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Human Hair Lead and Copper Levels in Three Occupationally Unexposed Population Groups in Calcutta

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The element lead (Pb) has been very widely studied in man due to its widespread occurrence and toxic effects. There is no known nutritional value of Pb and it is stored in the bone by replacing calcium. In the cellular level, Pb alters cell membrane structure and membrane ion function. It is a potent inhibitor of the Na+ K+ ATPase. Pb also interferes with the activity of the enzymes delta-aminolevulinic acid synthetase, delta-aminolevulinic dehydrase and intra-mitochondrial ferrochelatase. In the pre-natal level, Pb-exposure may lead to an increased risk of prematurity and reduction of gestational age in humans. Pb-exposure causes adverse neuro-psychological effects among young children and numerous endrocrinal disturbances among adults. It has been shown that Human Scalp Hair (HSH) Pb concentration can be used very successfully to document population exposure to this toxic element (Wilhelm et a1.1994).

Copper (Cu) is known to be biologically an essential element. Apart from playing a vital role in heme formation, it forms a major constituent of many important enzymes such as tyrosinase, cytochrome oxidase and lysyl oxidase. Since Cu is an essential element, HSH Cu levels may provide an indication of the nutritional status of a group of individuals (Gibson et a1.1985). Cu-poisoning is rare in humans, though, excess Cu causes certain hepatotoxic and nephrotoxic effects.

A detailed computer literature search revealed dearth of studies in the field of HSH trace elements in India. There are a limited number of studies on clinical science, occupation and environmental exposure (Sukumar and Subramanian 1992a,1992b,1992c; Chatterjee et a1.1993). In the major cities of India, the continued use of leaded-gasoline and Pb-based paints have led to

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widespread exposures to Pb. A glaring instance is the city of Calcutta. The city has built up an increasingly large amount of suspended particulate matter, such as Pb in the form of tetraalkyl-Pb, and polynuclear aromatic hydrocarbons in the air (Das et a1.1993).

Given above, in the present study an attempt has been made to document exposure and to determine "base-line" values for HSH Pb and Cu among three occupationally unexposed population groups in Calcutta.

MATERIALS AND METHODS

Scalp hair samples were collected from 125 adult male individuals (age group 25-35 years) belonging to the Bengalee Hindu Caste Population. The individuals were inhabitants of Jadavpur (southern Calcutta), Rajabazar (northern Calcutta) and Batanagar (south-western Calcutta) and occupationally unexposed to Pb and Cu. The hair samples were snipped with clean stainless steel scissors from the nape of the neck, and the proximal 5 cms were collected. Approximately 500 mg of hair was sampled from each individual and sealed in cellophane envelopes prior to analysis. The HSH samples were washed using a non-ionic detergent (Extran MAO3, #7550) and acetone (#14), with some suitable modifications of the methods of Harrison et al. (1969) and Jamall and Jaffer (1987). After drying, the HSH samples were weighed (dry weight: 200-500 mg) and were subsequently wet-digested in nitric and perchloric acids (#444 and #519) following the method of Harrison et al. (1969). All the reagents were manufactured by E.Merck (India) Limited. The glassware used for washing and digest ion of the samples, and the plastic vials used for storing the digested solutions after dilution were soaked in nitric acid for at least 24 hours and rinsed in double distilled water prior to use. After suitable dilutions, the Pb and Cu concentrations were determined by flame atomic absorption spectrophotometry (Varian, model AAS-575-ABQ). Standards manufactured by Johnson Matthey Materials Technology were used for the determination of the standard curves for these two elements.

The statistical computations were done using Minitab (version 6.1). One-way analysis of variance (ANOVA) was used for comparison among the three population groups with respect to HSH Pb and Cu concentrations. Further, correlation coefficients were calculated to examine relationships between HSH Pb and Cu concentrations among the three population groups under study.

RESULTS AND DISCUSSION

The means (AM), standard deviations (s.d), standard errors of means (s.e. mean) and ranges of the Pb and Cu concentrations in the scalp hair among the individuals of the three areas are given in Table 1. The individuals of Rajabazar showed elevated hair Pb concentrations (6.91 ug/g) as compared to those of the other two areas, Jadavpur (4.52 ug/g) and Batanagar (3.48 ug/g). The report of the German Federal Health Agency has indicated that hair Pb levels over 20.00 ug/g are to be considered critical (Krause and Chutsch 1987). However, the means of HSH Pb concentrations obtained in the present study were more than three times lower than this critical value of 20.00 ug/g. The mean HSH Cu concentrations were 8.04 ug/g, 9.38 ug/g and 11.34 ug/g for the samples from Jadavpur, Batanagar and Rajabazar respectively. The concentrations of HSH Pb and Cu in the present study were in agreement with reported values obtained from other populations that were not occupationally-exposed to Pb (Sukumar and Subramanian 1992a,1992b; Leotsinidis and Kondakis 1990; Wilhelm et al.1991). A very high concentration of HSH Cu (mean: 30.70 uq/q) was recorded by Jamall and Allen (1990) among Karachi women. Sukumar and Subramanian (1992a) also reported a high HSH Cu concentration (mean: 54.50 ug/g) on Indian men. However, in a later study, Sukumar and Subramanian (1992c) noted a lower value of 10.20 ug/g. These differences are difficult to comprehend at present, with possible reasons being the nature of the samples, location of sample collection and methods of washinq and analysis in the studies of Jamall and Allen (1990) and Sukumar and Subramanian (1992a). The distributlons of both HSH Pb and Cu concentrations in this study were seen to be log-normal, thereby agreeing with other studies like that of Wilhelm et al. (1991).

Age and sex are two variables that influence HSH trace element concentrations. In this study, the effects of age and sex on HSH Pb and Cu concentrations have been controlled by taking a small age-range of ten years of the individuals included and they belong to one sex i.e. male only.

Using ANOVA, statistically siqnificant F values of 13.36 and 24.03 ($p<0.05$) have been obtained for both Pb and Cu respectively. Hence, differences existed between individuals of these three areas of Calcutta with respect to these elements. It has been reported that the levels of Pb, Pb-compounds and other pollutants vary from area to area in Calcutta (Das et a1.1993). The locality of Rajabazar is situated more towards the heart of the city, followed by Jadavpur and Batanagar.

Table 1. Arithmetic means, standard deviations (s.d), standard errors of the means (s.e.mean) and ranges of HSH Pb and Cu levels among the individuals in the three areas of Calcutta (all values in ug/g; N denotes number of individuals).

	AREA					
	JADAVPUR		RAJABAZAR		BATANAGAR	
	Pb	Cu	Pb	Cu	Pb	Cu
N	50	50	50	50	25	25
AM	4.52	8.04	6.91	11.34	3.48	9.38
s.d	2.92	4.02	3.04	1.81	0.81	2.31
s.e mean	0.41	0.57	0.43	0.26	0.16	0.46
range	0.11-12.10	3.50-21.40	2.60-19.16	6.29-14.87	2.10-4.90	6.50-15.10

Hence, the individuals residinq in Rajabazar are more exposed to environmental-Pb followed by their counterparts in Jadavpur and Batanagar. The hair samples under study were collected from lndividuals occupationally not exposed to Pb and the effects of age and sex, if any, have also been controlled. Hence the difference in HSH Pb concentration may be attributed to the difference in the level of this element in the environment, and thus, to exposure. So, evidently the residents of Rajabazar have more concentration of Pb in their scalp hair than those of Jadavpur and Batanagar. Jamall and Allen (1990) found two cases of very high blood Pb in Karachi (21.90 ug/100ml and 31.40 ug/100ml). They further observed that in Karachi, 50% of the women have a hair Pb concentration of over 25.00 ug/g and thus, showed that high blood Pb levels were associated with high hair Pb levels. Samanta (1992) reported high blood Pb levels of 21.00 ug/100ml among the residents of Calcutta. Both Karachi and Calcutta being two sprawling metropolises with very high degrees of Pb pollution (Jamall and Allen 1990; Das et a1.1993), it was expected that hair Pb concentrations in Calcutta to be around 25.00 ug/g. But not a single individual in the present study showed a hair Pb concentration exceeding 25.00 ug/g. The highest obtained was 19.16 ug/g, expectedly from Rajabazar. The differences in HSH Cu levels between the three areas

cannot be solely attributed to environmental exposure. It has been reported that high HSH Cu concentrations indicate a higher nutritional status and the nature of the diet of the individuals concerned. Weir et al. (1988) showed that high HSH Cu is indicative of a non-vegetarian diet. The differences in HSH Cu concentrations in the present study could, therefore, be attributed to any or all of the above three factors. This study further indicated that the levels of HSH Pb and Cu varied from one area to another, even though the individuals were occupationally unexposed to these elements. Hence, "base-line" values for such individuals could not be estimated. At best a range of values were available, taking the three areas under consideration.

The correlation coefficient 'r' between HSH Pb and Cu concentrations among the three population groups under study were 0.06 ($p>0.05$), 0.54 ($p<0.05$) and 0.17 ($p>0.05$)) for Jadavpur, Batanagar and Rajabazar respectively. A high positive correlation between hair Pb and Cu concentrations was reported by Leotsinidis and Kondakis (1990), while Wilhelm et a1. (1991) found a low positive correlation. No possible explanations for the correlations were advocated by these researchers. The reason of both Pb and Cu being metals and that all metals are bound to hair keratin, can partly account for this correlation. But more studies are needed in this regard as Pb is a toxic element and Cu is a metabolically essential element.

The results in the present study were in broad agreement with similar studies worldwide. Human scalp hair is in a position to screen for environmental Pb exposure in Calcutta. However, as no single cause could be attributed to explain the differences in hair Cu concentrations, future studies should focus on the nutritional status and diet of the individuals under study.

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