Environmental Lead and Cadmium Exposure and Metabolic Syndrome in Women

Jintana Sirivarasai[1*], Rodjana Chunhabundit[1], Sirintorn Chansirikarnjana[2], Somporn Chottivitayatarakorn[3], Wilawan Prasanatikom[3], Nitchaphat Khansakorn[4], Sming Kaojarern[5]

[1]Graduate Program in Nutrition, Faculty of Medicine, Ramathibodi Hospital, Mahidol University
[2]Department of Medicine, Faculty of Medicine, Ramathibodi Hospital, Mahidol University
[3]Department of Nursing, Faculty of Medicine, Ramathibodi Hospital, Mahidol University
[4]Department of Community Health, Faculty of Public Health, Mahidol University
[5]Occupational and Environmental Toxicology Center, Faculty of Medicine, Ramathibodi Hospital, Mahidol University

Abstract

Lead and cadmium are presented as environmental pollutants and they can cause various kinds of detrimental health effects. Metabolic syndrome (MS) has been reported as one of the health risks related to chronic exposure to heavy metals. The aim of this study was to determine the association between blood lead and cadmium levels and MS risks in a cross-sectional study in Thai women (n= 779) with mean age of 47.3 years (range 35-67). Results showed that there were significant differences in various biochemical parameters, blood metal levels, and blood pressure between individuals with and without MS. The geometric means of blood lead (2.63 µg/dL) and cadmium (1.07 µg/L) levels in MS group were significantly higher than those without MS (2.17 µg/dL and 0.89 µg/L, respectively; p <0.05). In addition, the prevalence of MS showed significantly increasing trend with lead tertile and combination of lead and cadmium tertiles. Adjusting for age, BMI, alcohol consumption, total cholesterol and creatinine, cadmium and lead tertiles were associated with increased odds ratio of MS and its components. These findings also supported that environmental exposure to lead and cadmium in general population may lead to the increased risk for development of MS in women. The reduced contamination of both metals in environment is an important concern and additional biomarkers of metal induced alteration in MS should be further studied.

Keywords: Cadmium, Environmental exposure, Lead, Metabolic syndrome

*** Corresponding author**

Dr. Jintana Sirivarasai

Graduate Program in Nutrition, Faculty of Medicine, Ramathibodi Hospital, Mahidol University, Rama 6 Road, Bangkok 10400, Thailand

E-mail: jintana.sir@mahidol.ac.th

การรับสัมผัสตะกั่วและแคดเมียมจากสิ่งแวดล้อมและภาวะอ้วนลงพุงในกลุ่มผู้หญิง

จินตนา ศิริวราศัย[1*], รจนา ชุณหบัณฑิต[1], สิรินทร ฉันศิริกาญจน[2], สมพร โชติวิทยธารากร[3], วิลาวัณย์ ประสารอธิคม[3], ณิชชาภัทร ขันสาคร[4], สมิง เก่าเจริญ[5]

[1]กลุ่มสาขาวิชาโภชนศาสตร์ คณะแพทยศาสตร์โรงพยาบาลรามาธิบดี มหาวิทยาลัยมหิดล

[2]ภาควิชาอายุรศาสตร์ คณะแพทยศาสตร์โรงพยาบาลรามาธิบดี มหาวิทยาลัยมหิดล

[3]ฝ่ายการพยาบาล คณะแพทยศาสตร์โรงพยาบาลรามาธิบดี มหาวิทยาลัยมหิดล

[4]ภาควิชาอนามัยชุมชน คณะสาธารณสุขศาสตร์ มหาวิทยาลัยมหิดล

[5]โครงการอาชีวอนามัยและพิษวิทยาสิ่งแวดล้อม คณะแพทยศาสตร์โรงพยาบาลรามาธิบดี มหาวิทยาลัยมหิดล

บทคัดย่อ

ตะกั่วและแคดเมียมเป็นสารพิษในสิ่งแวดล้อมที่ส่งผลต่อสุขภาพในหลายระบบ ภาวะอ้วนลงพุงเป็นหนึ่งในความเสี่ยงต่อสุขภาพที่มีความสัมพันธ์กับการรับสัมผัสสารโลหะหนักเป็นระยะเวลานาน วัตถุประสงค์ของงานวิจัยนี้ เพื่อศึกษาความสัมพันธ์ระหว่างระดับตะกั่วและแคดเมียมในเลือดกับความเสี่ยงต่อการเกิดภาวะอ้วนลงพุงในหญิงไทย เป็นการศึกษาแบบภาคตัดขวางในเพศหญิง (จำนวน 779 คน) อายุเฉลี่ยเท่ากับ 47.3 ปี (ระหว่าง 35-67 ปี) ผลการศึกษาพบว่ามีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติของค่าเฉลี่ยทางชีวเคมี ระดับโลหะหนักและความดันโลหิตของกลุ่มควบคุมและกลุ่มอ้วนลงพุง ค่าเฉลี่ยของระดับตะกั่วในเลือด (2.63 ไมโครกรัมต่อเดซิลิตร) และแคดเมียม (1.07 ไมโครกรัมต่อเดซิลิตร) ของกลุ่มอ้วนลงพุงมีค่าสูงกว่ากลุ่มที่ไม่มีภาวะอ้วนลงพุงอย่างมีนัยสำคัญทางสถิติ (2.17 และ 0.89 ไมโครกรัมต่อเดซิลิตรตามลำดับ; $p < 0.05$) นอกจากนี้พบว่าอุบัติการณ์ของภาวะอ้วนลงพุงมีแนวโน้มเพิ่มสูงขึ้นอย่างมีนัยสำคัญทางสถิติในกลุ่มศึกษาที่มีค่าของตะกั่วและแคดเมียมในเลือดอยู่ในช่วง tertile ที่ 3 เมื่อควบคุมตัวแปรเรื่องอายุ ดัชนีมวลกาย การดื่มแอลกอฮอล์ ระดับโคเลสเตอรอลและค่าครีเอตินิน พบว่าช่วงระดับของตะกั่วและแคดเมียมในเลือดมีความสัมพันธ์กับการเพิ่มขึ้นของอัตราเสี่ยงต่อการเกิดภาวะอ้วนลงพุงและความผิดปกติร่วมของการเกิดภาวะอ้วนลงพุง ข้อมูลที่ได้จากการศึกษาครั้งนี้สนับสนุนเรื่องของการรับสัมผัสตะกั่วและแคดเมียมจากสิ่งแวดล้อมในกลุ่มประชากรทั่วไป กับความเสี่ยงต่อการเกิดภาวะอ้วนลงพุง การลดการปนเปื้อนของโลหะหนักในสิ่งแวดล้อมเป็นประเด็นที่สำคัญ และตัวชี้วัดทางชีวภาพที่บ่งชี้ถึงผลของโลหะหนักที่ทำให้เกิดภาวะอ้วนลงพุงควรที่จะได้มีการศึกษาต่อไป

คำสำคัญ: แคดเมียม การรับสัมผัสจากสิ่งแวดล้อม ตะกั่ว ภาวะอ้วนลงพุง

***ผู้รับผิดชอบบทความ:**

อ. ดร.จินตนา ศิริวราศัย

กลุ่มสาขาวิชาโภชนศาสตร์ คณะแพทยศาสตร์โรงพยาบาลรามาธิบดี มหาวิทยาลัยมหิดล ถ. พระราม 6 กรุงเทพฯ 10400

E-mail: jintana.sir@mahidol.ac.th

Introduction

The metabolic syndrome (MS) is one of the worldwide public health concerns since the ultimate consequences relate to risks of cardiovascular disease (CVD) and type 2 diabetes[1]. Criteria for diagnosis of MS as defined by the National Cholesterol Education Program ATP III are the presence of at least three of the five components (a) high blood pressure; BP ≥ 130/85 mmHg, (b) hypertriglyceridemia; TGL ≥ 150 mg/dL, (c) low of high density lipoprotein (HDL) cholesterol; HDL-C < 40, (d) increased fasting blood glucose; FBG > 100 mg/dL, and (e) increased waist circumference; > 102 cm for men and > 80 cm for women[2]. The proposed etiology of the syndrome are gene-gene and gene-environment interactions[3]. Environmental factors contributed to the predisposition to MS that have been mentioned in previous studies, including cigarette smoke, air pollution and toxic metals[4,5]. Effects of exposure to metals (lead, cadmium, mercury and arsenic) on components of MS and other cardiovascular risks were reported in both experimental and epidemiological studies[5-9]. Moreover, possible mechanisms of these metal-induced adverse health effects related to the induction of mitochondrial dysfunction, the increased oxidative stress and the up-regulation of mediators in inflammation[5-9].

Several studies have suggested the relationship of lead, and cadmium exposure to lipid profile, diabetes and hypertension[5,7,8-15]. The impact of lead exposure on low level of HDL and high triglyceride level was reported whereas cadmium exposure showed no changes in serum lipid profile[9]. Another study by Rogaslska, et al. found an increase in the serum of total cholesterol and low-density lipoprotein (LDL)-cholesterol with a simultaneous decrease in the HDL-cholesterol concentration in rats exposed to cadmium[7]. Current report among population in cadmium exposed area revealed the risk of reduced HDL-C (OR = 5.63, 95%CI: 3.33-9.53), hypertriglyceridemia (OR = 2.81, 95%CI: 1.72-4.60), elevated TG/HDL-C (OR = 3.78, 95%CI: 2.27-6.30) and increase oxidative stress (OR = 4.48, 95%CI: 2.17-9.24)[10]. A population-based study in China investigated the association between elevated heavy metals (23 metals) and fasting plasma glucose level (FPG)[11]. The results showed that after adjusting for potential confounders (age, gender, BMI, smoking cigarette, alcohol status, hypertension, hyperlipidemia, family history of diabetes, anti-diabetic drugs and insulin use), lead and cadmium level were associated with altered FPG, impaired plasma glucose or diabetes risk (all p <

0.05)[11]. Mean levels of lead and cadmium were significantly higher in diabetic patients as compared to healthy subjects ($p < 0.001$) but lower levels of chromium (Cr), magnesium (Mg), zinc (Zn) and manganese (Mn) were detected in types 2 diabetes ($p < 0.01$). Therefore, these elements may indicate some representative roles in the development and pathogenesis of diabetes[12]. However, the cross-sectional study in the Korean population examined the relationships of blood lead, cadmium and mercury with diabetes and their accumulative effect on diabetes[8]. These metals levels were slightly higher, but non-significantly in subjects with diabetes, compared with those non-diabetic[8]. Mechanisms of lead-induced hypertension and cardiovascular disease have been described, including alteration of cellular Ca^{2+} transport and intracellular Ca^{2+} distribution, impairment of nitric oxide system, dysregulation of vasoactive hormones, inflammation and oxidative stress[13]. Our previous study showed that both C-reactive protein (CRP) and systolic blood pressure levels were significantly higher in individuals with blood lead in quartile 4 (6.48-24.63 μg/dL) compared with those in quartile 1 (1.23-3.47 μg/dL, $p < 0.01$)[14]. Lead has been linked to the development of hypertension via oxidative stress, as seen by the decreased blood catalase activity together with increased lipid peroxidation among environmental lead exposed-population[15].

An emerging area of interest in the field of occupational and environmental health, especially heavy metals and metabolic disturbance has been more described. A representative study of the adult Korean population was conducted to investigate the potential association between cadmium, lead, or mercury and MS. The results showed that male subjects in the highest tertile of blood cadmium were 36.7% more likely to have MS versus those in the lowest tertile, whereas there were no significant ORs for MS with blood lead and mercury[16]. Another study evaluated the OR (95%CI) for MS prevalence according to the log-transformed lead quartiles. The OR and 95%CI for MS in the highest lead quartile was 2.57 (1.46-4.51), as compared with those of the lowest quartile[17]. Rotter et al., found no statistical differences in the concentrations of lead, cadmium, mercury arsenic and tungsten between the men with MS and control group[18]. However, the influence of heavy metals exposure and risks of MS still poorly understood and remained to be investigated. Base on this background, the aims of this present study was to determine the association between blood lead and cadmium levels, as the biomarker of exposure and risks of MS in Thai women.

Materials and Methods

Study Population

This study is a cross-sectional study, including 800 Thai women with age range 35-65 years old. Participants with chronic diseases such as chronic kidney and liver diseases, tuberculosis, cerebrovascular disease, and cancer were excluded (*n* = 21). Data from 779 participants were analyzed. This project was approved by the Ethical Committee, Faculty of Medicine Ramathibodi Hospital, Mahidol University. Baseline individual characteristic included age, education, physical activity, smoking cigarette, alcohol consumption, personal and family history. Height and weight measurements were performed with the participants wearing light clothing and no shoes. Body mass index (BMI) was calculated as weight in kilograms divided by the square of the height in meters. Regular exercise was defined as performing an exercise (more than 30 minutes per time) at least five times per week. Two blood pressure measurements were done in the sitting position after at least 5 min rest and means of systolic and diastolic blood pressure were presented. Weight, height, waist and hip circumferences were measured together with calculated value for body mass index (BMI). Venous blood samples were obtained from participants in the morning after fasting 12 h overnight. Criteria for diagnosis of MS has been defined by criteria of the National Cholesterol Education Program ATP III[2].

Determination of Lead and Cadmium in Blood

Blood lead and cadmium concentrations were measured by inductively coupled plasma mass spectrophotometer (ICP-MS, Agilent Technologies, 7700x Series). Quality control materials were purchased from Seronorm (Trace Elements whole blood control, SERO, Billingstad, Norway).

Biochemical measurement

Total cholesterol, LDL-cholesterol, HDL-cholesterol, triglyceride, creatinine, and fasting glucose concentration were analyzed by an automated analyzer (a Hitachi 917 biochemistry analyzer).

Statistical Analysis

Statistical analyses were carried out using the SPSS 16.0 for window software (SPSS, Inc., Chicago, IL). Descriptive statistics were presented as frequency distribution of categorical variables. Blood lead and cadmium concentrations were log-transformed and presented as geometric mean (GM) and standard error (SE). Arithmetic means (AM) and standard error (SE) of other biochemical variables were revealed. An independent t-test was used to compare variables between two groups of participants with and without MS. Tertile cut-points of blood lead and cadmium were based on weighted distributions in the whole study population. This was done for ease of interpretation and visualization of results. A linear test for trend was performed to evaluate dose–response relationships between tertiles of exposure and the MS. Odds ratios (ORs) and 95% CI values for MS and its component were calculated for tertiles of blood metal levels, using the lowest tertile subgroup as the reference.

Results

Demographic and clinical characteristics of subjects, classified by MS are presented in Table 1. Women with MS (n = 435) were older and have higher BMI than those (n = 344) without MS (49.2 VS 45.6 years old and 25.6 VS 22.5 kg/m^2, p < 0.05). In addition, mean of waist circumference of individual with MS (89.1 cm) was also greater than another group (82.9 cm, p < 0.001). SBP and DBP showed significant differences between both groups (133.5 VS 87.3 mmHg for MS group and 112.5 VS 68.7 mmHg for non-MS group, respectively, p < 0.001). Smoking status and alcohol consumption were not significantly different between the two groups. Biochemical profiles and FBS levels among the subjects with MS were found with considerable differences from those with non-MS. Moreover, the blood lead and cadmium concentrations in MS group were significantly higher (2.63 µg/dL for lead and 1.07 µg/L for cadmium), as compared to those with non-MS (2.17 µg/dL for lead and 0.89 µg/L for cadmium, p < 0.001).

Based on the log-transformed cadmium (tertile 1; 0.02-0.70 µg/L, tertile 2; 0.71-0.94 µg/L, and tertile 3; 0.95-4.00µg/L) and lead tertiles (tertile 1; 0.90-1.63 µg/dL, tertile 2; 1.64-3.01 µg/dL, and tertile 3; 3.02-11.00 µg/dL), the prevalence of MS were presented in Figure 1. For cadmium concentration, the prevalence of MS were not statistical increased from the lowest to the highest tertile. In comparison to cadmium, significant MS trends for blood lead concentration were observed according to the lead tertile (p < 0.001). In environmental or occupational situation, human usually expose to not only one kind of toxicants but also in various routes of exposure. Then, we further analyzed association between co-exposure to cadmium and lead and potential to develop MS. The results showed considerable trend of MS respected to the highest tertile of blood lead with three tertiles of blood cadmium with increasing from 22% to 29% and 48%, respectively (p < 0.001).

Adjusting for age, BMI, alcohol consumption, total cholesterol and creatinine, cadmium and lead tertiles were associated with odds ratio of MS and its components (Table 2). The highest cadmium tertile (0.95-4.00 µg/L) was associated with

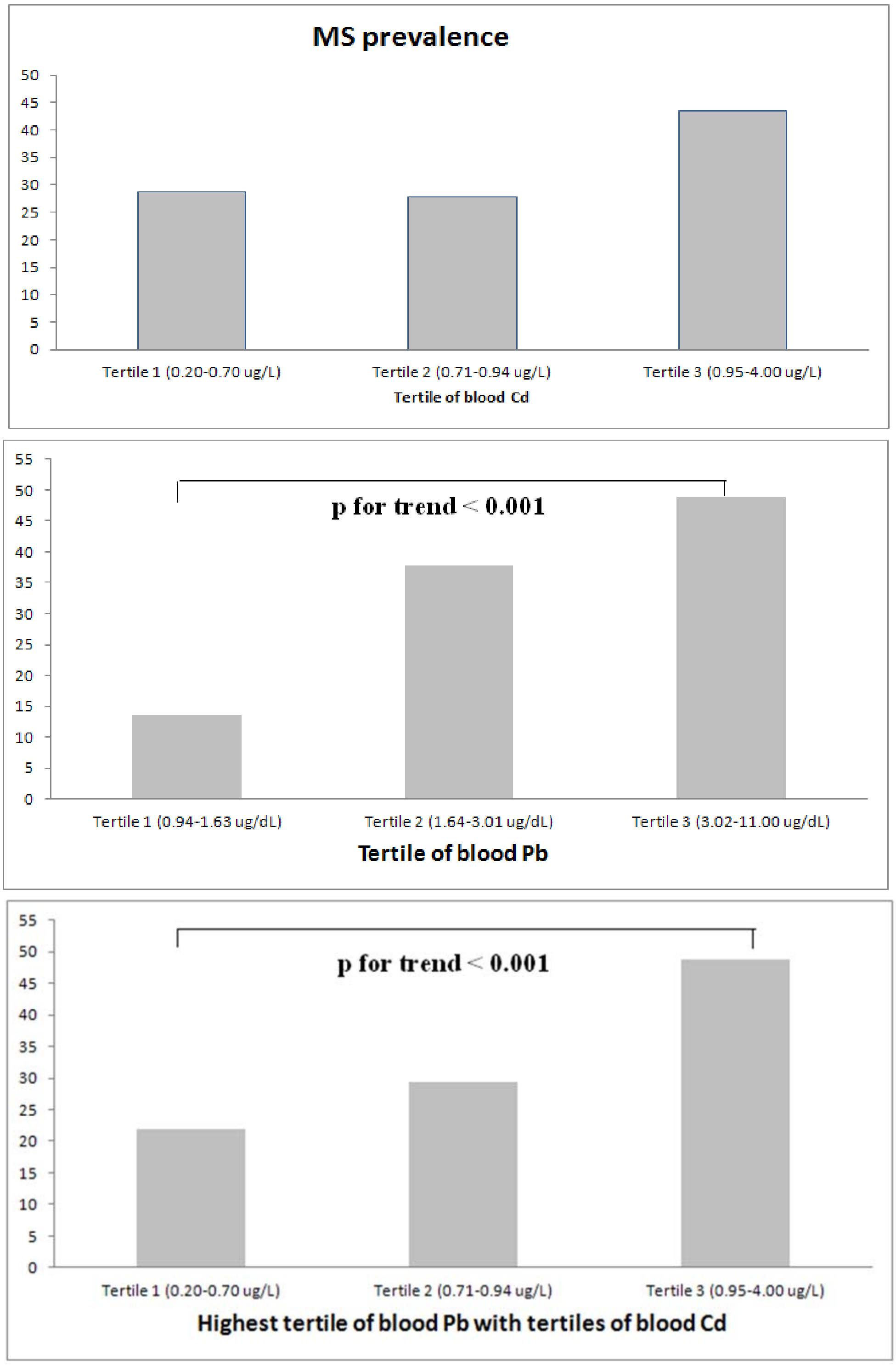

Figure 1 Prevalence of metabolic syndrome related to the tertiles of blood cadmium (upper figure), blood lead (middle figure) and both metals (lower figure).

Table 1 General characteristics and biochemical parameters according to metabolic syndrome (MS).

Variables	**Total (*n* = 779)**	**No MS (*n* = 435)**	**MS (*n* = 344)**
Age, years (AM ± SE)	47.2 ± 0.6	45.6 ± 0.4	49.2 ± 0.4*
Age group, *n* (%)			
30-39	182 (23.4)	115 (26.4)	67 (19.5)
40-49	272 (34.9)	130 (29.5)	142 (41.3)
50-59	287 (36.8)	179 (41.2)	108 (31.4)
>59	38 (4.9)	11 (2.5)	27 (7.8)
Body mass index, kg/m^2 (AM ± SE)	23.8 ± 0.1	22.5 ±0.2	25.6 ± 0.2**
Waist circumference, cm (AM ± SE)	85.8 ± 0.9	82.9 ± 0.7	89.1 ± 0.6**
SBP, mmHg (AM ± SE)	121.8 ± 0.6	112.5 ± 0.5	133.5 ± 0.9**
DBP, mmHg (AM ± SE)	74.9 ± 0.4	68.7 ± 0.4	87.3 ± 0.6**
Drinking status, N (%)			
Non-drinkers	673 (86.4)	379 (87.1)	294 (85.5)
Drinkers	106 (13.6)	56 (12.9)	50 (14.5)
Smoking status, N (%)			
Non-smokers	762 (97.8)	430 (98.9)	332 (96.5)
Smokers	17 (2.2)	5 (1.1)	12 (3.5)
Regular exercise, N (%)			
Yes	302 (38.8)	196 (45.1)	106 (30.8)
No	477 (61.2)	239 (54.9)	238 (69.2)
Biochemical tests (AM ± SE)			
Triglyceride, mg/dL	110.4 ± 2.2	86.3 ± 1.4	154.4 ± 4.1**
HDL cholesterol, mg/dL	62.1 ± 0.6	64.1 ± 0.7	50.2 ± 0.8**
LDL cholesterol, mg/dL	127.9 ± 1.1	124.4 ± 1.4	132.1 ± 1.8*
Total cholesterol, mg/dL	213.5 ± 1.3	210.7 ± 2.1	216.6 ± 2.1*
Fasting glucose, mg/dL	93.1 ± 0.6	87.5 ± 0.3	118.8 ± 1.3**
Creatinine, mg/dL	0.73 ± 0.01	0.71 ± 0.01	0.75 ± 0.01*
Blood heavy metals levels (GM ± SE)			
Cadmium, µg/L	0.93 ± 0.01	0.89 ± 0.04	1.07 ± 0.09**
Lead, µg/dL	2.34 ± 0.04	2.17 ± 0.07	2.63 ± 0.12**

*$p < 0.05$, **$p < 0.001$

Table 2 Association of blood cadmium and lead levels and Odds ratios for metabolic syndrome and its main components

	Odds ratio[a] (95% CI)					
	Blood pressure ≥ 130/85 mmHg	**Blood glucose ≥ 100 mg/dL**	**Serum HDL-C ≤ 50 mg/dL**	**Serum TG ≥ 150 mg/dL**	**Waist circumference ≥ 80 cm.**	**MS (≥ 3 main components)**
Blood cadmium (µg/L)						
Tertile 1: 0.20-0.70	1 (Reference)	1 (Reference)	1 (Reference)	1 (Reference)	1(Reference)	1 (Reference)
Tertile 2: 0.71-0.94	1.19 (1.02-1.81)	1.07 (0.79-1.67)	1.11 (0.94-1.62)	0.89 (0.74-1.26)	1.28 (0.84-1.88)	1.17 (1.06-1.51)
Tertile 3: 0.95-4.00	1.35 (1.19-1.73)	1.21 (1.09-1.58)	1.42 (1.29-2.07)	1.35 (1.03-1.69)	1.13 (0.76-1.69)	1.24 (1.10-1.83)
Blood lead (µg/dL)						
Tertile 1: 0.91-1.63	1 (Reference)	1 (Reference)	1 (Reference)	1 (Reference)	1 (Reference)	1 (Reference)
Tertile 2: 1.64-3.01	1.21 (1.05-2.19)	1.11 (0.92-1.51)	1.12 (0.84-1.44)	1.08 (0.85-1.37)	1.04 (0.88-1.24)	1.43 (1.15-1.84)
Tertile 3: 3.02-11.00	1.47 (1.14-2.35)	1.48 (1.05-1.94)	1.33 (1.16-1.95)	1.29 (1.07-1.78)	0.97 (0.82-1.75)	1.52 (1.21-1.79)

[a]Model: adjusted for age, BMI, alcohol consumption, serum total cholesterol and creatinine

significantly increased ORs of elevated blood pressure ≥ 130/85 mmHg (OR = 1.35, 95%CI 1.19-1.73), fasting glucose ≥ 100 mg/dL (OR = 1.21, 95%CI 1.09-1.58), serum triglyceride ≥ 150 mg/dL (OR = 1.35, 95%CI 1.03-1.69), and decreased HDL-cholesterol ≤ 50mg/dL (OR = 1.42, 95%CI 1.29-2.07). Additionally, the highest tertile of blood cadmium was significantly related to odd ratio (OR = 1.24, 95%CI 1.10-1.83) of MS (with ≥ 3 components). There were statistical associations between the tertile 2 and 3 of blood lead and increased ORs for each main components of MS and MS. ORs of the second tertile of blood lead for MS was 1.43 (95%CI 1.15-1.84) and for elevated blood pressure ≥ 130/85 mmHg was 1.21 (95%CI 1.05-2.19). For the highest tertile of blood lead, ORs of MS and its component were described with elevated blood pressure ≥ 130/85 mmHg (OR = 1.47, 95%CI 1.14-2.35), fasting glucose ≥ 100 mg/dL (OR = 1.48, 95%CI 1.05-1.94), serum triglyceride ≥ 150 mg/dL (OR = 1.29, 95%CI 1.07-1.78), and decreased HDL-cholesterol ≤ 50 mg/dL (OR = 1.33, 95%CI 1.16-1.95).

Discussion

There is increasing concern about the links between environmental factors and human health impacts. MS is one of the important public health problems that has been exhibited a relationship between increased environmental lead and cadmium exposure and the development of this syndrome. The etiology for these phenomena may be related to consequence of oxidative stress in MS. In addition, several studies in animal model and human suggested that long-term exposure to environmental toxicants could promote development of hypertension, hyperglycemia, hyperlipidemia, obesity, insulin resistance and MS. The geometric means of blood cadmium and lead concentration in the present study were 0.93 μg/L and 2.34 μg/dL with similar to those in Korean population (1.018 μg/L and 2.76 μg/dL, respectively[16]. Participants with MS in the study indicated significantly higher concentrations of both metals than those without MS. Consistent with findings of Choi et al.[19] which found the considerable lead level with MS and non-MS were 0.51 and 0.12 mg/dL, respectively. Lee et al.[16] reported that the means of blood cadmium and lead levels were significant differences between MS group and the control group (1.17 VS 0.98 μg/L, $p < 0.001$for cadmium level; 2.96 VS 2.73 μg/dL, $p = 0.002$ for lead level). However, a study in Poland found that concentrations of blood cadmium and lead in men with MS and without MS were 1.55 VS 1.53 μg/L and 7.51 VS 7.38 μg/dL, respectively[18]. These metal levels have been slightly higher than the present study and other Asians. It may be resulted from differences in characteristics of subjects, cigarette smoking status and main dietary intake with metal contamination or accumulation in staple crops in each area.

The prevalence of MS showed significantly increasing trend with lead tertile and combination of lead and cadmium tertiles in the present study (Figure 1). Furthermore, our findings showed the ORs and 95%CI for MS and its components of the highest compared to the lowest tertile of log-transformed blood cadmium and lead, after adjusting for age, BMI, alcohol consumption, total cholesterol and creatinine (Table 2). Previous evidences indicated that blood lead level < 10 μg/dL were associated with renal impairment and hypertension[15, 20-21]. Lead may indirectly affected on blood pressure via various mechanisms, including inhibition of endothelial nitric oxide synthase, alteration in signal transduction involving renal pathways, changes in transmembranal transport of ions and dysregulation of cytosolic calcium[13,22]. In addition, lead can cause excess production of proinflammatory proteins and reactive oxygen species (ROS)[14,23]. The intrinsic mechanism for lead or cadmium-induced oxidative stress was shown to disturb antioxidant activities and change in fatty acid composition of cell membrane. Cadmium was known as nephrotoxicant even at low levels of chronic exposure which primary mechanisms involving hypertension were mentioned. These included cadmium-induced renal proximal tubular injury, salt retention and volume overload, direct vasoconstrictor action, activation of the sympathetic nervous system and inhibition of vasodilator (nitric oxide)[24]. The current result was similar to study of Eum et al.[25] They reported that subjects in the highest tertile (1.87 to 5.52 μg/L) were 52% more likely to have hypertension than those in the lowest tertile (0.18 to 1.28 μg/L) of blood cadmium (OR = 1.52; 95% CI = 1.13–2.05).

Metals have been identified as endocrine disruptors, as seen by the influence of lead and cadmium exposure on markers of diabetics and abnormal glucose metabolism[26]. A large number of previous studies and our results have been indicated potential relationships of lead and cadmium exposure in general population and elevated FPG level[5,8,11-12]. The highest tertile of blood lead and cadmium among this study population showed significant OR for fasting glucose ≥ 100 mg/dL and MS, in comparison to another investigation that found increased odds of elevated fasting glucose only blood lead, not cadmium tertile, after adjusting for age, sex and percent body fat[5]. Nephrotoxicity of lead accumulation in kidney may lead to damage in the proximal tubule and interfere the reabsorption of glucose. For cadmium-induced hyperglycemia, mechanisms of toxicity were described related to increased lipid peroxidation, decreased insulin release, increased activation of gluconeogenic enzymes and impaired insulin receptor[27]. However, a study found that elevated blood cadmium levels are not associated with increased incidence of diabetes.

For another component of MS, dyslipidemia with serum triglyceride ≥ 150 mg/dL, and decreased HDL- cholesterol ≤ 50 mg/dL among Thai women showed significant association with the highest tertiles of both metals. In agreement with a report by Tangvarasittichai, et al.[10] that described elevated cadmium exposure and hypertriglyceridemia, reduced HDL-cholesterol, elevated TG/HDL–C ratio, oxidative stress and chronic kidney disease in residents of cadmium contaminated area. Based on the results, it can be noted that exposure to cadmium may cause inhibition and disturbance of numerous enzymes and metabolic processes in lipid metabolism and also changes in lipid compounds in tissue and circulation (Total cholesterol, triglyceride, LDL and HDL cholesterol). These alterations may be an indirect consequence of cadmium-induced intracellular oxidative stress by ROS production. Our findings of relationship between blood lead and serum lipid profile also suggested an altered lipid metabolism related to lead exposure, similar to studies by Sharma et al.[28] and Kristal-Boneh et al.[29] The possible underlying mechanisms could be increased synthesis or decreased elimination of lipoproteins. Increased lipoprotein synthesis may be due to lead induced-high level of hepatic enzymes involving in de novo cholesterol synthesis whereas changes of removal rate may resulted from lead influencing on inhibition of hepatic lipoprotein lipase activity or cell-surface lipoprotein receptors[29].

Many countries, including Thailand, have faced with detrimental health problems from environmental pollutants as seen by a large number of suggestive reports. Not only these researches but also the present study have some similar limitations. First, cross-sectional studies may not provide definite information about cause-and-effect relationships. However, association between toxic metals and increased ORs for MS or CVD risks will give rise to the development of a longitudinal study to explore physiological alterations and which in turn lay the groundwork for intervention studies. Second, this study was conducted only residences in limited area of urban and the study subjects cannot represent the entire Thai population. Furthermore, genetic determinants, including genetic polymorphisms, gene and protein expression which are important in the metabolisms of cadmium and lead do not investigate in this study. Despite these limitations, this is one of the limited studies in Thailand that focus on biomarkers of cadmium and lead exposure by using the ICP-MS. Since this technique has various advantages over other analytical methods such as considerable decrease chemical interference, simultaneously determining many elements of interest, and high detection power. This issue is very important for assessing low level of targeted toxicants in general population, not occupational setting, with appropriated analytical technique.

In conclusion, cadmium and lead have been reported as environmental toxicants at very low exposure from various natural and industrial sources. Single or co-exposure to both toxicants could potentiate cardiovascular risks in the MS via basically mechanism of excessive ROS generation or other disruption of molecular mechanisms related to blood pressure, glucose regulation, and lipid metabolism. Our findings provide additional evidences to emphasize an important role of these toxic metals and cardio-metabolic risks. Most of environmental exposure studies usually found that blood cadmium and lead concentrations do not exceed the recommended levels. But human bio-monitoring, especially the vulnerable groups (including pregnant women, lactating mother, or elderly) should be conducted to track exposure trends and potential health impacts.

Conflict of Interests

The authors declare no conflict of interests.

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