

BIOCHEMISTRY

Lead, Zinc and Copper Concentrations in Hair, Nails and Blood of Some Workers in Saudi Arabia

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Abstract. The levels of Pb, Zn, and Cu in hair, nails and whole blood in non smoking Saudi males were determined to find out the effects of occupation and exposure period on the concentrations of these elements and to compare it with those in the control group. The study included three test groups of subjects: workers in a gas station, printing industries and traffic policemen. The control group consisted of subjects not exposed to the environmental conditions of the test groups. The levels of Pb, Zn and Cu were found to be higher in all the three groups as compared to control group. The increase in the level of Pb over the control group was about 4, 2 and 2 times higher in gas station workers, printing workers and traffic policemen, respectively. The corresponding increases in the level of Zn was about 1.5, 1.3 and 1.4 times and that of Cu 1.2, 1.2 and 1.6 times higher in the test groups, respectively when compared with the control group. The exposure time was about 4.8, 10.8 and 15.4 years for the gas station workers, printing workers and traffic policemen, respectively. The increases in the concentration of these elements were dependent on the work involved which demands some adequate protective measures for these workers.

Introduction

When studying the biological effects of trace elements, it is necessary to know their chemical forms and possible sources. Due to man's activities, lead has been brought into circulation. It occurs in storage batteries, motor fuel, lead shielding soldering wire, shielding material for X-ray radiation, pigments, alloys, ceramic glazers and stabilizers for plastics and rubber. When introduced into humans, Pb is distributed through the blood stream in soft tissues (liver, kidney, brain and bones), which is slowly excreted through urine, faeces, sweat, and deposited in hair, nail and bone. Pb in blood and soft tissues (e.g. liver) has identifiable toxic effects. The immediate effects of acute Pb poisoning are well defined symptoms which include nausea, vomiting, abdominal pain, anoxia, constipation, insomnia, irritability, mood disturbance and coordination loss

[1,2]. Investigations on the contribution of petrol lead to blood lead levels has received a great deal of attention in the world. Individuals living in industrialized urban areas have higher lead level in blood, hair and teeth compared to individuals living in rural areas [3,4]. Zn and Cu are essential trace elements for all organisms. The adult human body contains an average of about 1.8 g zinc. In males the prostate is the organ with the highest concentration of Zn, together with liver, kidney and muscle account for about half of the body Zn, while the heart contains about a third. Relatively high levels of zinc salts can be given orally (dietary supplements) without severely damaging tissues or impairing their biochemical functions. Zn is a component in a number of enzymes particularly oxidoreductases, transferases, hydrolases, ligases and isomerases [5]. Zn is important in human growth and sexual development [6]. It is also important for the syntheses of RNA, DNA and for cell division. It is occasionally used therapeutically to promote wound healing and may be used in treating gastric ulcers [7]. Serum Zn decreases in cirrhosis and in some forms of anaemia, leukaemia and other blood diseases. Humans are exposed to copious quantities of Zn in the environment without realizing conditions for exposure which exist in coating iron, fixtures with Zn to prevent rust, galvanized iron containers, pipes, and utensils. Protection against Zn toxicity is achieved by taking metallothionein [8].

Copper has perhaps the narrowest margin of difference between nutritional need and toxicity. Nevertheless, it is essential for all living systems because it serves as a cofactor for oxidase enzymes, and is distributed within cells, organelles and plasma. The importance of Cu in human nutrition was shown earlier in malnourished children of Peru [5]. Other studies confirmed that it is required for infant growth, defence mechanism, bone strength, red and white cell maturation, cholesterol metabolism, myocardial contractility, glucose metabolism and brain development. Sources of Cu include dietary items which are highly variable. The richest sources are meat, oysters and chocolate, plant food, especially seeds. Fruits and vegetables tend to contain Cu which is variable depending on location. Drinking water is another potentially important source of high Cu, the concentration being influenced by pH of the water and the pumping system used. Recent studies showed that mean values of 1.24 mg day^{-1} Cu for men and 0.93 mg/day for women are required. In humans, acute overdose gives the sensation of a metallic taste with epigastric burning, nausea, vomiting, and severe diarrhoea. The condition becomes critical and life-threatening when the affected individual shows hypertension, shock and coma. Anemia caused by excessive hemolysis can be prevalent [5]. The liver is the most commonly involved organ with its central role in Cu uptake, distribution, and excretion, as it is the first site of deposition after absorption.

Materials And Methods

Samples of blood, hair and nails were obtained on the same day from volunteer donors from Riyadh region, Saudi Arabia. Blood specimens were collected in evacuated glass tubes vacutainers (10 ml), containing lithium heparin anticoagulant and stored

frozen in plastic vials. Solid samples of hair, and nails were washed immediately with alcohol and deionized water, then dried and stored. For wet sample preparation, fractions of blood (100 μ l each) were mixed with concentrated nitric acid in the ratio (1:4) to remove interfering organic materials and the supernatants were recovered by centrifugation. Samples of hair and nails (0.5 g) were added to concentrated nitric acid (10 ml) and heated moderately under refluxing for complete digestion. Dilute nitric acid was used for dissolution of the ash obtained by wet decomposition and the volumes were made up to 100 ml with deionized water. The undissolved residue was removed and supernatants were stored refrigerated in plastic vials. Standard solutions were prepared by dissolving 1.6 g of lead nitrate in 100 ml of deionized water, 1 g of Zn metal in 30 ml of 5 M hydrochloric acid and diluted to 1 liter with deionized water; 1 g of Cu metal in 50 ml of 5 M nitric acid and diluted to 1 liter with deionized water. Calibration solutions were prepared freshly everyday by dilution of standard solution to final concentrations of 50 and 25 ppb of Pb, Zn and Cu suitable for two standard calibration points.

Standards and samples were measured on electrothermal atomization atomic absorption spectrophotometer, Pye Unicam SP 9 equipped with graphite Furnace and Video Computer Pro-grammer. Instrument background corrections were carried out in the setting procedure by using deionized water acidified with nitric acid in the ratio of 1:4.

Results and Discussion

Hair and nails can be ideal indicators of the metal burden of the body, provided analysis is done accurately with proper interpretations of normal values [9]. The levels of these elements in blood are the best indicators of current exposure. The blood levels of these elements reflect dynamic equilibria between exposure, absorption, distribution, and elimination of these elements [10].

The results show increase in the level of lead in all three groups as compared to control, the highest in the gas station workers; 4 times higher in hair and 6.2 times higher in nails, and in whole blood about 2 times. The respective increases in printing workers, were 3 times in hair, 2 times in nails, and 1.4 in whole blood. The increase in traffic police was 3.1 times in hair, 2.3 times in nails, and in whole blood 1.4 times. The volunteer subjects were nonsmoking Saudi males with average age of about 33 years. Non smokers were selected to eliminate any effect of increases due to smoking or age. The highest increase in Pb concentration was found in gas station workers, despite their lowest exposure time (4.8 year) as compared to printing workers (10.8 year) and traffic police (15.4 year). The finding presumably reflects the fact that leaded gas is commonly used in Saudi Arabia.

Results of Zn analyses show increased level of Zn in gas station workers which had the highest increases; 1.5 times in hair, 1.3 times in nails and 1.7 times in whole blood as

compared to the control group. These values in printing workers were 1.2 times in hair, 1.25 times in nails and 1.4 times in whole blood. In traffic police it was 1.4 times in hair, 1.3 times in nails and 1.6 times in whole blood as compared to control.

The results of the Cu analyses show that the highest levels occurred in traffic police with an increase of 1.7 times in hair, 1.9 times in nails and 1.2 times in whole blood; while in printing and gas station workers the values were almost the same. These values were 1.3 times in hair, 1.3 times in nails and about 1.1 times in whole blood as compared to control.

Table 1. Concentration of Pb, Zn and Cu in hair, nails and whole blood of various groups (in each group n=5) . Results in Mean±SD

Groups	Gas station	Printing	Traffic police	Control
Age (yr)	33.6±1.3	33.2±1.6	33.4±1.4	36.3±2.3
Exposure time (yr)	4.8±0.85	10.8±1.3	15.4±2.6	-
(Pb) in Hair $\mu\text{g g}^{-1}$	17.1±0.46	12.93±0.3	13.09±0.03	4.2±0.12
(Pb) in Nails $\mu\text{g g}^{-1}$	26.11±1	8.12±0.9	9.31±0.6	4.18±0.3
(Pb) in whole blood $\mu\text{g dl}^{-1}$	24.1±0.1	17.3±0.7	17.7±0.8	12.5±0.4
(Zn) in Hair $\mu\text{g g}^{-1}$	227.2±2.1	186±1.5	213.3±4.1	156±1.2
(Zn) in Nails $\mu\text{g g}^{-1}$	210±96	202±1.3	209±1.03	161±0.86
(Zn) in whole blood $\mu\text{g dl}^{-1}$	1080±61	890±61.3	975±62.6	624±11.3
(Cu) in Hair $\mu\text{g g}^{-1}$	18.72±0.3	18.64±1.7	24.68±0.7	14.88±0.2
(Cu) in Nails $\mu\text{g g}^{-1}$	7.8±0.6	8.62±0.3	10.32±0	5.52±0.4
(Cu) in whole blood $\mu\text{g dl}^{-1}$	130.6±3	133.8±5	143.4±4	122.4±2

In general, the results show an increase in the level of Pb, Zn and Cu in all three groups as compared to control. This type of investigation has not been carried out so far on Saudi population. Earlier reports are only from soil and water [11]. International comparison of the data from humans presents difficulties since, there is considerable diversion in the concentrations of these elements in populations. For example, the normal level of whole blood ranges from 60 $\mu\text{g Pb L}^{-1}$ in Beijing (China) to 220 $\mu\text{g Pb L}^{-1}$ in Mexico city [5]. The present results show an increase in level of Pb, Zn and Cu in

all three groups as compared to control group even though the increase is lower than the pathological level which for lead is above $300 \mu\text{g L}^{-1}$ [12-13]. It is possible that longer exposure to these elements for these groups and other workers in related fields such as ceramic industries and radiator shops may occur. It is suggested that all the workers must be protected and following measures are recommended.

- 1) Routine checkup, at least once a year.
- 2) Wear gloves and protective coats during work.
- 3) Bath after each working day.
- 4) Eating and drinking restrictions in working areas.
- 5) Wash hands before leaving working areas and before eating meals.
- 6) Good ventilation of the working areas.

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قياس تراكيز الرصاص، الخارصين والنحاس في الشعر، الأظافر والدم لبعض العمال في المملكة العربية السعودية

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ملخص البحث. إن زيادة تراكيز بعض العناصر في أنسجة الجسم عن المعدلات الطبيعية يؤدي إلى تأثيرات حيوية ضارة وغالبا ما تكون الزيادة ناتجة عن التعرض لتراكيز عالية مما يؤدي إلى تجمعها في الجسم مع مرور الوقت. تم في هذا البحث قياس مستويات عناصر الرصاص، الخارصين والنحاس في الشعر، الأظافر والدم لثلاث مجموعات تشمل أشخاص سعوديين ذكور غير مدخنين وهذه المجموعات هي عمال محطات الوقود، عمال المطابع ورجال المرور وذلك لدراسة تأثير طبيعة العمل ومدة التعرض لهذه العناصر مقارنة مع المجموعة الرابعة لأشخاص لا تقتضي طبيعة عملهم التعرض لها. لقد أثبتت النتائج أن مستوى هذه العناصر مرتفع في المجموع الثلاثة، فالزيادة في مستوى الرصاص حوالي ٤مرات، ٢مرة و٢مرة في عمال محطات الوقود، عمال المطابع ورجال المرور بالتتابع بينما الزيادة في عنصر الخارصين حوالي ١,٥مرة، ٣,١مرة و١,٤مرة في نفس المجموع بالتتابع والزيادة في مستوى النحاس حوالي ١,٢مرة، ٢,١مرة و١,٦مرة بالتتابع مقارنة مع المجموعة الرابعة.

إن المدة الزمنية لتعرض الأشخاص في المجموع الثلاثة لهذه العناصر حوالي ٤,٨ سنة، ١٠,٨ سنة و١٥,٤ سنة لكل من عمال محطات الوقود، عمال المطابع ورجال المرور بالتتابع. والنتائج توضح تأثير طبيعة العمل على زيادة مستوى هذه العناصر عن المعدلات الطبيعية مما يستوجب اتخاذ الاحتياطات اللازمة لوقاية العمال الذين يعملون في هذه المجالات وما شابهها.