0163-4984/92/3401-0089 $02.00

Elements in Hair and Nails of Urban Residents of New Delhi

CHD, Hypertensive, and Diabetic Cases

A. SUKUMAR AND R. SUBRAMANIAN*

School of Environmental Sciences, Jawaharlal Nehru University, New Delhi-110 067, India

Received April 15, 1991; Revised June 11, 1991; Accepted August 2, 1991

ABSTRACT

The concentrations of Cd, Cr, Cu, Mn, Ni, Pb, and Zn were estimated in hair and nails of urban residents of New Delhi. Particularly, hair levels of Cu and Mn in hypertensive males, Cr and Zn in hypertensive females, and Zn in CHD and diabetic females, and nail levels of Zn in CHD and hypertensive females were significantly lower than controls. Thus, it is observed that there exists some positive correlation between element levels in hair and nails and CHD, hypertension, and diabetes of these subjects.

Index Entries: Elements; hair; nail; coronary heart disease (CHD); hypertension; diabetes.

INTRODUCTION

There are two general classes of abnormalities associated with trace elements: specific deficiency arising from dietary inadequacies or imbalances and accumulation of innate or toxic elements from the environment, which can either displace essential elements from their metabolically active sites and cause conditioned deficiency or act directly as cellular toxins. Both kinds of abnormalities can be diagnosed by analysis of trace elements in hair and nails, and the levels of elements can be correlated with disease (*1,2*).

*Author to whom all correspondence and reprint requests should be addressed.

In many studies, hair as one of the biological samples was analyzed for the levels of Cd, Cu, and Zn in hypertensives (*3,4*). Zn and Cu in survivors of myocardial infarction (*5*), Cd in hypertensives (*6,7*), and Cr in diabetic children (*8*). Further, it is reported that trace elements may have direct or indirect effects on one or more risk factors of CHD. These include effects on hypertension, circulatory lipid, lipoprotein levels, and diabetes. Klevay (*9*) and Masironi (*10,11*) reported that an imbalance of trace element metabolism may be involved in the etiology of CHD. In the present study, the samples of hair and nails were collected at the time of the epidemiological survey mainly from CHD, hypertensive, and diabetic residents of three selected urban areas of New Delhi, and analyzed for the levels of Cd, Cr, Cu, Mn, Ni, Pb, and Zn to find the relationship, if any, with these diseases.

MATERIALS AND METHODS

A random sampling of hair and nails was conducted in 1987 during a house-to-house survey of the residents of three urban areas of New Delhi: South Extension, Defence Colony, and Safdarjung Enclave, following the methods of the WHO (*12*). Along with the samples of hair and nails, the data regarding the personal characteristics of the donors were obtained by filling out a questionnaire. It was very difficult to define the condition of the normal subjects. They might be free from a polluted environment and be without deficiency of essential elements. There was inadequate evidence, first, a random sampling of hair and nails was collected from the residents of these three places with subsequent analysis of homogeneity of sampling and, then, such population was sorted into different subgroups, viz., controls and cases of CHD, hypertension, and diabetes.

Both the controls and subjects were from nonindustrial workers, such as officers of different positions, and had no possible element exposure from the known sources. Subjects with occupations in industries were not included in this study. The controls and cases were clinically identified with the help of medical doctors from the Sitaram Bharatya Medical Research Institute, New Delhi.

The samples of hair and nails were personally collected in separate polythene bags from the same subjects at their residences using clean stainless-steel scissors and nail clippers. Scalp hair was cut from the distal portion of the strand in the nape of males and females, since they were reluctant to cut their hair close to the scalp. Dyed hair and polished nails were not sampled.

Before washing, the nails were scraped with a clean stainless-steel scalpel to remove the external filth, adopting the method of Vance et al. (*13*), and both the hair and nail samples were subjected similarly to methods reported for washing, digestion, and element estimation (*14–*

16). The levels of Cd, Cr, Cu, Mn, Ni, Pb, and Zn were determined by an Instrumentation Laboratory AAS, Model 457. Considering the importance of analytical quality assurance reported earlier (*17*), a Certified Reference Material (CRM), human hair powder (NIES, Japan) was employed, and the observed values of elements of CRM were found to agree with the reported values for these elements.

RESULTS

In the present study, element levels in hair and nails of controls and subjects were separately analyzed for both sexes. Similarly, subjects were grouped into different subgroups with a possible combination of CHD, hypertension, and diabetes, and in such subgroups, concentrations of elements were shown.

In Table 1, hair element concentrations were compared between the male controls and subjects. Particularly, the levels of Cu and Mn were significantly lower in the hypertensives and total hypertensives than controls, but Cd level was higher in CHD subjects when compared to that of hypertensives.

In Table 2, hair element levels were compared between the female controls and subjects. Mainly, the levels of Cr and Zn in the hypertensives and total hypertensives and Zn in the females with CHD and hypertension, total CHD, and total diabetes were lower than controls.

Similar to hair element levels, nail element levels were compared and found insignificant between male controls and subjects (Table 3). When nail element levels were compared between female controls and subjects (Table 4), however, Zn levels alone were found higher in the hypertensive, total hypertensive, and total CHD cases than controls.

DISCUSSION

Element levels observed in hair of Delhi controls were consistent with previous reports (*5,18,19*), and also differed from the reported values of Cd and Zn (*3*). Hair levels of Cd (7.9 ± 1.9), Pb (53 ± 12), and Zn (251 ± 48), which were reported higher in hypertensives than normotensive adult black females (*20*), were higher when compared to the values of Delhi subjects. The Zn level (158 ± 5), which was observed to be higher in 29 male survivors of myocardial infarction than 23 controls (133 ± 34) from Warsaw (*5*), was lower, however, than the values of Delhi subjects.

Several investigations reported hair element status that was specific and significant to particular cases. Hair levels of Cd in hypertensive adult black females and males and babies of hypertensive mothers were higher (*5,7,20*), whereas no difference was observed in the hair level of Cd

Table 1
Correlation of Hair Element Levels Between Male Controls and Cases of CHD, Hypertension, and Diabetes from Urban New Delhi

S1 No.	Male subjects	n^a	Mean concentrations of elements, ppm ± SE, in hair						
			Cd	Cr	Cu	Mn	Ni	Pb	Zn
1	Controls	25	0.8 ± 0.2	2.7 ± 0.4	52.1 ± 11.2	7.8 ± 1.1	3.6 ± 0.5	8.5 ± 1.9	202.5 ± 16.8
2	CHD	12	1.1 ± 0.5	2.1 ± 0.5	35.1 ± 6.8	5.1 ± 1.2	2.8 ± 0.5	20.8 ± 8.5	182.1 ± 37.7
3	Hypertension (HT)	24	0.4 ± 0.08[d]	1.7 ± 0.4	24.5 ± 3.7[c]	1.9 ± 0.4[e]	2.8 ± 0.5	11.8 ± 3.2	172.7 ± 21.2
4	Diabetes (diab.)	1	0.3	0.8	38.3	NA	1.87	4.5	107.83
5	CHD and HT	10	0.8 ± 0.1	2.7 ± 0.8	26.0 ± 4	4.7 ± 0.7	4.7 ± 1.4	6.7 ± 1.6	202.5 ± 36.4
6	HT and diab.	1	1.67	5.53	29.98	NA[b]	4.76	3.57	124.2
7	CHD, HT, and diab.	2	0.4 ± 0.07	2.4 ± 1.8	29.5 ± 6.5	NA[b]	3.6 ± 0.07	11.8 ± 6.7	129.2 ± 13.2
8	Total CHD (2,5,7)	24	0.9 ± 0.2	2.4 ± 0.5	30.9 ± 3.8	4.9 ± 0.8	3.6 ± 0.7	14.2 ± 4.4	186.2 ± 23.9
9	Total HT (3,5–7)	36	0.5 ± 0.08	2.0 ± 0.4	25.2 ± 2.8[d]	2.5 ± 0.4[e]	3.4 ± 0.5	10.4 ± 2.2	178.6 ± 17.4
10	Total diab. (4,6, and 7)	4	0.7 ± 0.3	2.8 ± 1.2	31.9 ± 3.4	NA[b]	3.5 ± 0.6	7.9 ± 3.5	122.6 ± 7.8

[a] n = Number of samples.
[b] NA = not analyzed.
[c] Significance between controls and subjects $P < 0.05$.
[d] Significance between case of CHD and HT $P < 0.05$.
[d] $P < 0.02$.
[e] $P < 0.01$.

Table 2
Correlation of Hair Element Levels Between Female Controls and Cases of CHD, Hypertension, and Diabetes from Urban New Delhi

S1 No.	Female subjects	n^a	Mean concentrations of elements, ppm ± SE, in hair						
			Cd	Cr	Cu	Mn	Ni	Pb	Zn
1	Controls	85	0.9 ± 0.09	2.8 ± 0.2	54.5 ± 5.4	5.0 ± 0.3	4.9 ± 0.5	13.7 ± 1.7	229.5 ± 11.2
2	CHD	3	0.9 ± 0.3	1.9 ± 0.8	31.2 ± 18.3	9.1 ± 1.5	4.6 ± 0.8	6.3 ± 3.2	208.3 ± 30
3	Hypertension (HT)	67	0.7 ± 0.08	1.8 ± 0.1[e]	40.9 ± 5.3	5.1 ± 0.4	3.5 ± 0.3	12.1 ± 1.7	183.3 ± 14.5[d]
4	Diabetes (diab.)	2	0.6 ± 0.1	0.8 ± 0.01	22.4 ± 11	10.4 ± 3	0.4 ± 0.3	17.1 ± 1.7	181.2 ± 12.3
5	CHD and HT	11	0.4 ± 0.09	1.6 ± 0.3	69.1 ± 16.3	4.8 ± 0.2	4.6 ± 0.8	15.5 ± 5	139.0 ± 33.7[d]
6	HT and diab.	8	0.7 ± 0.3	2.6 ± 1	37.5 ± 11.2	4.9 ± 0.6	3.5 ± 0.7	11.4 ± 2.4	182.7 ± 45.9
7	CHD and diab.	2	0.3 ± 0.1	1.7 ± 1.2	29.4 ± 14.9	NA[b]	4.9 ± 0.9	2.0 ± 0.3	133.2 ± 8.5
8	CHD, HT, and diab.	3	0.6 ± 0.1	1.8 ± 1.2	56.2 ± 11.7	NA[b]	5.1 ± 1.9	8.2 ± 4.3	212.2 ± 47.4
9	Total CHD (2,5,7, and 8)	19	0.5 ± 0.09	1.7 ± 0.2	56.9 ± 10.4	6.2 ± 0.6	4.7 ± 0.6	11.5 ± 3.1	160.9 ± 26.6[d]
10	Total HT (3,5,6, and 8)	89	0.6 ± 0.07	1.9 ± 0.2[e]	44.7 ± 5	5.0 ± 0.3	3.7 ± 0.3	12.3 ± 1.5	178.8 ± 12.5[c]
11	Total diab. (4,6,7, and 8)	15	0.8 ± 0.2	1.1 ± 0.7	38.2 ± 6.9	6.3 ± 0.8	3.6 ± 0.6	10.3 ± 2.5	168.5 ± 28.6[c]

[a] n = Number of samples.
[b] NA = not analyzed.
[c] Significance $P < 0.05$.
[d] Significance $P < 0.01$.
[e] Significance $P < 0.005$.

Table 3
Correlation of Nail Element Levels Between Male Controls and Cases of CHD, Hypertension, and Diabetes from Urban New Delhi

S1 No.	Male subjects	n^a	Mean concentrations of elements, ppm ± SE, in nails						
			Cd	Cr	Cu	Mn	Ni	Pb	Zn
1	Controls	24	1.1 ± 0.2	0.9 ± 0.1	18.4 ± 2.3	1.7 ± 0.2	1.9 ± 1	9.0 ± 1	241.1 ± 19
2	CHD	2	1.4 ± 1	0.9 ± 0.1	5.5 ± 1.7	3.5 ± 2	2.9 ± 2	8.1 ± 4.5	184.2 ± 45
3	Hypertension (HT)	19	1.4 ± 0.3	1.4 ± 0.4	26.9 ± 9	2.8 ± 0.4	3.5 ± 2	8.3 ± 1.6	217.7 ± 28
4	Diabetes (diab.)	2	0.4 ± 0.1	0.6 ± 0.4	62.3 ± 47	1.8 ± 0.4	4.5 ± 4	4.0 ± 2.5	155.0 ± 12
5	CHD and HT	5	1.7 ± 0.6	0.7 ± 0.2	18.2 ± 11	1.7 ± 0.6	2.1 ± 1	9.5 ± 3	284.5 ± 19
6	CHD and diab.	2	2.2 ± 0.9	0.4 ± 0.1	7.7 ± 0.9	3.0 ± 2	0.8 ± 1	5.9 ± 0.5	299.8 ± 6
7	HT and diab.	1	0.4	0.5	18.5	2.3	0.7	7.5	134.8
8	CHD, HT, and diab.	1	0.4	0.5	28.4	3.4	0.7	7.5	121.7
9	Total CHD (2,5,6, and 8)	9	1.1 ± 0.3	0.7 ± 0.6	14.1 ± 5	2.6 ± 0.6	1.8 ± 0.5	8.7 ± 1.5	247.5 ± 24
10	Total HT (3,5,7, and 8)	25	1.4 ± 0.3	1.2 ± 0.3	25.3 ± 6	2.6 ± 0.3	3.0 ± 1	8.4 ± 1	221.3 ± 17
11	Total diab. (4,6,7, and 8)	6	1.0 ± 0.4	0.5 ± 0.1	31.1 ± 16	2.6 ± 0.8	2.6 ± 1	5.6 ± 0.8	194.3 ± 33

[a] n = Number of samples. No significance between any element levels of controls and subjects.

Table 4
Correlation of Nail Element Levels Between Female Controls and Cases of CHD, Hypertension, and Diabetes from Urban New Delhi

Sl No.	Female subjects	n^a	Mean concentrations of elements, ppm ± SE, in nails						
			Cd	Cr	Cu	Mn	Ni	Pb	Zn
1	Controls	34	1.2 ± 0.2	0.9 ± 0.1	27.9 ± 4	3.6 ± 0.4	2.7 ± 0.4	15.4 ± 2	287.6 ± 14
2	CHD	1	0.7	1.0	24.7	1.6	5.3	5.0	104.4
3	Hypertension (HT)	13	1.1 ± 0.3	1.2 ± 0.3	25.5 ± 6	3.9 ± 0.6	2.9 ± 0.7	9.4 ± 2	208.2 ± 35[c]
4	CHD and HT	3	2.2 ± 0.5	0.7 ± 0.01	18.4 ± 6	7.1 ± 1	3.6 ± 1	15.2 ± 4	194.3 ± 94
5	CHD and Diabetes (diab.)	2	0.8 ± 0.3	0.3 ± 0.07	6.1 ± 1	1.4 ± 0.1	2.2 ± 0.1	3.5 ± 3	253.4 ± 75
6	HT and diab.	1	1.1	0.3	3.9	4.3	1.6	10.6	304.3
7	Total CHD (2,4, and 5)	6	1.6 ± 0.4	0.6 ± 0.08	15.4 ± 4	4.2 ± 1	2.8 ± 0.6	11.0 ± 3	189.5 ± 60[b]
8	Total HT (3,4, and 6)	17	1.3 ± 0.2	1.1 ± 0.2	22.3 ± 3	4.6 ± 0.5	3.0 ± 0.5	10.5 ± 2	209.1 ± 31[c]
9	Total diab. (5 and 6)	3	0.9 ± 0.5	0.3 ± 0.07	5.3 ± 1	2.3 ± 1	1.9 ± 0.2	5.9 ± 3	270.4 ± 80.9

[a]n = Number of samples.
[b]Significance $P < 0.02$.
[c]Significance $P < 0.01$.

between hypertensives and normotensives (*3*). Cr levels in hair of severe Cr-deficient females and insulin-requiring diabetic children were lower than controls (*8,21*). The hair levels of Cu were not significantly different among controls, hypertensives, and male survivors of myocardial infarction (*3,5,18,20*). A decrease in myocardial concentration of Mn in infarcted subjects and increased Pb hair level in adult black hypertensives of Mississippi and survivors of myocardial infarction (*5,7,22*) were observed, whereas an insignificant level was found between hypertensives and normotensives (*3*). In our study, lower levels of elements, particularly, hair Cu and Mn in male hypertensives, hair Cr and Zn in female hypertensives, nail Zn in female hypertensives, and hair and nail Zn in female CHD and diabetes, were observed, when compared with the controls.

Many reports correlated the change in hair element status with human diseases. Schroeder and Nason (*23,24*) reported that deficiency of Zn and excess of Cd may cause arterial hypertension, and that deficiency of Zn and excess of Mn, Ni, and Cu may cause myocardial infarction. Tissue and hair Cd levels are associated with death resulting from heart disease and systolic blood pressure (*25–28*). Low Cu level is possibly associated with the development of atherosclerosis (*29*). Vivoli et al. (*18*) stressed that trace elements could be involved in the genesis of cardiovascular disease. In conclusion, it is discerned from the present study and other reports (*30–34*) that the levels of essential or nonessential elements appear to change in most cases of health disorders and that such changes in hair concentrations of elements are an indicator that can be employed in monitoring human health status.

ACKNOWLEDGMENTS

We are grateful to Professor V. Subramanian, School of Environmental Sciences, Jawaharlal Nehru University, New Delhi, Dr. D. J. Pariksh, National Institute of Occupational Health, Ahmedabad, and Professor N. Gopinath and Dr. S. L. Chadha, Sitaram Bharaya Medical Research Institute, New Delhi, for their help in element analysis and clinical identification of cases. We owe our thanks to the Indian Council of Medical Research (ICMR), New Delhi and Professor K. Okomoto, NIES, Japan for the generous grant and the supply of CRMs.

REFERENCES

1. D. W. Jenkins, U. S. EPA-600/4-79-049 (1979).
2. R. Subramanian, in *Elements in Health and Diseases*, H. M. Said, M. A. Rahman, and L. A. D'Silva, eds., Hamdard Foundation Pakistan, 1987, pp. 326–330.
3. P. Borella, M. Bergomi, G. Fantuzzi, S. Rovesti, and G. Vivoli, Proceedings

of the International Conference on "Heavy Metals in the Environment," vol. 2, New Orleans, CEP Consultants Ltd., U.K., 1987, pp. 89–91.
4. R. Subramanian and A. Sukumar, *J. Trace Elements in Exper. Med.* **2,** 88 (1989).
5. M. Bialkowska, A. Hoser, W. B. Szostak, R. Dybczynski, S. Sterlinski, H. Nowicka, J. Mafchrzak, J. Kaczorowski, and B. Danko, *Ann. Nut. Med.* **3,** 327 (1987).
6. G. Huel, C. Boudene, and M. A. Ibrahim, *Arch. Environ. Health,* **36,** 221 (1981).
7. D. M. Medeiros and L. K. Pellum, *Bull. Environ. Contam. Toxicol.* **34,** 163 (1985).
8. K. M. Hambidge, D. C. Rodgerson, and D. O'Drien, *Diabetes* **17,** 517 (1968).
9. L. M. Klevay, *Nutr. Rep. Int.,* **23,** 371 (1981).
10. R. Masironi, *Bull. WHO* **40,** 305 (1969).
11. R. Masironi, *Bull. WHO* **43,** 687 (1970).
12. WHO, Geneva Technical Report Series No. 336 (1966).
13. D. E. Vance, W. D. Ehmann, and W. R. Markwshary, *Neurotoxicol.* **9,** 17 (1988).
14. International Atomic Energy Agency, Vienna, IAEA/RL/50 (1978).
15. J. F. Alder, A. J. Samuel, and T. S. West, *Anal. Chem. Acta* **87,** 312 (1976).
16. W. W. Harrison, J. P. Yurachek, and C. A. Benson, *Clin. Chem. Acta* **23,** 83 (1969).
17. R. Subramanian and A. Sukumar, *Frezenius Z. Anal. Chem.* **332,** 623 (1988).
18. G. Vivoli, P. Borella, M. Bergomi, and G. Fantuzzi, *Sci. Total Environ.* **66,** 54 (1987).
19. M. H. Briggs, M. Briggs, and Wakatama, *Experientia* **23,** 406 (1972).
20. D. M. Medeiros and L. K. Pellum, *Bull. Environ. Contam. Toxicol.* **32,** 525 (1984).
21. K. N. Jeejeebhoy, R. C. Chu, E. B. Marless, G. R. Greenberg, and A. B. Robertson, *Amer. J. Clin. Nutr.* **30,** 531 (1977).
22. J. M. McKenzie, *Amer. J. Clin. Nutr.* **31,** 470 (1978).
23. H. A. Schroeder and A. P. Nason, *Clin. Chem.* **17,** 461 (1971).
24. H. A. Schroeder and A. P. Nason, *J. Invest. Dermatol.* **53,** 71 (1969).
25. A. W. Voors, W. E. Johnson, and M. S. Shuman, *Arch. Environ. Hlth.* **37,** 98 (1982).
26. D. G. Beevers, E. Ersking, M. Robertson, A. D. Beattle, B. C. Campbell, A. L. Goldberg, M. R. Moore, and V. M. Hawthorne, *Lancet* **2,** 1 (1976).
27. A. W. Voors and M. S. Shuman, *Bull. Environ. Contam. Toxicol.* **17,** 692 (1977).
28. M. Bergomi, P. Borella, G. Fantuzzi, P. C. Tartoni, and G. Vivoli, Proceedings of the International Conference on "Heavy Metals in the Environment," vol. 2, New Orleans, CEP Consultants, U.K., 1987, p. 92.
29. K. Haavikka, *Acta Paediat. Scand.* **318,** 205 (1985).
30. W. H. Strain, L. T. Steadman, and C. A. Lankan, *J. Lab. Clin. Med.* **68,** 244 (1966).
31. K. M. Hambidge and J. D. Baum, *Amer. J. Clin. Nutr.* **25,** 376 (1972).
32. R. Subramanian, in *Biological Monitoring of Exposure to Chemicals. Metals,* H. K. Dillon and M. H. Ho., eds., John Wiley & Sons, Inc., 1991, pp. 255–261.
33. V. Bencko, in *Biological Monitoring of Exposure to Chemicals, Metals,* H. K. Dillon and M. H. Ho., eds., John Wiley & Sons, Inc., 1991, pp. 243–254.
34. K. Bencze, *Fresenius J. Anal. Chem.* **337,** 867 (1990).