ASSOCIATION BETWEEN BLOOD MERUCRY AND OVERWEIGHT FOR KOREAN WORKERS

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Abstract— This study assessed the association of blood mercury levels with overweight in Korean manual workers. We analyzed cross-sectional data from 3,967 participants (2,292 men and 1,675 women) who completed the Korean National Health and Nutrition Examination Survey (KNHANES), 2007–2013. We use the WHO overweight (including obesity) criteria using BMI≥23.0 kg/m^2. Blood mercury levels were analyzed using a gold amalgam method with a DMA-80 instrument, categorized into quartiles, and stratified by sex. After adjusting for all covariates, blood mercury was significantly associated with overweight in a dose-dependent manner. The adjusted odds ratio of being in the highest blood mercury quartile was 2.06 (95% confidence interval [CI], 1.69-2.50) overall, 2.42 (95% CI, 1.88–3.13) in men, and 1.86 (95% CI, 1.39–2.50) in women. Additionally, a trend in overweight across increasing blood mercury levels was observed by the p for trend test in the multiple diagnostic criteria.

Keywords— Overweight, Weight gain, Korean manual workers, Heavy metals, Mercury.

I. INTRODUCTION

Obesity has been increasingly recognized as a serious worldwide public health concern in the 21st century. The rising prevalence of overweight and obesity in several countries has been described as a global pandemic and has not stopped spreading. The number of individuals classified as overweight and obese has dramatically increased globally from 857 million to 2.1 billion over 4 decades [1]. Approximately 18.4% of adults in the Organization for Economic Co-operation and Development countries were classified as obesity [2]. Many studies have reported that overweight and obesity are major causes of comorbidities that can lead to further morbidity and mortality, including non-communicable diseases (i.e., type 2 diabetes, hypertension, certain types of cancer, heart disease, and musculoskeletal disorders) [3-5]. Furthermore, obesity can increase mortality from cardiovascular disease (CVD), which is the leading cause of death in most countries worldwide [6, 7]. Indeed, many deaths are attributable to obesity. In the United States, 14% and 20% of all deaths from cancer in men and women, respectively, are attributable to overweight or obesity [5, 8]. The related annual medical expenditure of governments and individuals for reducing the obesity rate and obesity-related illnesses increased by 209.7 billion dollars [9]. New regulations have been implemented to tackle obesity in the United States, Japan, and the United Kingdom. Considering the public health efforts for obesity, the trend of increasing obesity prevalence remains an important problem [2, 10].

Physical inactivity, lifestyles, and individual food consumption patterns are well known risk factors for weight gain [5]. Unexpectedly, it was indicated that socioeconomic status (SES) also has effects on the distribution of obesity. A study indicated belonging to a lower SES class or working in a lower occupation position (i.e., manual workers) was associated with obesity[11]. Occupational environmental risk factors, these risk factors are not well known, but are important and should not be ignored [12-14]. Heavy metals are accumulated in the earth due to rapid industrialization and urbanization in the last 3–4 decades.

As a result, many toxic heavy metals have gradually redistributed within the environment from the earth's crust, thereby making it impossible for humans to escape the toxic heavy metals released through occupational and other environmental routes [15]. Most people are unaware of their exposure to toxic heavy metals via their environment and daily lifestyle, but interest has been generated in toxic trace elements and their role in the human body [16, 17]. Furthermore, belonging to a manual worker group in adulthood was significantly associated with increased general obesity in older women [18, 19]. Additionally, exposure to inorganic mercury can occur occupationally [20]. High inorganic mercury exposures can result in increased whole blood mercury [21]. Although there are countless risks for obesity, we focused here on occupational and environmental exposure of heavy metals, especially mercury, in manual workers. Some researchers have reported that mercury in human serum leads to gain weight [7, 12, 22-24], but the results have been inconsistent. The primary objective of this paper was to estimate blood mercury concentrations in manual workers in relation to overweight.

II. METHOD

2.1 Study Population and Data Collection

This study used data from the Korean National Health and Nutrition Examination Survey (KNHANES), which is a series of nationally representative surveys of the non-institutionalized civilian population, and is annually carried out by the Korea Centers for Disease Control and Prevention[25]. The KNHANES IV–VI (2007–2013) survey data was used for analysis in this current study. From an initial sample of 58,423 participants, we excluded those <20 years old, unemployed and non-manual workers; pregnant women; and those lacking data regarding age, sex, sociodemographic factors (i.e., education level, household income, and residential area) or health behavioral factors (i.e., smoking status, exercise level, alcohol consumption, total calorie intake, and dietary calorie restriction). We further excluded those with missing anthropometric measurements, non-responses for self-reported questionnaires, and missing data or no measurement of blood mercury concentrations and hematocrit. All participants provided written informed consent. Ultimately, 3,967 participants (2,292 men and 1,675 women) met the inclusion criteria for this study.

2.2 Main Variables

Information about whole blood mercury concentrations was obtained from the KNHANES. The blood mercury concentration was measured by a gold amalgam method with a DMA-80 instrument (Milestone, Bergamo, Italy). Some researchers have reported the importance of evaluating overweight and overweight-related serious illnesses, including heart disease, cancer, and chronic lower respiratory disease [26, 27]. We used the WHO overweight (including obesity) criteria using BMI ≥23.0 kg/m^2 for an Asian population. Blood mercury concentrations were categorized into quartiles (Q) and stratified by sex.

Due to social disparities, people with lower SES (i.e., poor education and working in lower occupation positions) are more likely to gain weight [2, 28]. Therefore, educational levels were categorized into 3 groups: middle school or less, high school, and college or more [29]. Household income was calculated using a standardized classification by 5-year age groups and sex, and then the value was compared with the standard income level of Korean citizens. Total household income was divided into 4 categories [20]. Type of residence was categorized into urban and rural areas according to the administrative divisions of cities in Korea [30]. For health behavioral factors, smoking status was classified as non-smoker (fewer than 100 cigarettes ever), former smoker (past smoker but not smoking at the time of the survey), and current smoker (currently smoking) [29]. Alcohol drinking was differentiated by sex as heavy drinking, which was defined as at least 7 glasses of alcohol on 2 or more occasions per week for men and at least 5 glasses of alcohol on 2 or more occasions per week for women. Exercise activity levels were classified as none, moderate (between none and high), and high (≥20 minutes at least 3 times per week of activity that results in increased respiration). Information regarding total calorie intake, and current diet therapy was obtained using a 24-hour dietary recall questionnaire administered by a trained nutritionist.

2.3 Statistical Analysis

Statistical analyses were performed using SAS statistical software (version 9.4; SAS Institute Inc., Cary, NC, USA). The χ^2 tests were used to compare differences between baseline characteristics. The association between blood mercury levels and overweight was evaluated by multiple logistic regressions. We also performed *p* for trend tests to evaluate whether there was a trend in the overweight in adults across increasing blood mercury concentrations.

III. RESULTS AND DISCUSSION

Table 1 and 2 lists the characteristic of manual workers according to the overweight. 1,430 men (62.4%) and 955 women (57.0%) were in the overweight group. The relationship between blood mercury levels and overweight using logistic regression with different models is shown in figure 1. The odds ratio (OR) (95% confidence interval [CI]) for the highest vs. reference blood mercury level,

Table 1 Baseline characteristics in men

Characters	Normal	Overweight	P-value
N (%)	862 (37.6)	1,430 (62.4)	0.0006
Age(years)	47.0 ± 14.4	47.7 ± 13.1	0.2732
Education, n (%)			0.8423
Less than Middle school	292 (33.9)	489 (34.2)	
High school	395 (45.8)	639 (44.7)	
College and more	175 (20.3)	302 (21.1)	
House income, n (%)			0.0060
1st quartile	129 (15.0)	153 (10.7)	
2nd quartile	269 (31.2)	445 (31.1)	
3rd quartile	267 (31.0)	439 (30.7)	
4th quartile	197 (22.8)	393 (27.5)	
Residence area, n (%)			0.5488
Urban	609 (70.6)	1,027 (71.8)	
Rural	253 (29.4)	403 (28.2)	
Smoking status, n (%)			0.0042
Non-smoker	157 (18.2)	254 (17.8)	
Former smoker	170 (19.7)	367 (25.6)	
Current smoker	535 (62.1)	809 (56.6)	
Drinking status, n (%)			0.0792
Never drink	107 (12.4)	187 (13.1)	
Moderate drink	582 (67.5)	903 (63.1)	
Heavy drink	173 (20.1)	340 (23.8)	
Exercise level, n (%)			0.1322
None	477 (55.3)	774 (54.1)	
Moderate	335 (38.9)	541 (37.9)	
High	50 (5.8)	115 (8.0)	
Calorie intake (kcal/day)	2413.8 ± 982.6	2464.9 ± 953.6	0.2193
Diet therapy, n (%)			<.0001

Yes	82 (9.5)	297 (20.8)	
No	780(90.5)	1,133 (79.2)	
With diet therapy (n=759), n (%)			0.1347
<2500(kcal/day)	54 (65.9)	207 (69.7)	
<4000(kcal/day)	21 (25.6)	80 (26.9)	
≥4000(kcal/day)	7 (8.5)	10 (3.4)	
Without diet therapy (n=3,208), n (%)			0.1215
<2500(kcal/day)	478 (61.3)	641 (56.6)	
<4000(kcal/day)	249 (31.9)	406 (35.8)	
≥4000(kcal/day)	53 (6.8)	86 (7.6)	
BMI (kg/m²)	21.0 ± 1.4	25.9 ± 2.3	<.0001
Blood mercury (μg/L)	4.8 ± 3.0	6.0 ± 4.5	<.0001

fully adjusted for age, sociodemographic factors, health behavioral factors, was 2.06 (1.69–2.50) in the overall manual workers, 2.42 (1.88–3.13) in men manual workers, and 1.86 (1.39–2.50) in women manual workers. In all models, a trend in overweight among manual workers across increasing blood mercury levels was revealed by a *p* for trend test (*p* - trend <0.0001).

In the present paper, we found a positive association between blood mercury concentration and overweight in a large population-based Korean dataset representative of the Korean population, after adjusting for possible potential confounders.
Previous researchers have examined the association between blood mercury concentration and obesity, but with inconsistent results [7, 22-24]. In some investigations, a significant association between blood mercury level and obesity was demonstrated in

Table 2 Baseline characteristics in women

Characters	Normal	Overweight	P-value
N (%)	720 (43.0)	955 (57.0)	0.0006
Age(years)	46.4 ± 13.0	51.4 ± 11.2	<.0001
Education, n (%)			<.0001
Less than Middle school	290 (40.28)	572 (59.90)	
High school	318 (44.17)	322 (33.72)	
College and more	112 (15.56)	61 (6.39)	
House income, n (%)			0.0011
1st quartile	106 (14.72)	206 (21.57)	
2nd quartile	218 (30.28)	301 (31.52)	
3rd quartile	212 (29.44)	248 (25.97)	
4th quartile	184 (25.56)	200 (20.94)	
Residence area, n (%)			0.0107
Urban	520 (72.22)	634 (66.39)	
Rural	200 (27.78)	321 (33.61)	
Smoking status, n (%)			0.4347
Non-smoker	640 (88.89)	852 (89.21)	
Former smoker	16 02.22)	29 (3.04)	
Current smoker	64 (8.89)	74 (7.75)	
Drinking status, n (%)			0.0306
Never drink	217 (30.14)	344 (36.02)	
Moderate drink	457 (63.47)	563 (58.95)	
Heavy drink	46 (6.39)	48 (5.03)	
Exercise level, n (%)			0.3496
None	525 (72.92)	681 (71.31)	
Moderate	158 (21.94)	234 (24.50)	
High	37 (5.14)	40 (4.19)	
Calorie intake (kcal/day)	1701.7 ± 626.9	1678.3 ± 630.0	0.4498
Diet therapy, n (%)			<.0001
Yes	114 (15.8)	266 (27.9)	
No	606 (84.2)	689 (72.1)	
With diet therapy (n=759), n (%)			0.2560
<2500(kcal/day)	105 (92.1)	242 (91.0)	
<4000(kcal/day)	8 (7.0)	24 (9.0)	
≥4000(kcal/day)	1 (0.9)	0 (0.0)	
Without diet therapy (n=3,208), n (%)			0.9234
<2500(kcal/day)	546 (90.1)	624 (90.6)	
<4000(kcal/day)	57 (9.4)	61 (8.8)	
≥4000(kcal/day)	3 (0.5)	4 (0.6)	
BMI (kg/m²)	20.9 ± 1.54	26.03 ± 2.48	<.0001
Blood mercury (μg/L)	3.81 ± 2.77	4.32 ± 3.19	0.0004

Korean adults [22-24]. Conversely, there was no notable relationship between blood mercury concent rations and obesity in another study [7]. These previous studies adjusted for only SES, but not for other potential confounding factors (i.e., occupational status). Some researchers have postulated possible mechanisms for the association between blood mercury levels and weight gain. According to current knowledge, mercury may play an important role in the development of weight gain by causing not only adipose tissue endocrine dysfunction, but also dysregulation of lipid metabolism and glucose metabolism [24, 31, 32]. According to a recent in vivo research about mechanism of blood mercury' effect on weight gain, mercuric chloride injected mice was showed a decrease in adipose tissue content such as adiponectin and leptin. Furthermore, a significant inhibition of both peroxisome proliferator-

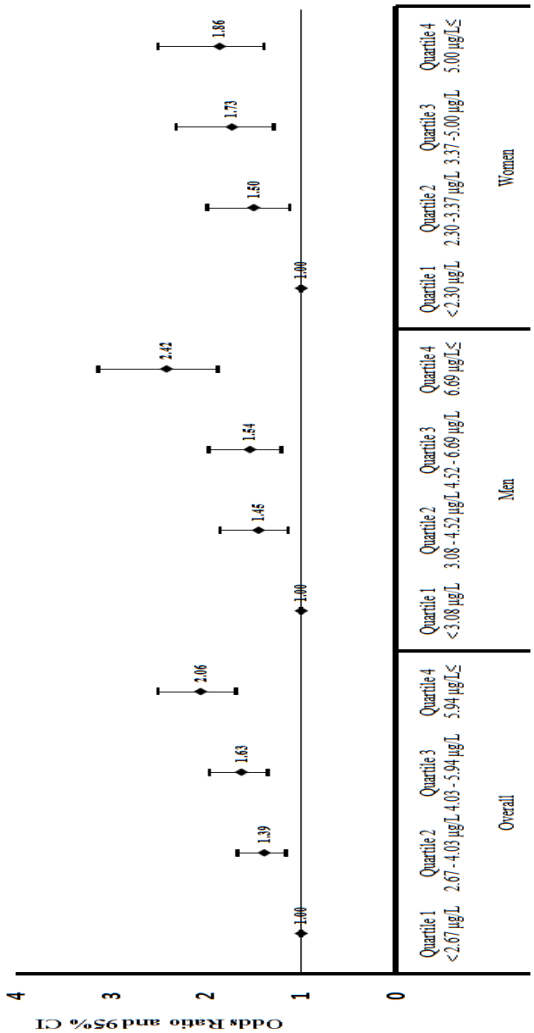


Figure 1 Odds ratio and 95% confidence intervals of overweight according to blood mercury levels

activated receptor (PPAR)α and γ translation of mRNA in adipocytes has been indicated, while PPARs regulated the cellular differentiation and metabolism of carbohydrate and lipid. Those results suppose that the observed changes may play an important role in the development of weight gain associated-pathology [33]. Furthermore, weight gain induced by environmental exposure to mercury supports potential risk factors of CVDs [12, 33, 34].

CONCLUSIONS

We found meaningful associations between blood mercury level and overweight in a dose-dependent manner, thereby enhancing our understanding of the effect of blood mercury levels on the increasing trend of weight gain. The specific mechanism that blood mercury leads to weight gain has not yet been reported. Further experimental, cohort, clinical and epidemiological studies are required.

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