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Evaluation of Some Cardiovascular Markers in Lead-Recycling Factory Workers

Onah C. Ejike[1*], Onah C. Florence[2], Oliseh C. Michael[3], Nnodim J[4], Onyegbule O. Athanasius[5], Ogbodo E. Chukwuemeka[1], Ijeomah A. Ukamaka[6], Meludu S. Chukwuemeka[7], Dioka C. Emmanuel[8]

[1]Department of Medical Laboratory Science, Faculty of Health Sciences and Technology, Nnamdi Azikiwe University, Awka, Nigeria.

[2]Department of Nursing Services, Nnamdi Azikiwe University Teaching Hospital, Nnewi, Nigeria.

[3]Department of Medical Biochemistry, Faculty of Basic Medical Sciences, Chukwuemeka Odimegwu Ojukwu University, Uli, Nigeria.

[4]Department of Medical Laboratory Science, Imo State University, Owerri, Nigeria.

[5]Department of Obstetric and Gynaecology, Federal Medical Centre, Owerri, Nigeria.

[6]Department of Biochemistry, Faculty of Natural and Applied Sciences, Nasarawa State University Keffi, Nigeria.

[7]Department of Human Biochemistry, Faculty of Basic Medical Sciences, Nnamdi Azikiwe University, Awka, Nigeria.

[8]Department of Chemical Pathology, Faculty of Medicine, Nnamdi Azikiwe University, Awka, Nigeria.

ABSTRACT

Lead is a naturally occurring metal that has no known safe blood concentration. This study was designed to assess the blood pressure, body mass index, fasting lipid profile and plasma glucose levels, and cardiac enzyme activity in lead-recycling factory workers in Nnewi. A total of eighty-two (82) subjects (41 test and 41 control subjects) aged between twenty and sixty years who gave their written informed consent were recruited for the study. After an overnight fast, 5 milliliters of blood sample was collected from each individual and dispensed into a sterile plain container and allowed to clot and retracted. The blood was centrifuged at 3000 rpm for 10 minutes and the serum was separated and used for the analysis of all the biochemical parameters. The determination of systolic and diastolic blood pressure (SBP and DBP), body mass index, as well as biochemical parameters including triglyceride (TG), total cholesterol (TC), high density lipoprotein cholesterol (HDL-C), low density lipoprotein cholesterol (LDL-C), very low density lipoprotein cholesterol (VLDL-C), creatine kinase (CK), lactate dehydrogenase (LDH) and fasting plasma glucose (FPG) levels, were done using standard methods. Results showed that the mean levels of SBP, DBP, TC, LDL-C, and FPG as well as the mean serum activities of CK, and LDH were significantly increased in the lead-recycling factory workers when compared tothe control ($p < .05$) but there was a significant decrease in the mean concentration of HDL-C when compared to control ($p < .05$). However, there were no significant alterations in TG and VLDL-C concentrations in factory workers when compared to control subjects ($p > .05$). These findings are suggestive of alterations in some cardiovascular markers in lead-recycling factory workers.

Keywords: Lead, Blood pressure, Body mass index, Lipid profile, Plasma glucose, Cardiac enzymes.

1. INTRODUCTION

Lead is a naturally occurring toxic metal found in the Earth's crust.[1] It has some beneficial uses, but it is also toxic to both humans and animals. Lead and lead compounds have been used in a wide variety of products such as paint, ceramics, pipes and plumbing materials, batteries, solders, gasoline, ammunition, and cosmetics. Exposure to the environment normally occurs as a result of its wide applications. Workers are typically exposed to lead via breathing in lead particles produced by burning products that contain lead, such as during informal recycling, smelting, stripping leaded paint, and using leaded gasoline.[2]

The health consequence of lead exposure does not depend on the environmental media or sources such as food, water, soil, or air, but on the cumulative dose of lead and the vulnerability of the person exposed.[3] Previously, a lower level of lead exposure was considered safe, but today it is known to produce a spectrum of injuries across multiple body systems such as kidney disease, hypertension, reduced intelligence quotient (IQ), reduced

Corresponding author
Onah C. Ejike
Email: ce.onah@unizik.edu.ng

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educational attainment, and learning problem.[1,4] This has made WHO declare that there is no known safe blood lead concentration.

Interestingly, both epidemiological as well as clinical studies have revealed a link between lead poisoning and raised blood pressure.[5-9] Blood lead levels even at low doses have been implicated in increased systolic blood pressure.[10,11] Apart from arterial hypertension, the low lead level can also cause metabolic, structural, and functional changes in the wall of the blood vessel which can hasten the process of atherosclerosis. Changes in lipid metabolism, an increase in the generation of free radicals, disturbances in homeostasis of some essential metals[14], endothelial dysfunctions as well as an inflammatory response have been documented as pro-atherosclerotic changes in lead exposure.[12-15] In lead-exposed rats, some previous studies have reported significant dyslipidemia characterized by 50% hypertriglyceridemia, 132% hyperphospholipidemia, and 50% hypercholesterolemia as well as raised markers of renal and liver damage.[16,17] Also, humans occupationally exposed to lead such as auto-mechanics, painters, battery chargers, etc. have been reported as high-risk individuals for atherogenesis and cardiovascular diseases as well as nephrotoxicity.[18-20] Sharma *et al*. in their work on battery workers in Lucknow city reported a significant increase in the levels of TC, TG, LDL-C, and VLDL-C and a significant decrease in the level of HDL-C in the exposed group when compared to the control subjects.[21] However, there exist some conflicting reports on levels of lipid profile in lead-exposed subjects in some publications. Kristal-Boneh *et al*. who studied men that worked in a battery recycling factory reported a significant increase in both HDL-C and TC levels in lead-exposed subjects compared to the control subjects with no significant difference in the levels of LDL-C and TG in both groups.[22] Ademuyiwa *et al*. reported raised levels of total cholesterol and low-density lipoprotein in artisans exposed to lead but also found that the levels of both TG and HDL-C were similar in both exposed and unexposed groups.[19]

The mechanism of development of cardiovascular disease (CVD) is based on the changes and impairment of the endothelial wall which leads to atherosclerosis and finally CVD and stroke. Cardiovascular damage leads to a detectable rise in the plasma concentration of myocardial enzymes normally confined within cardiac cells.[23] The enzymes most widely used in the detection of myocardial infarction are creatine phosphokinase (CPK), creatine phosphokinase MB (CK-MB), lactate dehydrogenase (LDH), and serum glutamate oxaloacetate transaminase (SGOT).[24,25] Zahid *et al.* in their study observed a significant increase in the levels of CPK, CK-MB, and LDH in workers exposed to industrial pollution.[26] Also, Dash *et al*. in the previous work showed significant ($p < .05$) elevation in the levels of both lactate dehydrogenase and creatine kinase in lead-exposed buffaloes.[27]

However, due to some conflicting reports from some previous studies coupled with the paucity of similar studies in this geographical area, especially in lead recycling factories, this work becomes imperative. Therefore the present study assessed the blood pressure, body mass index, fasting lipid profile and plasma glucose levels, and cardiac enzyme activity in lead-recycling factory workers in Nnewi, Nigeria.

2. MATERIALS AND METHODS

2.1 Study Sites

The present study was conducted in one of the lead-recycling factories in Nnewi, Anambra State, Nigeria. Analyses of biochemical parameters were carried out at the facilities of the Department of Chemical Pathology, Nnamdi Azikiwe University Teaching Hospital, Nnewi.

2.2 Study Population

This cross-sectional study involved a total of eighty-two subjects who were divided into test and control groups with equal subjects. A total population sampling method was employed and only those subjects that did not meet inclusion criteria or did not give written informed consent were not included in the study. The test group comprises forty-one male lead-recycling workers of the age range 20-60 years who gave their written informed consent. These subjects have actively worked between 1-20 years in one of the lead-recycling factories in Nnewi, Nigeria. Their work involved melting used battery cells using a high-temperature furnace to remove impurities and then remolding them into lead bars which will be used in manufacturing new batteries. They all reside within the vicinity of Nnewi North Local Government Area (LGA) of Anambra State. The control group comprises forty-one male subjects between the age ranges of 20-60 years. They were civil servants whose occupations do not expose them to lead. For comparative purposes, they reside in the same domestic vicinity as the test subjects. The purpose of matching them in terms of residential area was to cancel out other sources of lead exposures such as water, inhalation of exhaust fume, etc., thus differentiating them only by their occupation.

2.3 Inclusion criteria

Healthy male subjects occupationally exposed to lead (test subjects), and healthy male subjects not occupationally exposed to lead (control subjects) who gave their written informed consent were recruited into the study.

2.4 Exclusion Criteria

Subjects who have a history of chronic diseases such as diabetes mellitus, cardiovascular diseases, kidney disease, etc. and those who were on any medications such as vitamins or mineral supplementations that may influence the outcome of the study were excluded from the study.

2.5 Sample Collection

The specimen handling area was kept clean and free from dust. After 10-12 hours overnight fast, 5 mL of blood was collected from each individual and dispensed into a sterile plain container and allowed to clot and retracted. The blood was centrifuged at 3000 rpm for 10 minutes and the serum was separated and stored at -20 ºC. All the biochemical parameters were analyzed within two weeks of storage.

2.6 Laboratory Methods

Various laboratory methods followed are shown in Tables 1.

2.7 Anthropometric Measurements

Body mass index (BMI) was calculated using the following formula: BMI= weight (kg) / height^2 (m^2). A measuring tape was fastened to a piece of wood to determine the height, and a manual weighing scale was used to determine the weight. BMI of 25 and 30 kg/m^2 was classified as overweight and generalized obesity, respectively.

2.8 Blood Pressure Reading

Systemic blood pressure was obtained using an OMRON automatic digital blood pressure monitor on the left arm after 10-minute rest using a cuff of appropriate size with the subject in the sitting position. Blood pressure was expressed as systolic and diastolic rate and hypertension was defined as systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg.

2.9 Ethical Approval

The ethical approval for this study was obtained from the Ethics Committee of the Faculty of Basic Medical Sciences, Nnamdi Azikiwe University, Nnewi Campus with approval no: FBMS/EC/004/2014.

2.10 Statistical Analysis

Version 21 of Statistical Package for Social Sciences (SPSS) was used in statistical analysis. The variables were expressed as mean ± SD. The independent student t-test was used to assess the significant mean difference between the two independent variables. The level of significance was considered at $p < .05$.

3. RESULTS

The mean levels of SBP and DBP were significantly higher in lead-recycling workers than in control subjects ($p < .05$). Conversely, the mean levels of BMI were significantly lower in lead-recycling workers than in control subjects ($p < .05$) (Table 2).

The mean levels of FPG, TC, and LDL-C were significantly higher while the mean levels of HDL-C were significantly lower in lead-recycling workers when compared to the control subjects ($p < .05$). However, the mean levels of TG and VLDL-C were similar in both groups ($p > .05$) (Table 3).

The mean levels of CK and LDH were significantly higher in lead-recycling workers when compared with the control group ($p < .05$) (Table 4).

4. DISCUSSION

Lead recycling factory workers had lower BMI but higher SBP and DBP than in the control group. The stress of the work as well as an increase in blood lead level may have contributed to weight loss. Animal studies have reported that low lead exposure was associated with the development of hypertension.[36] According to Navas-Acien *et al*. both epidemiological as well as clinical studies have revealed a link between lead poisoning and raised blood pressure.[9]

In this study, levels of FPG and fasting lipid profile revealed that the subjects that were occupationally exposed to lead may be at more risk of atheroma or cardiovascular disorder. This is because the mean levels of TC, LDL-C, and FPG which are risk factors for cardiovascular disorders were significantly higher while the mean level of high-density lipoprotein cholesterol (also a risk factor) was significantly lower in the subjects occupationally exposed to lead than in the control subjects. A previous study on the assessment of lipid profile levels of chickens (*Gallus gallus domestica*) exposed to factory sites in Nnewi, Anambra State, South Eastern Nigeria showed significant elevations in the levels of total cholesterol and low-density lipoprotein cholesterol with an attendant reduction in the level of high-density lipoprotein cholesterol in chickens exposed to factory sites than in control.[37] Furthermore, men occupationally exposed to lead working as auto-mechanics, painters, and battery chargers have been reported as high-risk individuals for atherogenesis and cardiovascular diseases.[18,19] Increased levels of plasma lipids in lead exposure have been attributed to so many factors. For instance, there may be an altered distribution of cholesterol between the plasma and the tissues; increased absorption of cholesterol from the diet; increased production of endogenous cholesterol

Table 1: Parameters analyzed, assay kits and Laboratory methods followed

Parameters	*Kits*	*Methods followed*
Plasma glucose	Randox Diagnostics, UK	Assayed by glucose oxidase method as described by Trinder.[28]
Total cholesterol	Biosystems, Spain.	An enzymatic colorimetric method as described by Naito.[29]
Triglyceride	Randox Diagnostics, UK	GPO-POD enzymatic colorimetric reaction as described by Fossati et al.[30]
HDL-C		Precipitation and CHOD-POD enzymatic colorimetric reaction as described by Grove and Naito.[31,29]
LDL-C	Biosystems, Spain.	LDL-C was estimated by computation, according to the method described by Friedewald et al.[32]
VLDL-C		VLDL-C was estimated by computation, according to the method described by Friedewald et al.[30]
LDH	Roche Diagnostics, USA	Bais and Philcox Methods following International Federation of Clinical Chemistry (IFCC) recommendation.[33,34]
CK	Roche Diagnostics, USA	According to the method described by Szasz following IFCC recommendation.[35]

Table 2: Age, SBP, DBP, and BMI in lead-recycling workers and control groups (Mean ± SD).

Parameters	*Test Group N = 41*	*Control N = 41*	*t-value*	*P-Value*
Age (years)	35.24 ± 10.08	35.59 ± 6.81	-0.180	0.858
Systolic blood pressure (mmHg)	131.37 ± 16.23	117.51 ± 9.28	4.743	0.000*
Diastolic blood pressure (mmHg)	77.68 ± 11.07	66.95 ± 5.79	5.498	0.000*
Body mass index (kg/m^2)	23.40 ± 4.11	26.10 ± 1.46	-3.963	0.000*

Key: * = significant

Table 3: Fasting plasma glucose and Serum fasting lipid profile in lead-recycling workers and control groups (Mean±SD).

Parameters	*Test Group N = 41*	*Control N = 41*	*t-value*	*P-Value*
Fasting plasma glucose (mmol/L)	5.09 ± 0.77	4.54 ± 0.61	3.531	0.001*
Total cholesterol (mmol/L)	5.33 ± 0.77	4.82 ± 0.97	2.687	0.009*
Triglyceride (mmol/L)	0.93 ± 0.51	0.97 ± 0.36	-0.411	0.683
LDL-C (mmol/L)	3.35 ± 0.70	2.96 ± 0.87	2.266	0.026*
HDL-C (mmol/L)	1.34 ± 0.28	1.46 ± 0.24	-2.123	0.037*
VLDL-C (mmol/L)	0.42 ± 0.23	0.44 ± 0.16	-0.415	0.679

Key: * = significant
LDL-C = low-density lipoprotein cholesterol, HDL-C = high-density lipoprotein cholesterol, VLDL-C = very low-density lipoprotein cholesterol

Table 4: Serum cardiac enzymes in lead-recycling workers and control groups (Mean±SD).

Parameters	*Test Group N = 41*	*Control N = 41*	*t-value*	*P-Value*
Creatine kinase (U/l)	337.37 ± 196.04	175.87 ± 77.39	4.906	0.000*
Lactate dehydrogenase (U/l)	198.80 ± 37.45	177.75 ± 25.38	2.979	0.004*

Keys: * = significant

as well as decreased cholesterol transformation to bile acids.[38] Similarly, it could probably be a result of the overproduction of very low-density lipoprotein which increases the levels of triglyceride-rich lipoproteins on the common lipolytic pathway.[39]

However, other studies in men that worked in a battery recycling factory reported a significant increase in both HDL-C and total cholesterol and no change in the levels of LDL-C and TG in lead-exposed subjects.[20] Ademuyiwa *et al*. reported raised levels of total cholesterol and LDL-C and normal levels of both TG and HDL-C in artisans exposed to lead.[19] On the other hand, rats exposed to long-term low or moderate lead doses did not show any changes in their mean levels of TC, LDL-C, HDL-C, and TG.[40] They, therefore, concluded that long-term exposure to low or moderate lead concentrations should not be incriminated to the risk of atherosclerosis.

Furthermore, the mean levels of CK and LDH were significantly higher in lead-recycling workers when compared to the control group. This is in agreement with the previous work of Zahid *et al*. that observed a significant increase in the levels of CK-MB and LDH in workers exposed to industrial pollution.[23] Also, Dash *et al*. in their earlier study showed significant elevation in the levels of both lactate dehydrogenase and creatine kinase in lead-exposed buffaloes which is in keeping with the present report.[27] Both lactate dehydrogenase and creatine kinase are important markers of myocardial infarction and following cardiovascular damage, there is a detectable rise in the plasma concentration of these myocardial enzymes which are normally confined within cardiac cells.[23-25]

5. CONCLUSION

This study revealed significant elevations in the mean levels of SBP, DBP, FPG, TC, LDL-C, CK, and LDH with a corresponding reduction in the mean HDL-C concentration in lead-recycling workers when compared with the control group. This may imply that lead exposure has a deleterious effect on the cardiovascular health of lead-recycling factory workers.

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