

The relation between occupational exposure to lead and blood pressure among employed normotensive men

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Background: Lead is a pollutant with numerous adverse effects on health. Since it can affect blood pressure, peripheral blood vessels, and the heart, the present study aimed to evaluate the relation between occupational exposure to lead and blood pressure. **Materials and Methods:** This cross-sectional study included male individuals working in battery firms in Isfahan. A questionnaire covering demographic characteristics and the history of different diseases and occupational exposure to lead was completed. Each participant's blood pressure was also measured and recorded. After obtaining blood samples and determining lead levels, mean and frequency analyses were performed. In addition, Pearson's correlation test and linear regression were used to assess the relation between blood lead levels (BLLs) and systolic and diastolic blood pressure. All analyses were performed in SPSS.¹⁹ **Results:** The mean age of the 182 studied workers was 42.85 ± 13.65 years. They had worked in battery firms for a mean period of 23.67 ± 14.72 years. Moreover, the mean value of BLLs among the participants was 7.92 ± 3.44 $\mu\text{g/dL}$. Correlation between BLL and systolic and diastolic blood pressure was not significant. The effects of lead on systolic and diastolic blood pressure after stepwise regression were $B = -0.327$ [confidence interval (CI) 95%: -0.877 to 0.223] and $B = -0.094$ (CI 95%: -0.495 to 0.307), respectively. **Conclusion:** This study revealed that BLLs in battery firm workers to be normal. Additionally, BLLs were not significantly related with either systolic or diastolic blood pressure which might have been the result of normal BLLs.

Key words: Hypertension, lead, occupational exposure

How to cite this article: Taheri L, Sadeghi M, Sanei H, Rabiei K, Arabzadeh S, Afshar H, Sarrafzadegan N. The relation between occupational exposure to lead and blood pressure among employed normotensive men. *J Res Med Sci* 2014;19:490-4.

INTRODUCTION

Lead salts have always existed in the Earth's crust. However, the element itself has rarely been found in human body before industrialization and therefore, its effects were not identified until then.^[1] Today, lead is known as a major industrial pollutant,^[1] whose levels in the nature can be increased by activities such as production and burning fossil fuels.^[2] Although lead-containing gasoline and batteries are considered as most important sources of lead, the element can also be found in a variety of products including lead-containing diesel fuels, paints, ceramics, cosmetics, water pipes, agricultural equipment, hair colors, and airplanes.^[3] Consuming lead-contaminated food or water, breathing lead-polluted air, or even skin contact with lead can transmit the element to human body.^[4] Individuals in contact with lead in the workplace are also at risk through their contaminated clothes and equipment.^[4] The effects of lead contamination may vary according

to contact dose and duration, age, career, general health, and lifestyle.^[5]

Recent longitudinal studies found harmful effects at levels even lower than 40 $\mu\text{g/dL}$, that is, neurological impacts of lead occur at a level of 5 $\mu\text{g/dL}$ in children and 18 $\mu\text{g/dL}$ in adults.^[6] Some cohort studies found lead levels in workers exposed to lead to be more than 40 $\mu\text{g/dL}$.^[7] Investigations on the whole population, on the contrary, indicated blood lead concentrations of over 10 $\mu\text{g/dL}$ to be related with increased atherosclerosis, cardiovascular diseases, and mortality.^[8,9]

On the basis of above-mentioned facts, lead is regarded as an important pollutant of not only the Earth's surface but also specific workplaces. Although review articles and meta-analyses have shown blood lead levels (BLLs) to increase hypertension,^[3,10] some Iranian studies have failed to show such a relation between BLL and systolic blood pressure^[11,12] and only one study in the country

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Received: 01-02-2013; **Revised:** 21-10-2013; **Accepted:** 06-11-2013

could successfully establish a weak relation between BLL and diastolic blood pressure.^[11] This study also evaluated occupational exposure to lead and its consequent effects on blood pressure among male battery factory workers.

MATERIALS AND METHODS

Study design and sample

This cross-sectional study was conducted in Isfahan during 2011. Overall, 200 male normotensive battery company workers (age: 25-55 years) with chronic skin exposure to lead were included. In order to select participants, a full list of all battery companies in Isfahan (Iran) was collected. Simple random sampling was then used to refer to the companies and enroll workers who consented to participate. Sampling was continued until the desired sample size was reached. Subjects with a history of diabetes mellitus, hypertension, cardiac diseases, cancer, renal disease, or those consuming medicine affecting blood pressure were excluded.

Procedures

First, the objectives of the study were explained to the subjects and written informed consents were obtained. Then, the subjects completed a questionnaire including demographics, socioeconomic and professional data, history of lead exposure (career, duration of employment, previous jobs, and exposure method), history of respiratory diseases, medicine intake, and lifestyle behaviors (smoking, daily physical activity, and diet). Then the physical examination was performed by a physician and using standardized and 0-calibrated instruments. The blood pressure was measured twice in a seated position and recorded the average of two readings for the first and fifth Korotkoff sounds as systolic and diastolic pressures, respectively. Then height was determined barefoot in standing position to the nearest 0.5 cm using a secured metal ruler, and the weight was measured with light clothing and by a calibrated scales. Body mass index (BMI) was calculated as weight divided by squared height (kg/m^2). Lifestyle behaviors and anthropometric measurements were done for adjusting the model of effect of lead on blood pressure.

In order to assess BLL, venous blood samples were obtained from all subjects and kept in heparinized lead-free tubes at 4°C. All tests were conducted simultaneously in the morning. A flameless atomic absorption spectrophotometer was used to determine lead levels. The participants were divided into two groups of BLL <10 $\mu\text{g}/\text{dL}$ and BLL $\geq 10 \mu\text{g}/\text{dL}$.

Statistical analysis

Mean and frequency analyses were first used to evaluate the indices among the whole population. Then, chi-square and student's t-tests were performed to compare the BLLs

and other indices between the two groups. The effects of lead on systolic and diastolic blood pressure were assessed by stepwise linear regression and Pearson's correlation test. All analyses were conducted in SPSS19 with a significance level of $P < 0.05$.

RESULTS

From 200 invited subjects, a total number of 182 battery company workers in Isfahan were evaluated in this study. The mean age of the participants was 42.85 ± 13.65 years and they had worked in battery companies for an average of 23.67 ± 14.72 years. Table 1 shows demographic characteristics, lifestyle, disease history, lead-exposure history, anthropometric measurements, and blood pressure of the studied population. As it is seen, only 6% of the

Table 1: Demographic characteristics, risk factors, and hypertension of the studied population

Variables	Mean \pm SD or Number (percent)
Age (mean \pm SD)	42.85 \pm 13.65
Education	
Illiterate	4 (2.2)
Junior high school	92 (50.5)
High school	52 (28.6)
University degree	11 (6)
No definite response	159 (112.7)
Lead exposure method	
Inhalation	30 (16.5)
Skin	2 (1.1)
Both	150 (82.4)
Working years(mean \pm SD)	23.67 \pm 14.72
Working hours(mean \pm SD)	9.71 \pm 2.38
A second job	9 (4.9)
Time for rest(mean \pm SD)	8.93 \pm 4.43
Marital Status (married)	154 (84.6)
Average monthly payment (Toman)	
Less than 300	44 (24.2)
300-500	123 (67.6)
500-800	13 (7.1)
More than 800	1 (0.5)
A history of dyslipidemia	23 (12.6)
A history of respiratory diseases	29 (15.9)
Regular physical activity days/week(mean \pm SD)	3.40 \pm 2.56
minute/day(mean \pm SD)	16.51 \pm 26.19
Smoking	
Nonsmoker	123 (67.6)
Exsmoker	22 (12.1)
Smoker	36 (19.8)
Waist circumference (cm) (mean \pm SD)	90.27 \pm 9.70
Hip circumference (cm) (mean \pm SD)	100.01 \pm 7.28
BMI (kg/m^2) (mean \pm SD)	25.81 \pm 3.62
Systolic blood pressure (mm Hg) (mean \pm SD)	112.99 \pm 14.15
Diastolic blood pressure (mm Hg) (mean \pm SD)	70.39 \pm 10.14

BMI = Body mass index; SD = Standard deviation

participants held a university degree. Moreover, 82.4% were exposed to lead through both breathing and skin contact. The mean BLL was $7.92 \pm 3.44 \mu\text{g/dL}$ among the subjects.

The results of comparisons between groups with BLL $<10 \mu\text{g/dL}$ and BLL $\geq 10 \mu\text{g/dL}$ are presented in Table 2. Only hip circumference and systolic blood pressure were significantly higher in those with BLL $<10 \mu\text{g/dL}$.

BLL was not found to have any significant effects on systolic or diastolic blood pressure. Correlation coefficients between BLL and systolic and diastolic blood pressure were $r = -0.105$ ($P = 0.165$) and $r = -0.070$ ($P = 0.354$), respectively. The effects of lead on blood pressure, considering demographics, and lifestyle-related factors, were evaluated by stepwise linear regression [Tables 3 and 4]. In the crude model, the effects of lead on systolic and diastolic blood pressure before stepwise regression were $B = -0.422$ [95% confidence interval (CI): -1.019 to 0.175] and $B = -203$ (95% CI: -0.635 to 0.229),

Table 2: Comparison of different variables in subjects with blood lead levels $<10 \mu\text{g/dL}$ and $>10 \mu\text{g/dL}$

Variables	$<10 \mu\text{g/dL}$ 139 (76.4)	$>10 \mu\text{g/dL}$ 38 (20.9)	P value
Age	41.81 ± 13.65	45.26 ± 12.89	0.165
Education			0.065
Illiterate	2 (1.4)	2 (5.3)	
Primary school	64 (46.4)	25 (65.8)	
High school	55 (39.3)	7 (18.5)	
University degree	17 (12.3)	4 (10.5)	
Exposure method			0.770
Inhalation	24 (17.3)	5 (13.2)	
Skin	2 (1.4)	0 (0)	
Both	113 (81.3)	33 (22.6)	
Working years	22.29 ± 14.59	27.00 ± 14.47	0.084
Working hours	9.78 ± 2.38	9.78 ± 2.34	0.987
A second job			
Time for rest	8.88 ± 4.24	9.69 ± 4.22	0.324
Marital Status (married)	115 (82.7)	35 (92.1)	0.154
Average monthly payment			0.225
Less than \$300	35 (25.4)	6 (15.8)	
\$300-\$500	94 (68.1)	27 (71.1)	
More than \$500	9 (6.5)	5 (13.2)	
A history of hyperlipidemia:	17 (12.2)	6 (15.8)	0.589
A history of respiratory diseases:	21 (15.3)	8 (21.1)	0.401
Regular physical activity	3 (2.2)	2 (5.3)	0.295
Smoking			0.096
Nonsmoker	99 (71.7)	22 (57.9)	
Exsmoker	17 (12.3)	4 (10.5)	
Smoker	22 (15.9)	12 (31.6)	
Waist circumference (cm)	91.01 ± 9.63	88.46 ± 9.55	0.149
Hip circumference (cm)	100.82 ± 6.90	97.85 ± 7.97	0.025
BMI	26.00 ± 3.50	25.49 ± 3.82	0.443
Systolic blood pressure (mm Hg)	113.84 ± 14.37	108.68 ± 10.94	0.041
Diastolic blood pressure (mm Hg)	71.16 ± 10.19	66.84 ± 8.41	0.018

BMI = Body mass index

respectively. However, after entering age, exposure method, smoking, physical activity, waist circumference, and history of dyslipidemia and respiratory diseases in the regression model, the corresponding values were $B = -0.327$ (CI 95%: -0.877 to 0.223) and $B = -0.094$ (CI 95%: -0.495 to 0.307).

DISCUSSION

Despite expectations, the results of the present study on 182 normotensive adult men with a mean lead exposure duration of 23.67 years revealed normal BLLs among battery factory workers. Banihashemrad *et al.*,^[13] evaluated 50 battery factory workers in Mashhad, Iran. They found that although the subjects were in contact with lead for 23.4 ± 19.5 years, their mean BLL was $15 \mu\text{g/dL}$. Normal BLLs in our study might have been a result of novel battery usage and recycling methods. While several times of reopening and reuse of the batteries used to put workers in direct contact with lead plates, lead exposure has recently decreased due to the availability of new batteries and the General Safety Regulations for Auto Mechanics.^[14] On the contrary, previous studies have shown BLL to be an indicator of air lead levels.^[15] Therefore, reductions in BLL following a 2-year implementation of the mentioned regulations could have been caused by reduced lead levels in the air. Although we did not measure air lead pollution in the studied companies, it seems that the regulations have been successful in reducing air lead levels.

Table 3: The Effect of age, risk factors, and blood lead level on systolic blood pressure

Variable	B	P value	95% CI
Age	0.332	<0.001	0.175-0.489
Exposure method	2.183	0.220	-1.319 to 5.686
Smoking	-0.438	0.732	-2.960 to 2.083
History of dyslipidemia	-0.037	0.990	-6.016 to 5.941
History of respiratory disease	3.980	0.135	-1.258 to 9.218
Physical activity	-0.985	0.619	-4.893 to 2.922
Waist circumference	0.346	<0.001	0.137-0.556
Blood lead level	-0.327	0.242	-0.877 to 0.223

CI = Confidence interval

Table 4: The Effect of age, risk factors, and blood lead level on diastolic blood pressure

Variable	B	P value	95% CI
Age	0.138	0.018	0.024-0.253
Exposure method	1.069	0.410	-1.484 to 3.622
Smoking	-0.022	0.982	-1.859 to 1.816
History of dyslipidemia	0.557	0.801	-3.801 to 4.915
History of respiratory disease	0.632	0.744	-3.186 to 4.450
Physical activity	-2.497	0.085	-5.345 to 0.351
Waist circumference	0.321	<0.001	0.169-0.474
Blood lead level	-0.094	0.643	-0.495 to 0.307

CI = Confidence interval

Interestingly, a significant relation was not found between BLL and systolic and diastolic blood pressure in the present study. An early study by Pocock *et al.*,^[16] evaluated 7735 middle-aged men in 24 cities in England. They did not find a significant relation between BLL and systolic and diastolic blood pressure even after adjustments for age, alcohol consumption, BMI, and social class. Furthermore, the frequency of hypertension did not increase by augmented BLLs. However, in another study that did on 154 Croatian 19-53 years old showed significant increase in blood pressure that be lead dependent.^[17] It is noteworthy that the two last studies evaluated general population.

Several other studies have also assessed individuals in contact with lead and found conflicting results. Fenga *et al.*,^[18] evaluated 27 male battery factory workers and suggested a cumulative lead exposure increase blood pressure significantly in subject with low lead exposure. Another study compared 166 workers exposed to lead with 60 persons in a control group and reported significantly higher diastolic blood pressure among subjects in contact with lead. On the contrary, the two groups did not significantly differ in terms of systolic blood pressure.^[19] Schuhmacher *et al.*,^[20] also compared 36 men in occupational exposure to lead with 40 subjects not contacted with lead. They did not find a significant relation between BLL and blood pressure.

Fenga *et al.*,^[18] studied 27 normotensive battery factory workers without a history of mentioned diseases in a cohort study. The studied subjects had a mean BLL of 42.33 ± 15.16 $\mu\text{g/dL}$. The participants were divided into two groups including those directly working with lead and those indirectly exposed to the element. They suggested the participants working with lead to have higher mean systolic and diastolic blood pressure in comparison with those indirectly exposed to the material. However, Spearman test did not reveal any significant relation between BLL and blood pressure. Like Fenga *et al.*,^[18] we studied normotensive individuals without a history of cardiovascular diseases or diabetes and could not find a significant relation between BLL and blood pressure. However, BLL was more than normal range in their study. Excluding hypertensive persons cannot be responsible for the insignificant relations observed. Kaewboonchoo *et al.*,^[21] studied nonhypertensive bus drivers with normal BLLs and their results shown a significant correlation between BLL with systolic and diastolic blood pressure.

Limited Iranian studies have assessed the blood pressure of battery company workers. For instance, Ghiasvand *et al.*, found the mean BLL levels to be 43.3 $\mu\text{g/dL}$ in 497 male battery workers. However, they failed to establish a significant relationship between BLL and systolic blood

pressure. They only detected a weak association between BLL and systolic blood pressure (odds ratio: 1.03; 95% CI: 101-105).^[11] In another research on 165 male Iranian battery factory workers, BLL was not significantly related with either systolic or diastolic blood pressure.^[12]

Furthermore, considering all hypertension risk factors, such as stress (particularly occupational stress), could have affected the relation between BLL and blood pressure; the results of the present study might also have changed if all risk factors were included.

CONCLUSION

The present revealed normal BLLs among battery factory workers in Isfahan. A significant relation between BLL and systolic or diastolic blood pressure could not be found. Further studies comparing normotensive and hypertensive individuals seem necessary. In addition, a cohort study can better reflect the effects of lead on blood pressure by comparing at-risk individuals with a control group.

LIMITATIONS

Since the study required blood samples from the participants, some subjects did not consent to participate. Moreover, the length of food frequency questionnaire prevented us from asking all questions which might have altered the results. Finally, unavailability of lead levels in different areas of Isfahan eliminated the possibility of evaluating the effects of place of residence.

ACKNOWLEDGMENTS

This research was a Resident's thesis that supported by Vice Chancellor for research, Isfahan University of Medical Sciences (research project number was 389462). Authors would like to acknowledge all battery companies workers who participated in this study.

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Source of Support: Nil, Conflict of Interest: None declared.

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