Note

Variation of Elemental Concentration in Hair in Relation to Diabetes†

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With the help of reactor neutron activation analysis investigations of the trace elements such as copper, manganese, zinc, selenium, nickel, cadmium and mercury have been performed purposing to settle the problems of distinction between healthy persons and patients suffering from diabetes.

In this technique, $K_{\infty,0}$ -method as a new standardization technique, were applied, in which, the deviation of the $1/E^{1+\alpha}$ epithermal neutron flux distributions from $1/E$ law, true coincidence effects of cascade γ -rays, and the efficiency of the Ge-detector were taken into consideration. Short lived nuclides were determined by a short activation with the help of a pneumatic irradiation facility and automatic correction of dead time and decay. The medium and long lived nuclides were determined after 48 h irradiation and ten days cooling. The patients head-hair samples showed a significant differences in the Cu, Zn, Se, and Hg. The result indicates that early diagnosis by means of trace elements determination could be possible.

Key Words: diabetes, selenium, copper, zinc, mercury, hair, neutron activation analysis

1. Introduction

The awareness of the importance of trace metals in biological system continues to increase. In addition to the diseases related to trace element deficiencies or toxicity some trace metal variations have been observed between normal and diseased tissue⁽¹⁾⁻⁽⁹⁾. These variations have not always been conclusive since the trace element variations observed between the different control (normal) specimens were as large as those between the normal and diseased tissues. The initial goal of this study was to obtain precise trace element concentrations for a carefully controlled group of samples to determine if trace elements reflected the genetic abnormalities in hair, and in addition, to the possible use of trace elements for diagnostic purposes.

The present study was undertaken to inves-

tigate the potential of hair as an indicator of total body trace element burden for normal and diseased persons and the investigation of possible correlations with the diabetes. Significant changes were observed for certain elements such as Cu, Zn, Se and Hg. It was the aim of the present study to help in clarifying the issue and to extend the analysis to more elements.

$K_{\infty,0}$ -Neutron activation analysis

The $K_{\infty,0}$ method⁽⁷⁾⁻⁽⁹⁾ differs from the relative method in its treatment of standards; it simplifies preparation, activation and measurement of individual standards through replacing them by the nuclear data. For this reason the method is advantageous over the relative method for multielement analysis of hair samples, because it precludes the problems involved in preparation of multielement standards in a condition similar to hair samples.

When applying the $K_{\infty,0}$ -method to reactor

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neutron activation analysis (RNAA), the concentration of an element i can be calculated from the following equation;

$$\rho(x) = \frac{\left[\frac{(N_p)_{Cd}/t_m}{SDC} \right]_{\text{sample}} \cdot \frac{F_{Cd*}}{F_{Cd}} \cdot \frac{\varepsilon_p^*}{\varepsilon_p} \cdot \frac{Q_{0*}(\alpha)}{Q_{0*}} \cdot \frac{G_e^*}{G_e} \cdot \frac{Q_0}{Q_{0}(\alpha)} \cdot 10^6}{(A_{sp*}) \cdot K_{e,0}} \quad (1)$$

where the asterisk refers to a comparator (weight g in gram) coirradiated with the sample. Other symbols are as follows:

ρ : concentration (ppm) for an element in a sample

A_{sp} : specific activity of the measured γ -peak;

$$A_{sp} = \frac{A_p}{SDC}$$

where A_p is the measured average activity of the full energy peak $A_p = N_p/t_m$ with N_p the measured number of net counts under the full-energy peak.

$(N_p)_{Cd}$: measured number of net counts under the full energy peak of the monitor irradiated under cadmium cover

D : decay factor, with t_d the decay period

C : measurement factor correcting for decay during the measured period t_m ;

$$C = \frac{1 - \exp(-\lambda t_m)}{\lambda t_m}$$

$$K_{e,0} = \frac{(A_{sp})_{Cd}}{(A_{sp*})_{Cd}} \cdot \frac{F_{Cd*}}{F_{Cd}} \cdot \frac{\varepsilon_p^*}{\varepsilon_p}$$

F_{Cd} : cadmium epithermal neutron transmission factor¹⁰⁾

ε_p : absolute full-energy peak efficiency of the detector for the measured γ -line¹¹⁾

Q_0 : resonance integral to cross-section at 2200 m/s;

$$Q_0 = I_0/\sigma_{th}$$

$$Q_{0(\alpha)} = \frac{Q_0 - 0.429}{(\bar{E}_r)} + \frac{0.429}{(2\alpha + 1)(0.55)^\alpha}$$

$\bar{E}_r$: effective resonance energy^{12), 13)}

G_e : epithermal neutron self-shielding¹⁴⁾

α : deviation parameter from the $1/E$ shape.

2. Experimental

Head hair samples were collected from 16 male and 55 female patients and also 5 male and 5 female control subjects.

All patients and control subjects live in Mekka, Saudi Arabia. The hair samples were

washed with acetone and bidistilled water, according to the procedure recommended by the IAEA Advisory Group¹⁵⁾. After a final wash with acetone the samples were air-dried at room temperature. To determine the elements producing nuclides with short and long half lives, samples as well as comparator (Au-Al wire) were irradiated in polyethylene vials for two irradiation times in the Thetis reactor of the Rijksuniversiteit, Gent, followed by counting of short- and long-lived product radionuclides. The determination of Mn, Ni, Cu, Zn, Se, Cd and Hg were based on the (n, γ) reaction. This procedure was applied to ⁵⁵Mn, ⁶⁵Ni, ⁶⁶Cu, ⁶⁵Zn, ⁷⁴Se, ¹¹⁵Cd and ²⁰³Hg.

The decays during the measurements and the dead time losses in the multi-channel analyzer were taken into account.

3. Results and Discussion

Except for major constituents in hair, not all the elements could be determined for every sample analysed. The ranges, arithmetic and geometric means and the medians were obtained from samples which showed detectable contents. These values are compiled in Table 1. It should be noticed that arithmetic and geometric means and medians obtained from samples which are restricted to those containing more than detection limits of corresponding elements will tend to overestimate the real values because contents under the detection limits are not taken into account.

Table 1 presents the hair trace element concentrations of Mn, Ni, Cu, Zn, Se, Cd and Hg for the diabetic patients and for the control group. The arithmetic mean, geometric mean and median value for Cu, Zn and Hg in the diabetic patients are about 3, 3 and 7 times lower than the corresponding values in the control group, respectively. For Se in the patients in about 4.5 times higher than the corresponding value in the control group. Our results for Mn, Ni and Cd shows that, no significant changes in the hair concentrations of these elements. All element concentrations were 7% lower in female than in male, and there was no difference in levels among different age groups. These results could be used

Table 1 Elemental concentration (ppm) in hair of control subjects and patients

Element	Subject ^{a)}	Sex ^{b)}	Range	Arithmetic mean ± standard deviation	Geometric mean / standard deviation	Median
Mn	C	M	0.15-5.7	1.22±2.38	0.86/2.1	0.70
		F	0.14-5.4	1.20±1.30	0.87/2.5	0.63
	P	M	0.19-8.3	1.56±2.30	0.79/1.8	0.62
		F	0.17-8.0	1.48±2.10	0.74/2.2	0.58
Ni	C	M	1.0-32.8	8.80±15.3	3.9/1.1	3.70
		F	0.95-33.2	8.20±14.8	3.7/1.9	3.40
	P	M	0.97-38.0	9.10±11.8	3.5/2.1	3.13
		F	0.93-36.0	8.50±15.1	3.1/2.0	2.85
Cu	C	M	8.0-25.0	13.0±2.90	11.5/1.1	9.90
		F	7.3-23.0	12.0±3.60	10.3/1.5	8.95
	P	M	2.0-5.80	4.10±3.30	3.8/1.6	3.10
		F	1.9-5.50	3.83±4.20	3.6/1.4	2.96
Zn	C	M	95-322	188±40	172/1.3	178
		F	85-294	174±42	159/1.3	164
	P	M	14- 54	27± 8	25/1.5	26
		F	12.5- 47	24± 7	22/1.6	23
Se	C	M	0.5-5.6	0.83±0.63	0.74/1.5	0.66
		F	0.46-5.2	0.77±0.62	0.64/1.7	0.60
	P	M	2.0-26.0	3.70±1.10	3.1/1.4	3.60
		F	1.86-24.2	3.44±1.70	2.9/1.8	3.34
Cd	C	M	0.18-9.8	1.52±3.10	0.94/1.8	0.82
		F	0.16-9.2	1.50±3.10	0.85/1.9	0.74
	P	M	0.21-9.7	1.54±2.30	0.96/1.5	0.85
		F	0.20-9.1	1.50±2.20	0.90/1.5	0.79
Hg	C	M	1.10-4.80	2.30±0.70	1.98/1.2	2.10
		F	1.02-4.4	2.12±0.30	1.92/1.6	1.98
	P	M	0.36-1.6	0.74±0.20	0.69/1.7	0.70
		F	0.34-1.5	0.70±0.22	0.64/1.6	0.65

a) C : control and P : patients

b) M : male and F : female

to diagnose the early stage of diabetes, but we hope that further studies will verify our findings.

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