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Survey of Trace Elements in Human Nails: An International Comparison

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Evaluation of trace metals in human tissues such as hair and nails has proven useful in the studies pertaining to chronic body exposure. These have also been suggested as indexes to evaluate environmental exposure by toxic trace metals (Nord 1983; Hilderbrand and White 1974; Flynn 1977). Trace element profile of human hair has been uniquely linked to an individual's identity much the same way as finger prints (Bate and Dyer 1965; Perkins and Jarvis 1966). Since this tissue after a rapid growth remains somewhat isolated from the metabolic activities of the human body, trace elements accumulated in it reflect largely chronic exposure (Hopps 1977).

Though hair have been more extensively studied than finger nails, yet it remains that the latter tissue is equally promising in the characterization of certain diseases and abnormalities. Kapito and Shachman (1964) and Kapito et al. (1965) have reported that sodium and potassium concentrations in nail clippings of cystic fibrosis' patients occur at higher levels compared to normal individuals. Martin (1964) has likewise determined copper in hair and nails of patients suffering from Wilson's syndrome. Fite et al. (1972) have also advocated the use of copper in the finger nails as an indicator for the detection of cystic fibrosis in infants. Trace metals in finger nails and hair of patients with renal impairment have been determined by Mahler et al. (1970). Calcium and magnesium contents of nails have been employed to characterize chronic uremia patients and healthy and malnourished children (Lim et al. 1972; Robson and Brooks 1974). Hadjimarkos and Sheaver (1973) have suggested Se in human nails as a marker for epidemiologic studies pertaining to dental caries. Morris et al. (1983) have proposed the use of selenium in toe nails as an indicator in large scale epidemiological research. These studies reveal conti-

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nued interest in trace elements in the devitalized human tissues. The authors conducted earlier a survey of trace elements in human hair (Takagi et al. 1986) and in continuation of this study the present communication reports the data on trace elements in human nails in populations of diverse regions. Over 500 specimens drawn from Japan, India, Poland, Canada and U.S.A. were analyzed for 21 trace elements. An attenpt has also been made to differentiate trace elements distributed according to age, sex and living habits of the donors.

MATERIALS AND METHODS

Specimens were procured from selected locations in each country through a designated person. Each donor was requested to fill out a questionnaire giving vital data (age, sex, height, weight, occupation, dietary habits, general health, domicile and hobbies). The donors ages varied from 30 to 60 years except for Japan where these ranged from 2 to 80 years. The sample in each case was sealed in clean plastic vials soon after collection. In the laboratory each sample was cleaned with 3% H_2O-C_2H_5OH, water and dried with acetone at room temperature. One gram sample was then slowly wet ashed (10 mL HNO_3 + 2 mL $HClO_4$) and residue taken up in 20 mL 0.5M HCl. The 18 elements Ca, Mg, P, Na, K, Fe, Cu, Mn, Zn, Cr, Se, Ni, Co, V, Pb, Cd, Al and Sb were analyzed by argon inductively coupled plasma emission spectroscopy (model Shimazu ICP-1000) under the optimum instrumental conditions.

Five replicate analyses were done on each sample. The NBS sample SRM-1571 (Bovine liver) was employed for calibration and comparison. The recoveries of the elements ranged from 81-102% with coefficient of variation of 0.4-4.7% except for Co, V and Se, where up to 10% variation was recorded. As and Sn were determined by flameless atomic absorption using their hydride generated by sodium tetrahydroborate ($NaBH_4$) as reductant in the Perkin Elmer MHS-20 instrument. The recoveries in this case were 93% (As) and 92% (Sn). For mercury cold vapor atomic absorption a Rigorku Mercury-SP (model MD-A) apparatus was employed. In the analysis of mercury 5 mg nail samples were placed in a porcelin boat and fused in two stages using a flux Al_2O_3 (2g), $Ca(OH)_2$ + Na_2CO_3 (1:1) (1g). Initially heating was done at 370°C for 4 min and then at 700°C for 6 min with air circulation controlled at 0.5 L/min. The analytical signal was recorded using low voltage mercury tube (253.7 nm).

RESULTS AND DISCUSSION

Table 1. Distribution of nail samples drawn from different populations

Country	Male	Female	Total
Japan	125	127	252
India	73	27	100
U.S.A.	34	37	71
Canada	21	19	40
Poland	25	24	49
Total	278	234	512

Table 2. Mean analytical values of 21 elements in parts per million in nails according to countries

Element	Japan	India	U.S.A.	Canada	Poland
Ca	587	614	616	533	799
Mg	97.5	105	96.2	85.8	84
P	316	225	224	211	232
Na	220	127	155	178	205
K	183	76.9	102	101	140
Fe	40.4	55.9	27.1	50.1	42
Zn	93.6	97.1	105	109	124
Al	52.2	72.4	47.5	67.3	41.9
Cu	5.2	4.5	6.3	9.2	5.4
Cr	1.4	1.3	0.52	0.82	0.52
Se	1.6	0.79	0.32	0.45	1.0
Ni	1.1	3.9	0.57	1.3	1.3
Pb	3.1	1.8	2.2	1.9	2.0
V	0.15	0.08	0.08	0.08	0.11
Co	0.17	0.06	0.06	0.09	0.04
Cd	0.08	0.23	0.18	0.18	0.31
Mn	0.78	1.1	1.1	1.0	0.82
As	0.22	0.51	0.09	0.20	0.17
Sb	0.61	0.31	0.41	0.28	0.70
Sn	0.83	0.56	0.83	0.61	0.71
Hg	0.91	0.21	0.22	0.28	0.12

The distribution of samples procured according to gender is shown in Table 1. In all 512 samples were collected which were nearly equally divided between males and females. The mean concentration levels of trace elements are depicted in Table 2. At a first glance it is apparent that Ca, Mg, P, Na, K, Fe, Zn and Al occur at elevated concentration (40-800 ppm), while the rest

Table 3. Country wide distribution of trace elements in human nails occuring at significantly higher levels

Country	Elements (male)	Elements (female)
Japan	Na, K, Co, P, Hg	Na, K, P, Hg
India	Al, Fe, Ni	Al, Fe, Se
U.S.A.	Pb, Cu	Pb, Cu
Canada	Pb, Cu	Pb, Cu
Poland	Ca, Zn	Ca, Zn

occur at trace or sub trace levels (0.05-5 ppm). On a country wide basis trace elements occuring at significantly higher concentrations in male and female populations are shown in Table 3. The experimental data reveal further that Ca, Mg, P, Na, K, Fe, Ni, Cd and Hg generally occur at higher levels in males compared to females, while the reverse holds true for Zn. Age comparison shows that in females Cd, As, Cu, Ni and Cr occur at higher levels in the younger population (≈20 yrs) and these decrease considerably with age, while this distribution remains nearly constant amongst males. For Al and V both males and females concentration levels decrease with age.

Inter country comparison shows that Ca and Zn levels remain high in Polish samples, while this trend is shown by Hg in the Japanese samples. Indian and Japanese samples also show significantly higher levels of P and Al in all age groups and interestingly these increase with age. The American and Canadian samples consistently show increased concentration of Cu and Pb compared to others.

Accumulation of trace elements in nails in part could be influenced by the dietary and living habits of the people. It can be different in vegetarians and non-vegetarians, which may further deviate depending on increased consumption of meat or fish. The domicile (rural or urban) can as well be a contributing factor, while the same can be said for smoking and non-smoking population. In U.S.A. and Canada eating and living habits are somewhat similar, thus it is not surprising that trace elements distribution in nails also holds a close resemblance. Higher fish consumption in Japan can be associated with increased Hg, Al and Fe levels in nails for both male and female samples.

Increased levels of Al, Fe are also seen in essentially vegetarian Indian nail samples and in addition Sn is also observed at higher concentration compared to non-vegetarian. Probably this pattern results from tin coated iron and aluminium cookwares used extensively in the Indian cuisine.

A limited comparison amongst male smokers and non-smokers shows that for Japanese samples Mn occurs at higher level (1 ppm) in non-smokers compared to smokers (0.6 ppm). The same comparison for Se in samples from U.S.A., Canada and Poland shows that it occurs at higher levels (2.6 ppm) amongst smokers compared to non-smokers (0.96 ppm).

The limited survey for trace elements distribution in healthy human nail samples in populations of different origin is revealing since significant differences in the distribution pattern are observed. A detailed survey with well defined parameters can be useful in establishing the impact of dietary and living habits on the distribution pattern of trace elements in devitalized human tissues.

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