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NOTE

Atomic absorption spectrometric determination of Zn and Cr levels in scalp human hair samples. Influence of age, gender and diabetic condition

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Abstract : The pathogenesis of diabetics has been associated with changes in the balance of certain essential trace elements. The aim of this study was to evaluate the Zn and Cr contents in scalp hair samples of diabetic patients of urban residents of Hyderabad city (Pakistan). Scalp hair samples were collected from 300 patients (162 male, 138 female) of two age groups (31-45, 46-60 yr), and for comparative study, 250 normal, healthy subjects (135 male, 115 female) of same age groups residing in same city were selected. All samples were washed with standard method, and digested the samples with wet acid digestion method using nitric acid-hydrogen peroxide (2 : 1) ratio. The resulted digests were analysed for Zn by flame atomic absorption spectrophotometer (FAAS) and Cr by electrothermal atomic absorption spectrophotometer (ETAAS). Results were calculated in μg/g. The validity of this method was checked by certified human hair sample (BCR 397).

The mean values of Zn and Cr of scalp hair samples of diabetic patients were altered and change in diabetic patients as compared to the control subjects of both genders. Mean Zn concentration in male patients, 179.6 and 67.57 μg/g vs controls, 230.0 and 206.1 μg/g, ($p < 0.002$ and 0.003) in both age groups respectively. The Zn level was also lower in scalp hair samples of female diabetic patient as compared to control, groups with ($p < 0.001$-0.005). The concentration of Cr in the scalp hair samples of the diabetic patients of both sexes were significantly lower as compared to the controls ($p < 0.001$-0.003). Deficiency of both essential trace metals may play a role in the etiology of diabetic disease in the subjects of this study.

Keywords : AAS, zinc, chromium, human hair, diabetics.

Diabetes mellitus is a global disease, found in all nations of the world. The prevalence rate of the disease varies from country to country. It has been reported that 1.49% prevalence of diabetes in NWFP, Pakistan[1]. A number of studies have reported an association between diabetes mellitus and alterations in the metabolism of several trace minerals. Impaired insulin release, insulin resistance and glucose intolerance in experimental animals and humans with diabetes mellitus have been linked to a compromised status of chromium, magnesium, selenium, vanadium and zinc. Zinc is involved in the synthesis, storage, secretion and conformational integrity of insulin[2].

Patients with type 2 diabetes were found to have decreased plasma Zn and intracellular Zn concentrations, and increased urinary Zn excretion compared to nondiabetic subjects[3]. Low dietary Zn intake appears to be related to a higher risk for developing diabetes. In a cross-sectional survey in 3575 Indian subjects, lower dietary Zn intake was associated with a higher prevalence of diabetes, glucose intolerance and coronary artery disease[4].

Chromium (Cr) is implicated in maintenance of blood sugar, and lipid metabolism. The proposed mechanism includes the enhancement of insulin binding by increasing the number of insulin receptors and the activation of insulin receptor tyrosine kinase, thus leading to increased insulin sensitivity. Cr deficiency results in glucose intolerance and insulin resistance[5].

In this study we evaluated the levels of Zn and Cr in the hair of Pakistani diabetic patients of two age groups and both gender, with related to control subjects. The scalp hair samples were digested with acids, prior to subjecting atomic absorption spectrometry. Hair Analysis appears to be a reliable simple method of assessing body elements stores. The scalp hair samples were prepared by microwave assisted acid digestion method, and the validity of analytical procedure was checked by correspond-

ing conventional wet acid digestion of certified reference material of human hair (BCR 397) (Table 2).

Results and discussion

Concentration of elements in hair vary widely among individuals, thus significantly large number of samples from large population need to be analyzed and the results were treated statistically for meaningful correlation. The results are shown in Table 1. The scalp hair samples analyzed were categorized according to the age and gender.

The hair follicle is a potentially useful tool for determining the status of zinc and the status of other trace elements and also for assessing any pathological states. Hair zinc levels have received more research attention than any other mineral. Low hair zinc has been associated with zinc deficiency in diabetes mellitus[2]. Our study showed that the mean levels of Zn and Cr in the scalp hair samples of normal persons is higher as compare to the diabetic patients in both genders i.e. male and females of both age groups (31–45) and (46–60) years.

The elderly people with reduced digestive power, do not get sufficient nutrients. It has also been postulated that the low levels of Zn in diabetic patients may be due to excessive urinary output especially inpatients with diabetic nephropathy, gastrointestinal malabsorption or genetic factors or signs of infection during which Zn will act as a defense mechanism.

Since Zn plays a clear role in the synthesis, storage and secretion of insulin as well as conformational integrity of insulin in the hexameric form, the decreased Zn, which affects the ability of the islet cell to produce and secrete insulin, might then compound the problem, particularly in Type 1 diabetes. Several of the complications of diabetes may be related to increased intracellular oxidants and free radicals associated with decreases in intracellular Zn and in Zn dependent antioxidant enzymes. There appears to be a complex interrelationship between Zn and diabetes. There is a concurrent hypozincemia and a decrease in tissue zinc stores, but it is not clear if this is a result of the hyperzincuria or an independent event related to the effect of insulin or hyperglycemia on loss of Zn from the tissue stores with a resultant loss of zinc to the plasma from where it is excreted with a net loss of total body zinc and eventual hypozincemia. It has been postulated that hyperglycemia interferes with the active transport of Zn back into the renal tubular cells[6].

Mertz[7] elucidated the action of Cr in diabetes showed that the administration of Cr may have beneficial effects on the disease. In general, based on observations from different groups of studies, and our investigation revealed that, in addition to impaired Cr utilization, age plays a major role in the status of Cr. Cr levels stabilize at certain ages and then decline.

Recent studies have reported the beneficial effects of supplemental Cr on plasma glucose and related variables of people with diabetic mellitus and steroid-induced diabetes[8]. Accompanying these data, there are also suggestive studies to show that Cr also improves cellular antioxidant capacity in rats. Therefore, since Cr and Zn act in normalizing glycemia and are postulated to function as antioxidants, a restored Zn and Cr status in people with diabetic mellitus may counteract the deleterious effects of oxidative stress and help to prevent complications associated with diabetes.

Table 1. Comparative data of Zn and Cr in normal and diabetic subjects (μg/g)

Age group (years)	Human subjects	Normal (number)	Diabetic patients (number)	*p*-Value	Pearson correlation (*r*)
		Zinc			
31–45	Male	230 ± 17.07 (69)	179.57 ± 12.00 (90)	0.002	0.991
	Female	264.4 ± 13.26 (63)	184.14 ± 19.8 (78)	0.001	0.997
46–60	Male	206.14 ± 8.5 (66)	179.57 ± 12.00 (72)	0.003	0.995
	Female	240.4 ± 18.2 (52)	92.43 ± 6.1 (60)	0.005	0.981
		Chromium			
31–45	Male	4.1 ± 0.5 (69)	1.9 ± 0.4 (90)	0.003	0.997
	Female	3.6 ± 0.2 (63)	2.2 ± 0.3 (78)	0.001	0.990
46–60	Male	3.5 ± 0.3 (66)	2.1 ± 0.4 (72)	0.001	0.983
	Female	3.6 ± 0.5 (52)	2.4 ± 0.5 (60)	0.002	0.997

Table 2. Elemental concentrations in CRM 397 after microwave acid and conventional wet acid digestion methods (μg/g)

Elements	Conventional digestion method (CDM)	% RSD	Microwave digestion method (MDM)	% RSD	Recovey (%) $= \frac{MDM}{CDM} \times 100$	Certified values
Zinc	203.5	6.3	201.5	5.6	99.02	199 ± 5
Chromium	90.52	6.8	88.6	10.6	98.1	91.0 ± 10[a]

[a]Informative value.

The mechanism by which Cr acts as an antioxidant is still not totally understood. Increased formation of lipid peroxidation products is associated with insulin perturbations[9]. Chromium decreases transport of insulin and might lessen lipid peroxidation through the glucose/insulin system. Chromium, like vitamin E, also protects rats from oxidative damage related to carbon tetrachloride.

The mean value of the concentration of Zn and Cr in the scalp hair samples of normal persons is higher as compare to the diabetic patients in both genders i.e. male and females of both age groups, i.e. (31–45) and (46–60) years. Even though the data presented in this paper is consistent in some aspects with previous findings of other researchers, the author feel, that additional and more reliable quantitative data must be performed, and large number of specimens should be obtained in order to fully elucidate the relationship between the trace elements and diabetic mellitus.

Experimental

Hair samples were digested and sample solutions prepared by microwave assisted acid digestion using concentrated nitric acid and hydrogen peroxide (2 : 1) ratio, for comparative purpose conventional wet acid digestion was also used (Table 2), as reported in our previous work[10]. A Hitachi 180-50 Atomic Absorption Spectrophotometer was used. Standard solutions of zinc and chromium of 1000 ppm were prepared from certified standards (Fluka kamika, Switzerland).

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