 2021 to December 2021. It was compared and analyzed by dividing into 6,630 DW and 2,565 SW (two shift: 170, three shift: 2,395). Serum uric acid quartiles were used as follows: Q1(<4.8 mg/dl), Q2 (4.8-<5.6 mg/dl), Q3 (5.6-<6.8 mg/dl) and Q4 (≥6.8 mg/dl).

2.2 Statistical Analysis

For the comparison between the two groups, the student-t test and Chi-square test were used for continuous and categorical variables, respectively. In both groups, the correlation of other variables with serum UA concentrations was analyzed using Pearson's analysis. The serum UA levels were divided into 4 quartiles and analyzed the differences of variables among quartiles using analysis of variance (ANOVA) for continuous variables and Chi-square test for categorical variables. Multiple logistic regression analysis was performed to obtain the odds ratio (OR) of MetS according to serum UA quartiles in both groups. Six models were used to correct the confounding factors (Model 1; unadjustment, Model 2; age, Model 3; Model 2 + WBC, GOT, GPT, Model 4; Model 3 + Cr, Model 5; Model 4 + alcohol, smoking, exercise, Model 6; Model 5 + BMI). Additionally, the OR of metabolic components were obtained using Model 6.

2.3 Characteristics of the Study Population

The prevalence of MetS was significantly increased in DW (23.7%) than in SW (20.6%) (P=0.001). Age, waist circumference (WC), diastolic blood pressure (DBP), fasting plasma glucose (FPG), total cholesterol (T-Chol), low density lipoprotein cholesterol (LDL-C), serum creatinine (Cr), number of metabolic components (MS) and alcohol consumption status increased significantly in DW, and body mass index (BMI), systolic blood pressure (SBP), white blood cell (WBC), HDL-C, UA, smoking status and exercise increased significantly in SW [Table 1].

2.4 Relationships of Clinical Characteristics with Serum UA levels

In DW, age, FPG and HDL-C showed significant negative correlation and the other variables showed positive correlation. In SW, only FPG did not show correlation, but results of the others were the same as those of DW. Depending on serum UA quartiles using ANOVA, age and HDL-C correlated negatively with significance in both groups. In DW, higher quartiles showed significantly positive correlations in BMI, WC, SBP, DBP, WBC, GOT, GPT, T-Chol, LDL-C, TG and Cr. There were significant differences in FPG with quartiles but it did not show positive or negative relation. SW showed significantly positive correlation in BMI, WC, SBP, WBC, LDL-C, TG and Cr. Both groups showed significantly increased prevalence of MetS and number of metabolic components according to higher serum UA quartiles [Fig. 1].

2.5 Associations of MetS with Serum UA Quartiles

The unadjusted OR for MetS in the highest UA quartile compared with the lowest quartiles was 2.146 (95% CI, 1.839 to 2.505) and 2.174 (95%CI, 1.658 to 2.851) in DW and SW, respectively. After adjustment of age, WBC, GOT, GPT, Cr, alcohol, smoking and exercise, the ORs for MetS increased significantly in 3rd and 4th quartiles (Model2-Model 5) in both groups.

In addition, its significance was remained in 4th quartiles after adjustment of BMI (Model 6) in each group. Among metabolic components, hypertriglyceridemia and low HDL-C levels were significantly associated with 3rd and 4th quartiles in both groups (P<0.001), while hypertension was significantly associated with DW (P=0.001) and high FPG (P=0.019) with SW. However, WC was not significantly associated in both groups.

Table 1. Clinical characteristics of the participants

Variables	DW	SW	*P* value
Age	43.5 ± 9.6	38.7 ± 9.7	< 0.001
BMI	24.9 ± 3.1	25.2 ± 3.2	< 0.001
WC	85.2 ± 7.8	84.5 ± 8.2	0.001
SBP	122.6 ± 11.1	123.3 ± 11.9	0.004
DBP	77.8 ± 9.0	76.9 ± 9.5	< 0.001
WBC	5940 ± 1464	6333 ± 1539	< 0.001
GOT	26.9 ± 18.9	26.7 ± 16.7	0.634
GPT	31.0 ± 23.9	30.9 ± 23.3	0.760
FPG	99.0 ± 17.7	97.6 ± 15.4	< 0.001
T-chol	203.8 ± 37.6	200.1 ± 35.0	< 0.001
HDL-C	53.1 ± 12.2	53.8 ± 11.8	0.017
LDL-C	126.2 ± 34.1	123.8 ± 32.3	0.002
TG	140.7 ± 112.3	141.2 ± 113.7	0.820
UA	6.25 ± 1.30	6.41 ± 1.30	< 0.001
Cr	0.96 ± 0.15	0.92 ± 0.13	< 0.001
MS	1.6 ± 1.3	1.4 ± 1.3	< 0.001
Alcohol			< 0.001
Yes (%)	1371 (20.7)	363 (14.2)	
No (%)	5255 (79.3)	2202 (85.8)	
Smoking			< 0.001
No (%)	2846 (43.0)	1155 (45.0)	
Former (%)	2214 (33.4)	689 (26.9)	
Current (%)	1566 (23.6)	721 (28.1)	
Exercise			0.002
Yes (%)	1756 (26.5)	761 (29.7)	
No (%)	4870 (73.5)	1804 (70.3)	
MetS			0.001
Yes (%)	1573 (23.7)	529 (20.6)	
No (%)	5057 (76.3)	2036 (79.4)	

3. Conclusions

Although the prevalence of MetS was higher in DW than in SW, and the ORs according to the increase in serum UA quartiles was similar to that of SW, HU is an independent risk factor of MetS in male workers. Since most SW work in three shifts, there is a possibility that they have been less affected by circadian rhythm changes. In addition, age, lifestyle habits such as alcohol drink and lack of exercise may affect the MetS.

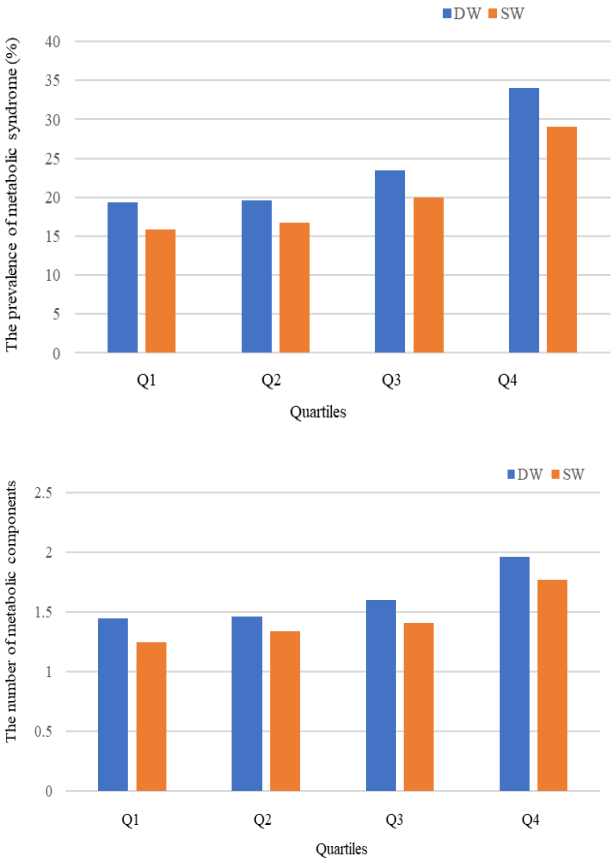

Fig. 1. The prevalence of MetS was significantly different from the Q1 to Q4 quartiles (P<0.001). The number of metabolic components showed similar relationships with serum UA quartiles (P<0.001).

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