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Age and Sex Dependence of Copper, Nickel, Lead and Zinc Levels in Scalp Hair of Urban Pakistani Population

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Human hair has been employed extensively in the study of environmental expsure to toxic metals [1-3] and in the assessment of body nutritional status of several essential metals [4,5]. The scalp hair has been suggested as a valuable tissue for recording the levels and changes in concentration of many trace metals in the body over a long period of time [6,7]. The age and sex dependence of trace metal concentrations in human hair is also well documented [8-10] in addition to site specificity and pollution status assessment [5,10].

In the present study levels of two essential (Cu and Zn) and two non-essential (Pb and Ni metals were estimated in scalp hair of a typical urban segment of population ranging in age from 2 to 60 years, using the atomic absorption method. The objective of the study was two-fold: firstly, to evolve a base-line trace metal data on the nutritional status of local urban population and, secondly, to evaluate the dependence of hair trace metal concentration on the age and sex of donors. Also, the study would be helpful towards assessing the probable environmental pollution impact on local population, providing possibility of coordination with other similar studied aimed at evolving future strategy for better public health. The inter-metal concentration correlation with age and sex was investigated statistically through the MSTAT package run on an NEC computer. The results of the study are compared with those reported in literature for the hair samples of people living in other part of the world.

The male/female scalp hair samples were obtained from local hair dressing saloons of Islamabad and Rawalpindi according to the sampling procedure [9]. For various ages of donors, a total of 61 female and 60 male hair samples were arranged. For each sample the hair were cut into centimeters length, washed with 1% detergent solution and rinsed thoroughly with distilled water. After drying the washed samples overnight in an electric oven at 80°C, 0.50g of specimens of a given samples were weighed in triplicate and treated separately with 5.0 ml of 65% nitric acid at room temperature in an Erlenmayer flask. The content of each flask was then heated to about 60°C and treated with 1.5 ml of perchloric acid, until white fumes were evolved. The clear digest was diluted with 5% nitric acid [7] to 25.00 ml and was aspirated for the determination of the selected metals. A Hitachi atomic absorption spectrophotometer, model 170-10 was used throughout this work. Spectroscopic grade chemicals (purity >99.9%) were used for the preparation of standards.

Metal concentrations in hair of male and female donors are listed in Table 1, averaged for triplicate subsamples for which the results mostly agreed within ±1.5%. The data reflects mostly the maximum frequency of sampling for the 21-27 year age group of males, and 25-29 year age group of females. As there is no clear correlation between metal concentration and age of either sex (Table 1), the mean concentrations of the metals (Cu, Zn, Ni and Pb) are reported along with necessary statistical parameters in Table 2 to see if a normal distribution pattern exist for these metals in the hair of male and female donors. The data in Table 1 indicated random variation in the levels of both essential (Cu and Zn) and non-essential (Ni and Pb) metals,a fact duly supported by relatively larger ± SD values, followed by skewness factors which have substantial magnitude for Ni and Pb, reflecting their random distribution in hair. The Kurtosis factors were observed to be high for these metals, marking a wider spread around the mean concentrations values. The data of Table 1 and 2 suggested relatively small variation in the levels of the two essential while larger variations were observed for the non-essential metals, in the hair samples of both sexes. The significance of this incidence could be attributed to the body burden and subsequent balance of essential and non-essential metals in human body, defined by metabolic processes [11].

The distribution of metal levels in the hair of both sexes indicated that the following order of decreasing metal concentration existed, irrespective of the sex; Zn>Cu>Pb>Ni. However, the male hair had, in general, higher concentration of Cu and Zn, while the converse situation existed for Ni and Pb. This indicated a distinct individual variability towards the levels of essential and non-essential metals in the male and female hair. Highest average Pb content (26.9 9mg/kg) was found in the hair samples collected from 3 electronic engineers, working in a typical repair/maintenance shop. Perhaps the elevated metal concentration emerged from Pb fumes from the solder. Similarly, highest average Ni content (11.2 mg/kg) was found in hair of five members of a family using hydrogenated oil in their food over the last several years. Also, the highest average Pb content (44.0 mg/kg) was found in the hair of a female donor who claimed a more frequent use of an "eye darkener" preparation, which was found to contain about 40% Pb. These find-

TABLE 1. AVERAGE METAL CONCENTRATIONS (µg/g; DRY WEIGHT) IN MALE AND FEMALE HAIR AS A FUNCTION OF NUMBER (N) AND AGE OF DONORS

	Male Group							Female Group					
Sample No.	N	Age	Cu	Zn	Ni	Pb	Sample No.	N	Age	Cu	Zn	Ni	Pb
1	1	3	6.2	130	1.7	10.0	1	2	2	11.3	195	3.3	2.6
2	1	4	3.7	150	4.0	6.2	2	1	4	12.5	119	1.9	7.5
3	2	6	4.6	94	2.3	8.8	3	1	5	12.5	180	1.2	12.5
4	2	8	7.5	108	4.0	8.7	4	3	7	10.2	142	6.8	4.6
5	1	11	7.5	120	2.7	6.9	5	2	8	16.3	210	0.3	2.6
6	2	14	8.5	119	5.3	5.5	6	2	10	7.8	178	1.1	4.7
7	4	17	9.0	98	2.2	7.5	7	3	11	10.4	197	0.9	3.4
8	2	18	6.3	90	7.7	1.2	8	3	12	12.1	293	0.6	5.4
9	1	19	7.5	120	2.8	6.9	9	1	13	13.7	200	2.6	7.5
10	5	20	7.1	105	11.2	6.4	10	1	14	10.0	250	1.4	N.D.
11	5	21	5.5	123	2.4	8.2	11	1	16	12.5	120	1.2	5.0
12	3	22	10.9	120	3.0	9.2	12	3	17	7.5	202	1.2	3.4
13	6	23	10.2	119	2.0	4.7	13	1	19	10.0	118	2.4	1.3
14	4	24	7.5	133	2.2	4.1	14	4	21	11.4	168	4.1	12.7
15	2	25	7.9	113	1.7	4.4	15	4	22	15.6	223	1.7	3.3
16	4	26	9.7	102	3.1	5.4	16	1	24	8.8	165	1.0	3.2
17	3	27	10.1	120	4.2	5.4	17	1	27	15.0	300	5.1	1.2
18	2	28	6.9	80	1.7	3.2	18	3	28	13.2	272	3.0	2.4
19	1	29	6.3	110	1.7	3.7	19	2	30	13.8	219	2.0	9.4
20	1	30	11.0	86	2.2	26.9	20	4	31	10.0	220	1.4	0.6
21	3	32	6.6	83	2.4	1.2	21	7	33	7.5	337	1.4	8.7
22	1	34	5.0	114	3.3	6.6	22	4	35	12.1	180	1.1	3.4
23	2	38	6.9	120	1.7	1.2	23	2	36	10.9	226	1.7	14.4
24	1	40	7.5	108	1.4	10.0	24	1	40	16.3	238	0.7	1.9
25	2	60	7.5	100	3.3	5.6	25	1	41	7.5	150	2.4	3.8
-	-	-	-	-	-	-	26	1	42	13.7	220	1.7	3.8
-	-	-	-	-	-	-	27	3	45	12.1	142	2.3	4.7
-	-	-	-	-	-	-	28	1	46	11.2	250	1.7	1.3
-	-	-	-	-	-	-	29	1	49	7.5	150	1.2	1.3
-	-	-	-	-	-	-	30	1	50	11.2	215	1.3	44.0

ings revealed that occupational exposure, food habits and status of personal hygiene and care plans do have impact on the levels of the respective metals in human hair [12].

The metal-to-metal, sex-based correlation data appear in Table 3, indicating a positive, but weak, correlation between Zn and Cu concentrations in the female hair; for the male two pairs of slightly significant correlations were obtained between Zn and Pb ($r<0.500$) at $p=0.001$). These correlations, although not very significant, suggested that the origin of essential an non-essential metals in relation to their distribution in hair of the two sexes were distinctly different. Therefore, the role of the environment in defining the metal distribution in human hair cannot be overemphasized in addition to other factors such as habitat socioeconomic background of the individuals. the regression analysis (Table 4) evidenced a marginal positive age-dependence of Cu in the male hair, and a relatively stronger age-dependence of Zn and Pb in the female hair. This revealed that the local females are more prone to domestic and environmental effects, in agreement with an earlier finding [13].

TABLE 2. CONCENTRATION OF SELECTED METALS IN MALE/ FEMALE SCALP HAIR ALONGWITH RELEVANT STATISTICAL PARAMETERS.

Sex	Min.	Max.	Mean	Variance	±SD	Skewness	Kurtosis
Male	3.70	11.0	7.56	3.25	1.80	0.245	-0.012
	80.0	150.0	110.8	274.0	16.55	0.0507	0.1473
	1.40	150.0	3.20	4.68	2.16	2.600	7.680
	1.20	26.9	6.71	24.2	4.92	2.924	12.009
Female	7.50	16.3	11.48	6.63	2.57	0.0918	-0.5711
	118.0	337.0	201.9	2871	53.59	0.448	0.1303
	0.30	6.80	1.95	1.88	1.37	2.015	4.7937
	0.60	44.0	6.22	65.93	8.12	3.863	17.491

The present data on the levels of Cu,Zn, Ni and Pb in female/male hair of donors belonging to the local population compared well with those given in literature for donors be-

TABLE 3. METAL-TO-METAL CORRELATION COEFFICIENT FOR MALE AND FEMALE HAIR METAL CONTENT.

Male / Female	Cu	Zn	Ni	Pb
Cu	1.00	0.197	0.036	-0.026
Zn	0.082	1.00	-0.086	0.041
Ni	-0.231	-0.064	1.00	-0.061
Pb	-0.050	-0.113	-0.135	1.00

TABLE 4. REGRESSION ANALYSIS OF MALE/FEMALE (M/F) AGES AS RELATED TO METAL CONCENTRATION*

Sex	Metal	Regression Analysis
Male	Cu	[Cu] = 0.009 x M + 7.34
	Zn	[Zn] = -0.488 x M + 122.47
	Ni	[Ni] = -0.029 x M + 3.91
	Pb	[Pb] = -0.029 x M + 7.42
Female	Cu	[Cu] = -0.014 x F + 11.83
	Zn	[Zn] = 0.649 x F + 185.79
	Ni	[Ni] = -0.014 x F + 2.29
	Pb	[Pb] = 0.160 x F + 2.19

* [ ] = PPM

longing to various parts of the world. Our average hair copper levels were identical to those reported as 9.42 and 10.7 mg/kg for the counterpart from Poland and Japan ; zinc and nickel levels to those as 124 and 114 mg/kg for USA and Japan and lead levels to those reported as 5.38 and 5.35 mg/kg for Canada and USA[14]. Other supporting data also appear in literature [15,16,17]. In conclusion, the present study showed difference for trace metals in hair of male and female donors; the observed differences, however, might have resulted due to cumulative effects arising from dietary and environmental factors. Even with a limited data body, the study showed that scalp hair could be used as an indicator of community exposure to trace metals.

Key words: Hair analysis. Trace metals in hair. Age/sex dependence.

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