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THE ROLE OF ZINC AND CADMIUM IN HUMAN DIET AND DISEASES WITH SPECIAL REFERENCE TO DIABETIES MELLITUS AND HYPERTENSION

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ABSTRACT

"In this paper, the results of examination of soil, water food, blood and urine samples of people in Jabada Para area have been described. Concentrations of Zinc and Cadmium have been determined by atomic absorption spectroscopy and spectrophotometry. Relationship between Zinc and Cadmium status of soil, water food etc. and their influence on human health and diseases, like diabetes mellitus and hypertension has been established.

KEY WORDS: Zinc and Cadmium, Atomic Absorption Spectroscopy and Spectrophotometry.

INTRODUCTION

Most of the diseases are water born, most are due to faulty food habits. But trace and toxic elements play major roles in explaining various diseases as Cancer, Atherosclerosis, Hypertension and others. [1]. Many minerals occur in inorganic and in complex organometallic compound forms. These are absorbed by digestive tract [2]. Biochemical measurements of blood and urine etc. serve as important indicator of metabolic states [3] and are used in diagnosing diseases and regular treatments. A cardinal example is diabetes mellitus caused by deficiency or activation of pancreatic hormone, insulin, which in turn produces profound metabolic disorders [4].

After series of experiments, in the present case, changes in blood and urine components in uncontrolled diabetes mellitus has been described in table.

1. It clearly shows that acidosis (5) is due to extensive formation of ketone bodies (6) in the liver and delivery into the blood.

Apart from faulty food habits, under nutrition, mineral imbalance in water and staple food, trace elements also have their important role in life processes.

MATERIALS AND METHODS

All the chemicals used were of B.D.H.-S.M. Grade. Solvents used were redistilled to meet the demands of high degree of purity required for biochemical investigations. Samples of soil, water, plants food stuffs, whole blood, urine, hair and nails were analysed for Zinc and Cadium. Spectrophotometry was done in the laboratory of the research atomic absorption spectroscopy was carried out at chemical laboratory of BALCO, Korba.

Spectrophotometric determination of Zinc

Stock solution was prepared by dissolving 220mg of Zinc Sulphate in 500ml Zinc was estimated spectrophotometrically using dithiozone reagent. [7].

Spectrophotometric determination of Cadmium

Stock solution was prepared by dissolving 20mg/litre of Cadmium Chloride in water cadmium was estimated spectrophotometrically using dithiozone [8].

Water samples from different sources were analysed for Zn and Cd concentrations. Results are mentioned in Table No. 3.

In Chhattisgarh State, Dharwar system consists of phylite, schist, slate, gneiss, haematite and quartzites. Shale

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of all types contain 0.03 to 11.0 mg/g of Cadmium. According to the rock formation of the area, soil has appreciable amount of Zn (22 to 50%) and Cd (0.05 to 0.3%)

Extensive soil analysis was done due to scanty information about the trace elements composition of the soil of Chhattisgarh State. [11, 12].

RESULTS AND DISCUSSION

Balance Studies : Zn

In terms of body metabolism the balance method is a comparison of nutrient intake and loss from body.

Balance = Intake – Excretion

Positive balance means intake is more excretion. The balance technique has been widely used as a criterion for determining dietary adequacy.

The average Zn retention was between 96.47 to 106.97 µg.

The average retention of Cd varied from 0.06 to 0.09 µg.

Zinc in the Body System

Zinc plays a vital role in protein synthesis and in the formation of certain growth hormones. It promotes seed maturation and production in plants. It influences many body systems and functions including growth, bone formation, development of brain. Insulin is present as crystalline Zn complex in β cells of islets of langerhans in pancreas. Zn is a constituent of carbonic anhydrase [13]. Angiotension converting enzymes are glycoprotein containing Zn. This way Zn has role in Hypertension.

Zn and Cd were determined in kidney cortex, liver and pancreas from 292 subjects in Sweden [14]. Kumar and Rao [15] estimated Zn in the urine and plasma of normal subjects and diabetes. They found high concentration of Zn in the urine and low concentration in the plasma and blood cells of diabetics. In the normal subject, the plasma Zn was found to be 123.2 mg% and 8.3 mg% in diabetics.

Extensive soil analysis was done due to scanty information about the trace elements composition of the soil of Chhattisgarh State. [11, 12].

Cadmium in the Body System

Amongst environmental pollutants, Cd, a heavy metal merits a special reference as potentially toxic elements. Although evidence of Cd requirement for growth in rat has been reported [16]. Mankind is exposed to Cd viz. food, water and air. There is abundant evidence to indicate that Cd accumulates in significant concentrations in different organs with age [17]. The half life period in human being has been estimated to be 16 to 33 years [18]. Cd develops hypertension in rats [19]. Cd ingestion causes secondary deficiency of Cu and Zn [20]. Accumulation of Cd in the kidney has been considered to be a causative factor in human hypertension. [21-22].

Because of effective blood brain barrier which restricts passage of Cd into the central nervous system, there is no or little uptake of Cd into the brains of dogs or rabbits [23]. Cd is carcinogenic to animals when administered subcutaneously or intramuscularly [24]. Cadmium in urine is indicator of body burden [25].

Effect of Cd on Lipid Metabolism

Increased levels of cholesterol and free fatty acids were observed by Yoskikawa et al in plasma in rabbits [26] that had been given daily doses of 0.5 to 1.0 mg Cd/kg body weight for six weeks.

The net effect of increase in free fatty acids with affect pyruvic acid oxidation and so glucose oxidation is ultimately affected. This way Cd may cause diabetes by replacing Zn from insulin complex.

Zn AND Cd AND DIABETES METTITUS AND HYPERTENSION

Diabetes Mellitus

It is a complex disease that affects several hundreds of people. It is characterized by an elevated of glucose in the blood and in the urine. The loss of glucose causes depletion of carbohydrates store. This leads to the breakdown of fat and protein. The mobilization of fats results in the formation of large amounts of acetyl CO Enzy. A ketone bodies are formed when acetyl Co. A. can't enter into citric acid cycle because there is insufficient oxaloacetate.

Diabetes and Hypertension are two common conditions which accelerate the production of shamic heart disease. The damage is compounded if both the conditions co-exist in the same patient. The ratio of Cd : Zn on the earth crust is 500 = 1000. Scroeder came to the conclusion that Cd in kidneys in relations to Zn is contributory if not the whole cause of high blood pressure. [27].

Obesity, NIDDM, old age and hypertension have some thing in common as shown below :-

Signals

↓↓↓ Strongly decreasing
↓↓ Mild decrease
↔ No change

Sulphonyl urea drugs and Biguanides are less or ineffective drugs in NIDDM so insulin sensitizing agents are important. They are ciglitazone, proglitazone and others.

Hypertension

Epidemiological studies have confirmed that higher the pressure (systolic and diastolic both) greater is the risk of cardiovascular disease. Some drawbacks are associated with antihypertensive durg. For example Ca channel blockers decreases insulin release and can accentuate diabetes. Diuretics are not suggestible to young patients. The major physiological function of controlled sequence of peptidase reactions restore the blood pressure

the below mentioned reactions [31-32]. Contribute to hypertension.

Angiotensinogen
↓
Angiotensin 1
↓
Converting coenzyme (A Zn protein)
↓
Angiotensin 2
↓
Angiotensin 3

Both Angiotensin 2 and 3 raise B.P. by direct vaso constriction and increase blood volume by their sodium retaining actions. Angiotensin 3 is 50% as potent as Angiotensin 2 as a vasoconstrictor. But slightly more effective as a stimulator of release of Na retaining Harmone, "Aldosterone" [35]. Cd induced hypertensive rats showed greater amount of fluid consumption. Saline consumption was more in hypertensive rats. Disordered Na balance in experimental hypertensive rates produces renal artery constriction [36]. Severs and Severs [37] observed that increased level of angiotensin specifically stimulates fluid intake and aldosterone secretion which cause Na retention. Doyle et al. [38] also observed Na was retained by Cd in the Kidney and hypertension induced in female log evans rats when fed 5 mg. Cd/L in drinking water. Cd itself causes hypertension as it is nephrotoxic. However Zn and Se diet bring about regression in Cd induced hypertension due to antagonistic behaviors. In the present context the Zn content in whole blood is 9.228 ppm. Low Zn content causes serious impairment of blood glucose homeostasis as Zn is necessary for normal insulin secretion and carbonic anhydrase activity.

Case Studies

Trace elements play important role in protein synthesis. Amino Acid contents are influenced by a various amounts of trace elements fed to the plants [42]. See figure 1. Valley and Gibson determined Zn content of normal human blood values reported by them is 9.1 ± 0.9 µg/ml. In the present studies the whole blood Zn content is 9.288 ppm.

Significant reduction in Zn concentration in the whole blood is observed in diabetics. The value was 6.368 ppm. This significant reduction is due to presence of phytate ion, and Cd ion concentration Zn is essential for normal insulin store and carbonic anhydrease activity. Zn concentration is significantly below the normal in hypertensives.

Willden and Hyno [48] have estimated Cd in the whole blood of normal adults and the mean values reported by them are 2.38 ± 0.32 µg/100ml. Valley et al [49] found Cd level in the blood of hypertensive being higher as compared to the normal.

Three typical cases have been selected from the population of the area under investigation. Case No. 1 has optimum value of Zn concentration in the blood and urine. Case No. 2 and 3 had lower value of Zn and elevated value of Cd. Case No. 2 and 3 had higher values of W.B.C. and neutrophil counts showing severe infection. Occlusion of lipids in the coronary artery. This causes anoxia and ultimately degeneration of a localized protein of the heart muscle resulting in myocardial infraction. Such damage causes leakage of certain enzymes from the injured heart cells into the blood stream. SGOT value is very high in Case No. 2 and 3.

Creatine Kinase can give important information regarding the severity of the damage to the heart. Creatine Kinase is the first heart enzyme appears in the blood after coronary attack. It also disappears quickly from the blood. SGOT in next to appear and GPT follows.

Lactic acid dehydrogenase also leaks from the injured heart muscles as shown in the case 2 and 3. All these have been tablised in the table No. 8.

Results of Pathological Investigation

Table 1. Changes in the concentration of ph, several ions in the blood and urine samples from peoples of Jabada Area, Bilaspur (C.G.)

S.No.	Compounds or ions and volume and pH	Concentration in Urine
1.	Glucose	Increases
2.	Ketone bodies	Increases
3.	Na^+	Increases
4.	NH_4^+	Increases
5.	Urea	Increases
6.	Volume	Increases
7.	pH	Decreases
	Concentration in Blood	
1.	Glucose	Increases
2.	Ketone bodies	Increases
3.	Urea	Increases
4.	pH	Decreases
5.	Total CO_2 and HCO_3^{-1}	Decreases

Table 2. Concentrations of Zn and Cd in µg/ml in water samples

S.No.	Water Source	No. of Samples	Mean of trace element	
			Zn	Cd
1.	Arpa river fresh	20	0.040	0.009
2.	Arpa river after domestic effluents	20	0.050	0.025
3.	Hand pump water sarkanda	20	0.049	0.015
4.	Hand pump water in low lying areas of Jabada	20	0.055	0.010
5.	Jora talab	20	0.045	0.005
6.	Corporation water	20	0.049	0.020

Concentration of Zn and Cd in some food stuffs have been expressed in ppm. It has been shown in Table No. 4

Table 3. Food Grains and Vegetables used in Jabada Mohalla were analysed concentration

S.No.	Samples	Zn	Cd
1.	Polished rice 23	10.3 – 22.3	0.10 – 0.116
2.	Un polished rice 23	13.6 – 20.3	0.15 – 0.036
3.	Wheat and wheat products (5)	9.5 – 17.3	0.123 – 0.196
4.	Pulses 6	16.3 – 17.3	0.14 – 0.183
5.	Nuts 22	8.7 – 9.6	0.056 – 0.106
6.	Roots and Tubers 4	4.2 – 5.3	0.096 – 0.15
7.	Vegetables 5	4.3 – 6.66	0.1 – 0.156
8.	Sugar and gur 3	1.66 – 1.166	0.015 – 0.018

Table 4. Whole blood in ppm in 10 normal, 10 diabetics and 10 hypertensive subjects (Spectrophotometrically)

S.No.	Normal Subjects		Diabetics		Hypertensive	
	Zn	Cd	Zn	Cd	Zn	Cd
01.	9.57	0.10	6.39	0.09	5.45	0.20
02.	9.45	0.13	7.25	0.09	5.53	0.21
03.	9.45	0.10	6.35	0.08	5.69	0.20
04.	9.39	0.08	7.05	0.06	5.49	0.23
05.	9.00	0.07	5.89	0.05	4.97	0.20
06.	8.79	0.09	6.80	0.09	4.38	0.23
07.	8.88	0.12	6.05	0.07	4.89	0.24
08.	9.09	0.09	6.35	0.05	4.87	0.10
09.	9.54	1.06	0.05	1.40	4.90	0.15
10.	9.07	0.09	5.80	0.05	5.37	0.21
Mean	9.228	0.095	6.368	0.065	5.238	0.197
S.D.	0.299	0.018	0.523	0.0183	0.398	0.042

Table 5. Hair and Nail analysis of 10 Normal, 10 Diabetics and 10 Hypertensive have been done (Spectrophotometrically)

S.No.	Normal Subjects				Diabetics				Hypertensive			
	Zn		Cd		Zn		Cd		Zn		Cd	
	H	N	H	N	H	N	H	N	H	N	H	N
01.	170	150	0.16	0.08	150	140	0.10	0.05	140	130	0.10	0.05
02.	160	140	0.15	0.07	145	140	0.12	0.06	140	130	0.15	0.09
03.	165	150	0.12	0.07	135	130	0.14	0.08	135	130	0.20	0.15
04.	160	140	0.20	0.10	150	140	0.16	0.07	100	95	0.50	0.09
05.	140	120	0.35	0.25	135	130	0.19	0.07	110	100	0.45	0.27
06.	130	120	0.35	0.25	140	130	0.20	0.10	95	95	0.40	0.29
07.	125	120	0.20	0.15	120	100	0.18	0.07	110	95	0.37	0.27
08.	130	125	0.20	0.14	110	105	0.19	0.08	120	100	0.45	0.40
09.	135	125	0.25	0.15	130	110	0.20	0.04	100	95	0.35	0.30
10.	160	150	0.20	0.10	140	120	0.25	0.15	130	110	0.37	0.30
Mean	147.5	134	0.218	0.138	135.5	124.0	0.73	0.079	118	108	0.334	0.241
S.D.	10.124	17.038	0.071	0.073	5.503	6.325	0.031	0.025	3.458	3.458	0.137	0.109

Symbol used : H = Hair, N = Nail; Concentration expressed in ppm

Table 7. Effect of Insulin

S.No.	**Effect of Insulin**	**Obesity**	**NIDDM**	**Old age**	**Essential Hypertension**
1.	Whole body glucose	↓↓↓	↓↓↓	↓↓	↓↓
2.	Glucose oxidation	↓	↓	↓↓	↔
3.	Non-oxidative glucose disposal	↓↓	↓↓↓	↔	↓↓↓

Table 8. Biochemical Observation

S.No.	**Biochemical Observation**	**Case No.**		
		I	**II**	**III**
1	W.B.C./CU.M.M.	Nil	12000 Cells	1000 Cells
2	Neutrophil	Nil	78%	70%
3	S.G.O.T.I.U./L.	Nil	385	250
4	Creatine Kinase (N.A.C.) I.U./L	Nil	2355	1800
5	Creatine Kinase (M.B.I.U./L.)	Nil	95	70
6	Lactic acid dehydrogenase	Nil	800	750

CONCLUSION

1. The Chhattisgarh area has not been analysed for trace elements.
2. Soils have optimum amount of Zn and Cd. Cd is a potential health hazard with a high half life period in the human body. It replaces Zn from various Zn enzymes and thereby acts as a poison.
3. The area under investigation has people of diverse socio economic conditions. Male mortality rate is high. Diabetes and hypertension are very common as observed in the present investigations.
4. Dietary analysis reveals that unhygienic conditions and unbalanced diet with deficiency of essential trace elements and vitamins being the main cause of various diseases.

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