

## *The Trace Element Pattern In Occupational Lead Exposed Workers*

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**Abstract**— The aim of this study was to determine the effect of occupational lead exposure on blood levels of copper, zinc, chromium and selenium. In this study, retrospective evaluation of 2379 patients presenting to Ankara Occupational Diseases Hospital for lead measurement from 2010 to 2014 was done. Blood lead levels >10 µg/dL was considered as exposure limit and participants were classified into 2 groups as “lead-exposed group” and “control group”. Median copper and

zinc values of exposed group were significantly lower than control group ( $p=0.004$  and  $p=0.010$ , respectively). In group comparison data, there was not any significant difference in terms of selenium and chromium levels ( $p=0.422$  and  $p=0.371$ , respectively). Further studies must be done to establish link between lead and essential elements.

**Key words:** Lead exposure, copper, zinc, chromium, selenium.

## I. Introduction

Lead has been used since ancient times. It is a pervasive and persistent environmental pollutant which exists in almost all phases of environment and biological systems. Lead is still being widely used in industry and life hence it has indispensable properties like resistance to corrosion, malleability and low melting point [1]. Unfortunately exposure to lead is unavoidable since it has many applications in the current life of human being from work to home and its accumulation in environment. Regarding the use, it is the fifth highest metal throughout the world [2]. Lead causes neurological, hematological, gastrointestinal, reproductive, circulatory and immunological pathologies depending upon the level and duration of exposure [3]. It is rapidly taken up in blood and soft tissues with a half life 28-30 days and followed by a slower redistribution to bone (half life 27 years) [4]. The body burden of lead in humans is stored mostly in the skeleton therefore bone acts as a reservoir of lead that may be mobilized by certain states such as pregnancy, lactation and osteoporosis [5].

Lead is a redox inactive metal [6] however it interacts with a group of essential elements such as copper, zinc, selenium and chrome. Copper is an essential microelement found in all living organisms and can adopt two different redox states: in the oxidized ( $\text{Cu}^{+2}$ ) and reduced ( $\text{Cu}^{+1}$ ) [7]. Cu is required for fundamental biological functions and serves as an important catalytic cofactor in redox-regulating enzymes, such as superoxide dismutase, caeruloplasmin, tyrosinase and lysyl oxidase [8]. One of the important roles of Cu is associated with the mobilization of iron and its absorption. Though Cu is a part of antioxidant defense system it is possible to suggest that its activity might alter because of lead induced oxidative stress.

The essential trace element Zinc (Zn) plays a variety of physiological roles, in particular being required for growth and functioning of the immune system. Zn is also essential for cellular membrane integrity and metabolism. In Zn deficiency physiological processes impairs leading to clinical consequences which include failure to thrive, skin rash, and impaired wound healing [9]. Several researchers reported that Pb exposure interferes with

the metabolism of Zn in blood, kidney, liver, spleen, testes, bone and brain, leading to decreased cellular Pb accumulation [10, 11]. Workers exposed to Pb showed a significant decrease in blood Zn levels [2]. Zn competes with lead for similar binding sites on a metallothionein-like protein in the gut so reduces its absorption and subsequently decreases the Pb toxicity [13]. Zn is required for superoxide dismutase activity and possess antioxidant properties thereby reduces lead-induced oxidative stress [14].

Selenium (Se) has been proven to play an important role in the protection of cells from free radical damage and, as a cofactor of glutathione peroxidase, it decreases the lipid peroxidation and protects DNA, RNA and proteins from oxidative damage. Se also has other health effects in humans such as decreasing the incidence of cancer, protecting against cardiovascular diseases, treating certain muscle disorders [15]. Se interacts with lead and forms inactive selenium-lead complexes so the availability of free lead ions in the body declines [16, 17].

Chromium (Cr) is an essential element and also a human carcinogen

primarily when exposed by inhalation in occupational settings [18]. The oxidation state and solubility determines the biologic activity of Cr. Chromium is found mostly in its metallic form (Cr O) as a component of iron-based alloys such as stainless steel. Cr may exist in the natural environment in two main valence states: hexavalent chromium (Cr VI) and trivalent chromium (Cr III). While Cr (III) is generally non hazardous, Cr (VI) is a strong oxidizing agent and low levels of this form can induce DNA base oxidative damage [20].

The effect of occupational lead exposure may be modified in the presence of certain essential metals such as Cu, Zn, Se and Cr but their interactions are diverse and not clearly understood yet. Therefore the aim of this study was to determine the effect of occupational lead exposure on blood levels of above mentioned essential elements.

## II. Material and methods

### Study population

In this study, retrospective evaluation of 2379 patients presenting to Ankara Occupational Diseases Hospital for lead measurement from 2010 to 2014 was

done. Blood lead levels  $>10$   $\mu\text{g/dL}$  was considered as exposure limit and participants were classified into 2 groups as “lead-exposed group” and “control group”.

### Collection of biological samples

Blood samples were taken from the participants at ‘end of workshift’. Blood samples were drawn in 10 mm EDTA-containing trace elements tubes (BD Vacutainer) for whole blood lead and chromium analysis, in 10 mm trace elements tubes (BD Vacutainer) for serum copper, zinc and selenium analysis, For serum analyses, the specimens were centrifuged at 1500xg for ten minutes after at least 30 minutes of incubation. All samples were analyzed on the same day.

### Analysis methods

Lead, chromium, copper, zinc and selenium levels were determined using Inductively Coupled Plasma Mass Spectrometry (ICP-MS) (Agilent 7700 series, Tokyo, Japan). Blood samples were digested by the microwave induced acid digestion method. Standard solution of lead was prepared by dilution of certified standard solutions (High purity Standards,

Charleston, SC, USA). Two level quality control materials were used (Seronorm, Billingstad, Norway).

### Statistical Analysis

Statistical analysis of data was made by using SPSS (Version 18.0) (SPSS Inc, Chicago, IL, USA) package program. Coherence to normal distribution analysis was made by using Kolmogorov-Smirnov test. Values were presented as mean $\pm$ SD or in the case of non-normally distributed data, as median (minimum-maximum). The presence of a statistically significant difference between the groups in terms of continuous variables was examined with Student’s t test for parametric variables and Mann–Whitney U test for non-parametric variables. Spearman’s correlation analysis was also performed All results were accepted statistically significant for  $p<0.05$ .

### III. Result

The demographic and laboratory characteristics of 2379 patients who participated in the study are shown in

Table. Participants with lead exposure were categorized into two groups according to blood lead levels as  $< 10$  and  $> 10$   $\mu\text{g}/\text{dL}$ . No significant difference was observed between groups in terms of age.

Median copper and zinc values of exposed group and control group were significantly different ( $p=0.004$  and  $p=0.010$ , respectively). In group comparison data, there was not any significant difference in

**Table . Biochemical Parameters and Demographic Characteristics of Groups**

	Non-Exposed Group (n=1200)	Exposed Group (n=1179)	P values
Lead ( $\mu\text{g}/\text{dL}$ )	2.5(0.30-9.50)	26.05(10-50)	$<0.001^*$
Copper ( $\mu\text{g}/\text{dL}$ )	97(55-197)	91(71-134)	0.004*
Zinc ( $\mu\text{g}/\text{dL}$ )	97(54-171)	93(60-200)	0.010*
Selenium ( $\mu\text{g}/\text{L}$ )	79(42-166)	79(49-150)	0.422
Chromium ( $\mu\text{g}/\text{L}$ )	4.5(1-21)	4.75(1-12)	0.371
Age (year)	$34.8 \pm 7.6$	$35.2 \pm 8.8$	0.250

Values are represented as median (Min-Max) or mean  $\pm$  SD

\*Significantly difference

terms of selenium and chromium levels ( $p=0.422$  and  $p=0.371$  , respectively)

Analysis using Spearman's correlation coefficient showed that lead correlated negatively with copper levels ( $r = -0.035$ ;  $p=0.014$ ) and zinc levels ( $r = -0.030$ ;  $p=0.040$ ) . There was no correlation between lead and selenium ( $r = -0.032$ ,  $p =$

$0.143$ ), lead and chromium levels ( $r = -0.017$ ,  $p = 0.371$ ).

#### IV. DISCUSSION

Heavy metals such as lead and mercury are known to markedly alter the function and metabolism of some micronutrients. We evaluated the status of essential elements, Cu, Zn, Se and Cr, in

workers occupationally exposed to Pb. The association between levels of Zn and Cu was demonstrated.

The influence of essential elements on lead toxicity has been investigated in several studies. Mehdi et al. measured the blood levels of some trace metals in 37 male workers exposed to Pb at storage-battery factories. They observed that mean blood Cu levels of workers were lower than the control group [21]. Likewise in our study we found that the blood levels of workers occupationally exposed to Pb were significantly lower than control subjects. This may be related with either depression of Cu absorption or increased urinary excretion of Cu, secondary to Pb induced tubular dysfunction. However, in a study designed by Wasowicz et al., no significant difference was found between the blood concentrations of Cu in 43 male workers employed in the lead–acid batteries department and control group [22]. Inconsistent results with our study were observed in another study by Kasperczyk et al., who reported that the copper concentration of 192 male employees of zinc-lead works were significantly higher than control group [23]. The authors attributed the increase in the Cu level to

the increased activity of antioxidant enzyme, CuZn-superoxide dismutase. Lead is also thought to displace the Cu ions competitively from the tissues. Ugwuja et al. postulated that elevated blood levels during pregnancy was associated with increased plasma copper concentration [24]. The fate of Cu in lead intoxication is less well-established than that of zinc.

In the present study the mean blood Zn levels of Pb exposed workers were significantly lower than control group. Dioka et al. observed that the Zn blood level in artisans who were occupationally exposed to lead decreased by 34% compared with unexposed subjects [25]. Likewise, when examining the workers employed in the lead- acid batteries department Wasowicz et al. also observed that the mean plasma Zn concentration was lower than the reference group [22]. However, Mehdi et al [21] and Chiba et al. [26] observed no significant differences between mean Zn plasma levels in workers occupationally exposed to Pb and the control group. Furthermore Malekirad et al. showed a positive correlation amongst Zn and lead blood levels and significant elevation of these parameters in the zinc-lead miner workers

compared with control group [2]. Zinc competes with lead for binding sites in the gut and reduces lead induced oxidative damage hence it takes an important role in the antioxidant defense. Zinc deficiency worsens the caused by lead poisoning.

There was no significant difference in the selenium plasma levels between the Pb exposed workers and control group in the present study. Similar result was found by Wasowicz et al. [22] whereas in a study, plasma selenium levels of 25 lead-exposed secondary smelter workers were found slightly but statistically lower than in 25 matched controls [27]. The author also postulated that there was a significant negative correlation between blood lead level and plasma selenium. Lead toxicity causes a decrease in selenium concentration in the blood, that leads to an increase in the rate of free radical production [28]. We did not observe any difference in chromium levels between Pb exposed workers and the control subjects.

Although the effect of occupational exposure to Pb on trace metals pattern seems to be diverse and associated mainly with their tissue distribution, results of this study indicate that lead exposure

significantly effects the blood levels of Cu and Zn. The clinicians should monitor the blood levels of these essential metals in case of lead exposure. The adequate dietary intake of the these trace elements is necessary as that they might reduce the lead induced oxidative damage.

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