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ASSESSMENT OF METAL HAZARD TAKING HAIR AS AN INDICATOR OF TRACE ELEMENT EXPOSURE TO WORKERS IN OCCUPATIONAL ENVIRONMENT

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Abstract

The use of biological tissues as diagnostic tools of trace element level for recognising the disease status of an exposed human population is an important area of investigation. Quantitative analysis of 10 trace elements viz lead, calcium, magnesium, chromium, manganese, iron, nickel, copper, and zinc in the human body was performed using hair as biopsy material. In the present investigation, workers in a roadways workshop, locomotive workshop and Pb battery units were included as subjects. Head hair samples were collected from the nape region of the skull. Subsequent to sampling of hair, a questionnaire recommended by the World Health Organization was filled in order to obtain details about the subjects regarding occupation, duration of exposure, medical history, etc. Concentration of elements in hair was determined using an atomic absorption spectrophotometer. Workers under mental stress were treated as cases and workers without any symptoms of mental stress were chosen as controls. Significant difference in concentration of lead, calcium, magnesium, manganese, nickel, copper and zinc was found in hair of subjects with mental stress than those of controls. Concentration of chromium and iron was found higher in hair of subjects with mental stress but this difference was not significant with respect to controls.

Key words: hair, mental stress, trace elements, occupational environment, health hazards.

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OCENA ZAGROŻENIA ZATRUCIEM METALAMI NA PODSTAWIE ANALIZY WŁOSÓW JAKO WSKAŹNIKA WYSTAWIENIA ROBOTNIKÓW NA DZIAŁANIE PIERWIASTKÓW ŚLADOWYCH W ŚRODOWISKU PRACY

Abstrakt

Ważnym obszarem badań jest wykorzystywanie tkanek biologicznych do określania zawartości pierwiastków śladowych w celu diagnozowania chorób wśród populacji narażonych na skażenie środowiskowe. Analizowano zawartość 10 pierwiastków śladowych, m.in. ołowiu, wapnia, magnezu, chromu, manganu, żelaza, niklu, miedzi oraz cynku, w ciele ludzkim na podstawie włosów pobranych od robotników z warsztatów drogowych, kolejowych oraz mających do czynienia z akumulatorami zawierającymi rtęć. Próbki włosów pobrano z okolicy potylicznej czaszki. Po pobraniu próbek włosów, uczestniczący w badaniu wypełnili ankiety Światowej Organizacji Zdrowia, których celem było zebranie szczegółowych danych dotyczących miejsca pracy, czasu trwania ekspozycji na czynniki ryzyka, historii przebytych chorób, itp. Zawartość pierwiastków we włosach określono za pomocą spektrofotometru absorpcji atomowej. Robotnicy doświadczający stresu psychicznego zostali ujęci jako przypadki chorobowe, natomiast nie przejawiający objawów napięcia zostali potraktowani jako przypadki kontrolne. Stwierdzono istotne różnice w zawartości ołowiu, wapnia, mangezu, manganu, niklu, miedzi i cynku we włosach osób z objawami napięcia psychicznego w porównaniu z włosami pobranymi od osób bez takich symptomów. Zawartość chromu i żelaza we włosach osób z objawami stresu była także wyższa, ale różnice nie były istotne w porównaniu z kontrolą.

Słowa kluczowe: włosy, stres psychiczny, pierwiastki śladowe, zagrożenie zdrowia.

INTRODUCTION

Rapid industrialization with discharges from metallurgical and chemical plants has redistributed many elements in the environment. Chemical and metallurgical plants in India continue to be among the world's top ten polluters. This has increased the risk of human exposure to toxic elements, in particular metals, through ingestion, inhalation, injection and absorption through exposed parts of the body. The level of these elements in humans can be determined by using human tissues as biopsy material (NOWAK, CHMIELNICKA 2000). Hair is easily available and gives significant information about element levels in the body as compared to other biopsy material (MEHRA, BHALLA 2000, MEHRA, JUNEJA 2003, SELA et al. 2007). Biomonitoring of hair in recent times has been gaining significance in various fields of science such as environmental science, medical science, forensic science and archaeological science (MEHRA, JUNEJA 2005 a,b,c, MEHRA et al. 2010 a,b, VALKOVIC, LIMIC 1986, POZEBON et al. 2008, DANIEL et al. 2004, DU et al. 1996, SEMPLE 2005). Accumulation of trace elements leads to various adverse effects on health of an organism. It is therefore desirable to evaluate the trace element concentrations, so that necessary measures can be taken to prevent the trace element pollution in the environment as also caused by undue exposure of human population to trace elements. This simple, non-invasive biopsy materials will help in identifying human populations in the environment at risk of elemental pollution so that necessary preventive actions can be taken (MEHRA, JUNEJA 2004, 2005 a,b,c,d, QUANDT et al. 2010, YORIFUGI et al. 2010).

Monitoring biological tissues is considered as an ideal step of integrated exposure monitoring for health risk assessment and also for use in forensic science (DANIEL et al. 2004). Human hair and nails are considered to be reliable indicators of elemental exposure including trace and toxic elements in natural and work environment and their concentration can be linked to parameters characterizing and conditioning human life such as nutrition, environment, race, health, age, sex etc. In occupational exposure, health aliments have been observed including neurological and respiratory problems such as fatigue, poor memory, dizziness, asthma and other risks (DURAND, WILSON 2006, MEHRA 2002, MEHRA, JUNEJA 2005 a,b,c, TELISMAN et al. 2001, CHIEN et al. 2010, FREIRE et al. 2010, GALLAGHER et al. 2010, ANDERSON 1986, GUSTAFSON et al. 2007).

The present study is a case control study in which workers of roadways workshops, locomotive workshops, and Pb-Cd battery units reporting mental stress were included as case subjects and without mental stress - as control subjects. In total, 40 subjects of the same age, sex and eating habits were included as subjects, among which 20 subjects were cases with mental stress and the other 20 subjects were controls without mental stress. Head hair samples were collected, which were analysed for concentration of lead (Pb), calcium (Ca), magnesium (Mg), chromium (Cr), manganese (Mn), iron (Fe), nickel (Ni), copper (Cu), and zinc (Zn). It was hypothesised that workers reporting mental stress have higher concentration of trace elements in their hair as compared to workers without mental stress. It was also the goal of this study to verify whether hair could be an indicator of health hazards caused by accumulation of trace elements. The main aim of this study is to identify a population at risk of exposure to trace and toxic elements in the environment. This study will also help in evaluating metal body burden and its relation to health.

MATERIAL AND METHODS

In the present study, workers of roadways workshop, locomotive workshop, and Pb-Cd battery units presenting mental stress and without mental stress were taken as subjects. A total of 40 subjects of the same age, sex and eating habits were included in this study. Out of these 40 subjects, 20 were cases complaining of mental stress and the remaining 20 were controls without mental stress. All the workers included in the study worked for 8 hours a day, six days a week. Head hair samples were personally collected from all subjects using stainless steel scissors and stored in airtight polythene bags. Other information about the subjects regarding the age, sex, occupation, nature of occupation, medical history etc. was obtained from a questionnaire recommended by the World Health Organisation, which was filled in while sampling.

Hair samples were cut into small pieces of 1 cm to make washing feasible. Pretreatment of hair samples was done to decontaminate them using non-ionic detergent (Triton X-100), acetone and deionised water and kept for drying at 110°C in an oven for one hour. Pretreated hair samples were then digested using nitric acid and perchloric acid in a 6:1 ratio in order to obtain colourless clear solution. The acid is now evaporated to obtain white residue, which was then dissolved in 0.1 N nitric acid (BABU et al. 2009, MEHRA, BHALLA 1996, MEHRA, JUNEJA 2003, 2004). The quantitative analysis of lead (Pb), calcium (Ca), magnesium (Mg), mangnese (Mn), nickel (Ni), copper (Cu), zinc (Zn), chromium (Cr) and iron (Fe) was performed in an Atomic Absorption Spectrophotometer (AAS) Perkin Elmer Model-5000 using air acetylene flame. Cathode lamps were used, set at different wavelengths separately for individual elements. The data thus obtained were then analysed to achieve mean standard deviation and the test of significance was performed using Student *t* test.

RESULTS

Mean and standard deviation of the level of all the tested trace elements in hair samples of workers with mental stress and controls have been calculated and summarized in Table 1. On applying student *t* test for significance, it was revealed that the concentration of Pb, Ca, Mg, Mn, Ni, Cu, and Zn in hair of subjects with mental stress differ significantly from the controls. However, concentration of Cr and Fe in hair of subjects with mental stress was found higher but this was not significantly different from the control subjects.

Table 1 reveals that the concentrations of all the nine elements in hair of subjects with mental stress are higher than in the hair of controls. I becomes evident from the given data that the case subjects are exposed to these elements at their work place and these elements are accumulated in their hair. Figure 1 summarises the total concentration of all nine elements in hair of subjects and controls. The sum of the total and mean concentration of all the nine elements in hair of subjects with mental stress and without mental stress was 3,349.84 mg g^{-1} and 2,078.95 μg g^{-1} respectively.

Table 1

Concentration of lead, calcium, magnesium, manganese, nickel, copper, zinc, chromium and iron in hair of workers with mental stress and controls

Trace Elements	Mental stress		Controls	
	range (μg g^{-1})	mean (±SD)	range (μg g^{-1})	mean (±SD)
Pb	6.58-22.91	19.33* (± 1.86)	3.12-13.43	10.91 (± 2.12)
Ca	1428.57-3458.42	2237.01* (± 738.07)	775.13-1963.64	1372.48 (± 584.60)
Mg	252.63-614.73	465.95* (± 201.39)	180.25-460.52	223.14 (± 86.06)
Mn	6.76-9.30	8.16* (± 1.01)	1.88-10.46	6.71 (± 2.34)
Ni	28.44-41.47	34.44* (± 3.28)	10.54-35.76	25.58 (± 13.85)
Cu	7.19-47.68	26.66* (± 15.03)	3.52-13.07	9.66 (± 4.55)
Zn	131.53-392.56	291.97* (± 96.13)	101.82-216.91	198.94 (± 50.37)
Cr	27.55-112.06	80.73 (±16.89)	18.11-85.70	65.90 (± 24.65)
Fe	104.57-255.43	185.59 (± 47.38)	77.23-210.72	165.63 (± 70.68)

*significant difference (P<0.05)

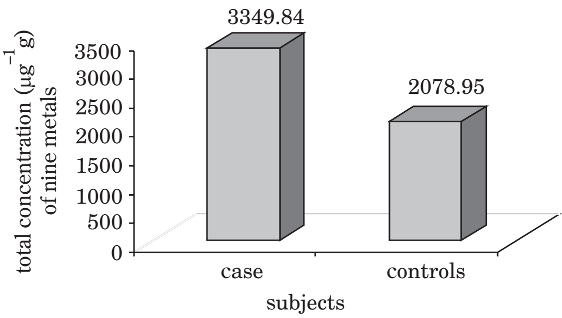

Fig. 1. Total concentration (μg g^{-1}) of all the nine metals under in hair of case and control subjects

DISCUSSION

Exposure to trace elements lead to their accumulation in the biological tissues, which evokes various adverse responses in organisms. The balance of trace elements in the body is very much required for proper functions of body systems. Any imbalance in the concentration of elements in the body leads to various disorders; likewise, maintaining a correct balance of trace elements is required in the body for the proper functioning of the nervous system. Various mental disorders relating to elements have been studied, as illustrated in Table 2.

Table 2

Different mental disorders related with elements

Disorder	Reason	Reference
Behaviour disturbances	elevated Cr, Mo, Pb depressed Co, Pb	Rimland et al. 1983
Learning disability	elevated Cd, Cu, Mg, Pb	Rimland et al. 1983
Mental retardation	elevated Pb depressed Na	Rimland et al. 1983
Behaviour problems	elevated Ab	Moon et al. 1986
Manic depression	elevated V	Naylor et al. 1984
Mental retardation (in children)	elevated Ca depressed Fe, Cu, Mg	Shrestha et al. 1988

The result of this work indicate that the concentrations of lead, calcium, magnesium, manganese, nickel, copper and zinc in scalp hair of workers with mental stress were significantly different from those without mental stress. Because both groups of workers – with and without mental stress – are from the same community, within the same age bracket, of the same sex and experienced similar socioeconomic conditions, the difference in hair trace elements between these two groups could not have resulted from these variables. It is clear that the difference in the lead, calcium, magnesium, manganese, nickel, copper and zinc concentrations in scalp hair of workers with mental stress and controls, being a significant one, is not accidental. The reported results support our finding that the level of elements affect the metal status in a human organism (Rimland, Larson 1983, Moon, Marlowe 1986, Naylor et al. 1984, Shrestha, Carrera 1988).

CONCLUSIONS

In this study, some trace elements in scalp hair of workers with mental stress showed quite a different pattern of concentrations than in controls, which indicates that such differences might be related to exposure to these metals. Although the levels of these elements in human hair are a function of many complex variables, as is also the cause of mental stress, information on some essential element imbalance might provide clues for further studies in this area.

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