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# The Relationship between Workplace Environment and Metabolic Syndrome

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## Abstract

**Background:** Metabolic syndrome, a major risk factor for cardiovascular disease and diabetes, is recognized as an important health problem.

**Objective:** To investigate whether the workplace environment was associated with metabolic syndrome.

**Methods:** This study was a cross-sectional study using medical records and workplace environment reports of 1297 blue-collar Korean male workers who were exposed to work hazards in one workplace. The metabolic syndrome was confirmed using the NCEP ATP III. The workplace environment was classified into organic compounds, metals, acids and bases, metalworking fluid, dust, noise and shift worker.

**Results:** Among the total subjects, 257 (19.8%) had metabolic syndrome. Age, BMI, current smoking status, and at risk alcohol drinking were found to be significant predictors of metabolic syndrome. In seven workplace environment categories, the odds ratio (OR) of metabolic syndrome increased 1.785 (95% CI 1.058 to 3.013) times in the metalworking fluid environment.

**Conclusion:** The workplace environment, especially metalworking fluid is associated with metabolic syndrome.

**Key words:** Metabolic syndrome; Workplace; Environment; Metals; Lubricants

## Introduction

The prevalence of metabolic syndrome, a risk factor for cardiovascular disease and diabetes, varies from 11.9% to 37.1% in most Asian countries, and show a continuously increasing trend in some countries.<sup>1</sup> In Korea, metabolic syndrome is recognized as a major health problem. The prevalence of metabolic syndrome in Korean adults is reported to be 28.9% in 2013.<sup>2</sup>

Lifestyle is an important factor in the development of metabolic syndrome; so do sex and age. Smoking, alcohol con-

sumption and physical activity were common lifestyle factors associated with metabolic syndrome.<sup>3,4</sup> Type of occupation is also important in development of metabolic syndrome. For example, the incidence of metabolic syndrome in the white collar workers is higher than other male workers.<sup>5</sup> Those with sedentary or shift work carry a higher risk of metabolic syndrome.<sup>6,7</sup> The incidence of metabolic syndrome is 2.3-fold higher in those working for 10 or more hours per day.<sup>8</sup> Workplace environment may also affect the occurrence of metabolic syndrome. In animal experiments, it was confirmed that chronic

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Received: May 3, 2018  
Accepted: Aug 4, 2018

Cite this article as: Jeong HS. The relationship between workplace environment and metabolic syndrome. *Int J Occup Environ Med* 2018;9:176-183. doi: 10.15171/ijoem.2018.1346

noise increases blood glucose.<sup>9</sup>

According to the Occupational Safety and Health Act in South Korea, there are three occupational health services provided to workers, including periodic occupational medical examinations, workplace environment measurements, and health management services.<sup>10</sup> Korean workers who particularly exposed to 177 hazardous substances and environments must receive certain health examinations.<sup>11</sup>

However, studies investigating the relationship between work environment and metabolic syndrome are scarce. We therefore, conducted this study to determine the relationship between work environment and metabolic syndrome among a group of Korean blue-collar male workers.

## Materials and Methods

Using medical records, this cross-sectional study was conducted on 1334 Korean blue-collar workers who received special health checkup at a health center affiliated to a university hospital in Gyeongju, South Korea, from March 1 to July 31, 2016. According to the Occupational Safety and Health Act of South Korea, we classified the workplace environment into six categories based on exposure to organic compounds, metals, acids and bases, metalworking fluid, dust, and noise. The categorization was based on the 177 occupational hazardous substances using the individual worker's reports for workplace environment measurement in the same workplace (Appendix).<sup>12</sup> We also identified shift workers. Data collected included demographic variables and results of blood tests.

In this study, we used the diagnostic criteria of the National Cholesterol Education Program's Adults Treatment Panel (NCEP ATP) III to identify metabolic syndrome.<sup>13</sup> Alcohol consumption was defined as "drinking more than 14 glasses over a week regardless of the main alcoholic

### TAKE-HOME MESSAGE

- The workplace environment is associated with metabolic syndrome.
- The prevalence of metabolic syndrome was 19.8% among a group of Korean blue-collar male workers.
- Those chronically exposed to metalworking fluid is more likely to develop metabolic syndrome compared with non-exposed workers (OR 1.79, 95% CI 1.06 to 3.01).

beverage."<sup>14</sup> For assessment of physical activity, short form of the Korean version of the International Physical Activity Questionnaire (IPAQ) was used. The reliability and validity of the questionnaire were approved earlier.<sup>15</sup> The questionnaire consists of seven questions on vigorous activities (*eg*, aerobics, fasting bicycling), moderate activities (*eg*, double tennis, bicycling at a regular pace), walking activities and inactivity for last seven days. The total physical activities converted to total METs using the following equations:<sup>16</sup>

$$\text{Total METs (week)} = (3.3 \times \text{Walking minutes} \times \text{days}) + (4.0 \times \text{Moderate activities minutes} \times \text{days}) + (8.0 \times \text{Vigorous activities})$$

where, "Walking" is equivalent to 3.3 METs, "Moderate activity" is 4.0 METs, and "Vigorous activities" is 8.0 METs. A physical activity <600 METs was considered "lack of physical activity."<sup>17</sup>

### Ethics

All studied participants gave written informed consent. The study protocol was approved by the same hospital Institutional Review Board.

### Statistical Analysis

SPSS ver 20.0 (SPSS Inc, USA) was used for data analyses. Logistic regression anal-

**Table 1:** Univariate and multivariate analysis of the relationship between workplace environmental factors and metabolic syndrome. Values are either mean (SD) or n (%).

Variables	Total (n=1297)	Metabolic syndrome		OR (95% CI)	
		Yes (n=257)	No (n=1040)	Crude	Adjusted
Age (yrs)	45.5 (12.3)	48.0 (10.2)	44.9 (10.2)	1.02 (1.01 to 1.04)	1.04 (1.03 to 1.06)
Body mass index (kg/m <sup>2</sup> )	24.3 (2.8)	26.3 (2.9)	23.8 (2.5)	1.42 (1.34 to 1.51)	1.48 (1.39 to 1.58)
Current smoking					
No	277 (21.4%)	183 (71.2%)	837 (80.5%)	1	1
Yes	1020 (78.6%)	74 (28.8%)	203 (19.5%)	1.67 (1.22 to 2.27)	1.55 (1.09 to 2.21)
At risk alcohol drinking					
No	595 (45.9%)	118 (45.9%)	584 (56.2%)	1	1
Yes	702 (54.1%)	139 (54.1%)	456 (43.8%)	1.51 (1.15 to 1.99)	1.44 (1.06 to 1.96)
Lack of physical activity					
No	246 (19.0%)	57 (22.2%)	189 (18.2%)	1	1
Yes	1051 (81.0%)	200 (77.8%)	851 (81.8%)	0.78 (0.56 to 1.09)	0.86 (0.59 to 1.25)
Organic compounds					
No	429 (33.1%)	189 (73.5%)	770 (74.0%)	1	1
Yes	868 (66.9%)	68 (26.5%)	270 (26.0%)	1.03 (0.75 to 1.40)	0.98 (0.67 to 1.44)
Metals					
No	338 (26.1%)	164 (63.8%)	704 (67.7%)	1	1
Yes	959 (73.9%)	93 (36.2%)	336 (32.3%)	1.19 (0.89 to 1.58)	1.05 (0.75 to 1.48)
Acids/Bases					
No	217 (16.7%)	205 (79.8%)	875 (84.1%)	1	1
Yes	1080 (83.3%)	52 (20.2%)	165 (15.9%)	1.35 (0.95 to 1.90)	1.51 (0.99 to 2.28)
Metalworking fluid					
No	101 (7.8%)	228 (88.7%)	968 (93.1%)	1	1
Yes	1196 (92.2%)	29 (11.3%)	72 (6.9%)	1.71 (1.09 to 2.69)	1.79 (1.06 to 3.01)
Noise					
No	505 (61.1%)	163 (63.4%)	629 (60.5%)	1	1
Yes	792 (38.9%)	94 (36.6%)	411 (39.5%)	0.88 (0.67 to 1.17)	0.85 (0.60 to 1.19)

*Continued*

**Table 1:** Univariate and multivariate analysis of the relationship between workplace environmental factors and metabolic syndrome. Values are either mean (SD) or n (%).

Variables	Total (n=1297)	Metabolic syndrome		OR (95% CI)	
		Yes (n=257)	No (n=1040)	Crude	Adjusted
Dust					
No	213 (16.4%)	204 (79.4%)	880 (84.6%)	1	1
Yes	1084 (83.6%)	53 (20.6%)	160 (15.4%)	1.43 (1.01 to 2.02)	1.34 (0.89 to 2.02)
Shift worker					
No	929 (71.6%)	80 (31.1%)	288 (27.7%)	1	1
Yes	368 (28.4%)	177 (68.9%)	752 (72.3%)	0.85 (0.63 to 1.14)	0.82 (0.58 to 1.16)

ysis was used to determine the independent work environmental factors affecting the development of metabolic syndrome after adjusting for demographic and life-style factors. A p value <0.05 was considered statistically significant.

**Results**

Of 1337 workers, 1297 (97.0%) were included in the final analysis, excluding women and those with missing data. Characteristics of studied workers are presented in Table 1. Two-hundred and fourteen (16.5%) workers were taking medication for hypertension or diabetes. The prevalence of metabolic syndrome was 19.8% (95% CI 17.6% to 22.0%).

The independent predictors of metabolic syndrome were age, body mass index (BMI), smoking, alcohol consumption, and exposure to metalworking fluid (Table 1). Although exposure to dust was found a significant risk factor of metabolic syndrome in univariate analysis, the significance was abolished after adjusting for confounders (Table 1).

**Discussion**

The prevalence of metabolic syndrome in Korean male adults is 30.8%.<sup>2</sup> The prevalence observed in this study was 19.8%. The observed difference may be attributed to the age difference of the studied subjects. Furthermore, we studied blue collar workers rather than office workers.<sup>5</sup>

Metalworking fluid, commonly used in work for machining, is a liquid used to reduce heat and friction during metal work. We found that those handling metalworking fluid were more likely to develop metabolic syndrome. This was still significant after adjusting for age, BMI, smoking, and alcohol consumption, which are known to be associated with metabolic syndrome. Because metalworking fluid exists in the form of mist, some are absorbed by inhalation and some through the skin.<sup>18</sup> Existing medical conditions related to metalworking fluid are respiratory diseases such as work-related asthma and hypersensitivity pneumonitis.<sup>19</sup> A recent observational study about exposure to metalworking fluid and disease outbreaks for 10 years revealed a the exposure causes skin diseases more often than respiratory illnesses.<sup>20</sup> In addition, some studies report the associa-

For more information on the association between metabolic syndrome and job rank see <http://www.theijoem.com/ijoem/index.php/ijoem/article/view/1197>



tion between development of certain cancers and exposure to metalworking fluid.<sup>21</sup>

The mechanism through which metalworking fluid causes respiratory disease is believed to be mainly inhalation of mist contaminated with micro-organisms and various chemical additives in the fluid that are known to be stimulants of the respiratory tract.<sup>22</sup> On the other hand, animal experiments show that some components of the metalworking fluid would cause acute inflammation and oxidative stress in the body.<sup>23</sup> In fact, the low-level persistent inflammatory response exists in those chronically exposed to metalworking fluid, is recognized as an important factor in the pathogenesis of metabolic syndrome.<sup>24</sup> This mechanism may explain the association between exposure to metalworking fluid and metabolic syndrome observed in our study.

This study had some limitations. First, according to the law, workers in this study were wearing personal protective equipment and we could not assess the exposure dosage of the studied environmental factors. Second, because the studied workers in this study worked in only one workplace, the result cannot be generalized.

In conclusion, the workplace environment is associated with metabolic syndrome. It seems that workers who are handling metalworking fluid would be particularly at higher risk of developing metabolic syndrome.

### Acknowledgments

This work was supported by the Dongguk University Research Fund, 2014.

**Conflicts of Interest:** None declared.

**Financial Support:** None.

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Appendix

**Table 1S:** List of 177 substances considered occupationally hazardous by Korea Occupation Safety & Health Agency(KOSHA). Available from <http://english.kosha.or.kr/english/cms/Tiles.do?url=/cms/board/board/Board.jsp?communityKey=B0488&menuId=1240> (Accessed July 31, 2018).

Organic compounds (108)	Gasoline; Gluataraldehyde; $\beta$ -Naphthylamine; Nitroglycerin; Nitromethane; Nitrobenzene; p-Nitrochlorobenzene; Dinitrotoluene; Dimethylaniline; p-Dimethylaminoazobenzene; N,N-dimethylformamide; Diisobutyl ketone; Dichloromethane; o-Dichlorobenzene; 1,2-Dichloroethylene; 1,4-Dioxane; Dichlorofluoromethane; Magenta; Maleic anhydride; 2-Methoxyethanol; Methylene bisphenyl isocyanate; Methyl n-butyl ketone; o-Methyl cyclohexanone; Methyl cyclohexanol; Methyl n-amyl ketone; Methyl alcohol; Methyl ethyl ketone; Methyl isobutyl ketone; Methylchloride; Methyl chloroform; Diethylenetriamine; Diethylether; 4,4-Diamino-3; 3-Dichloro-diphenyl-methane; Benzene; Benzidine and its salts; 1,3-butadiene; 2-butoxyethanol; 2-butoxyethanol acetate; n-Butyl alcohol; sec-Butyl alcohol; 1-Bromopropane; 2-Bromopropane; Methyl bromide; Carbon tetrachloride; Stoddard solvent; Styrene; Cyclohexanone; Cyclohexanol; Cyclohexane; Cyclohexene; Aniline&homologues; Acetonitrile; Acetone; 2-Ethoxyethyl acetate; Acetaldehyde; Acrylonitrile; Acrylamide; 2-Ethoxyethanol; Ethylene glycol; Ethylene glycol dinitrate; Ethylene imine; Ethylene chlorohydrins; Ethyl benzene; Ethylacrylate; 2-3-Epoxy-1-propanol; Epichlorohydrin; Chlorobiphenyl; Auramine; Methyl Iodide; Isobutyl Alcohol; Isoamyl alcohol; Isoprpyl Alcohol; Ethylene dichloride; Carbon Disulfide; 2-Methoxyethyl acetate; Isoamyl acetate; Coal Tar; Cresol; Xylene; Chloromethyl Methyl Ether; Bis-chloromethylether; Chlorobenzene; Oil of turpentine; 1,1,2,2-Tetrachloroethane; Tetrahydrofuran; Toluene; Toluene-2,4-Diisocyanate; Toluene-2,6-diisocyanate; Trichloromethane; 1,1,2-Trichloroethane; Trichloroethylene; 1,2,3-Trichloropropane; Perchloroethylene; Phenol; Pentachlorophenol; Formaldehyde; $\beta$ -Propiolactone; o-Phthalodinitrile; Phthalic anhydride; Pyridine; Hydrazine; Hexamethylene diisocyanate; n-hexane; n-heptane; Dimethyl sulfate; Hydroquinone.
Metals (19)	Copper dusts; fume and mists; as Cu; Lead and inorganic compounds; as Pb; Nickel and inorganic compounds; as Ni; Manganese and inorganic compounds; as Mn; Zinc oxide dust; as Zn; Iron oxide dust and fume; as Fe; Arsenic; Mercury and compounds as Hg; Antimony and compounds as Sb; Aluminium and compounds as Al; Tetraalkyl lead; Vanadium pentoxide dust and fume; as $V_2O_5$ ; Iodide; Tin and compounds as Sn; Zirconium and compounds; as Zr; Cadmium and compounds; as Cd; Cobalt dust and fume; as Co; Chlromium and compounds as Cr; Tungsten and compounds; as W.
Acids and bases (8)	Acetic anhydride; Hydrogen fluoride; Sodium Cyanide; Potassium Cyanide; Hydrogen chloride; Nitric acid; Trichloro acetic acid; Sulfuric acid.
Gaseous materials (14)	Fluorine; Bromine; Ethylene oxide; Arsine; Hydrogen cyanide; Sulfur dioxide; Chlorine; Ozone; Nitrogen dioxide; Nitrogen monoxide; Carbon Monoxide; Phosgene; Phosphine; Hydrogen sulfide.
Substance requiring permit (13)	Dichlorobenzidine and its salts; $\alpha$ -Naphthylamine and its salts; Zinc chromate; o-Tolidine and its salts; Dianisidine and its salts; Beryllium and compounds; as Be; Arsenic and inorganic compounds; as As; Chromite ore processing; as Cr; Coal tar pitch volatiles; as benzene soluble aerosol; Nickel subsulfide; as Ni; Vinyl chloride; Benzotrchloride; Asbestos; chrystoile.
Metalworking fluids (1)	Mineral oil mist

*Continued*

**Table 1S:** 177 Occupational Hazardous Substances in South Korea, Appendix cited Korea Occupation Safety & Health Agency(KOSHA). Enforcement regulations of the occupational safety and health act. Available from <http://english.kosha.or.kr/english/cms/Tiles.do?url=/cms/board/board/Board.jsp?communityKey=B0488&menuId=1240> (Accessed July 31, 2018).

Dusts(6)	Grain dust; Mineral dust; Cotton dust; Wood dust; Welding fume; Glass fiber dust
Physical factors(8)	Noise; Vibration; Ionizing radioactive ray; High pressure; Low pressure; Hazardous rays(Ultraviolet ray; Infrared ray; microwave and radiowave

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