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Research Article

IMPACT OF FOOD HABIT ON BODY ELEMENTS LEVEL AND HEALTH

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ABSTRACT

The requirement of trace element to an individual is depends on many factors like age, developmental stage such as, in uterus, infancy and the elderly, gender, pregnancy and lactation, genetical variation, acquired disorders of homeostasis and interaction between the essential trace elements. Similarly, food habit (i.e. vegetarian/ non-vegetarian) of an individual may have association with the changes in body element levels and may form the causal factor for multi-element exposures. Such altered status of elements may causes metabolic imbalance and leads to chronic health disorders such as diabetes and hypertension etc. In this regard, the present study aims to find out the influence of food habit on body levels of trace elements (Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn) and in turn it's effect on physical health of Mysore subjects. With the use of ICP-AES and AAS the body elements level was measured through whole-blood, urine, scalp hair, fingernail and tooth samples which were collected randomly from volunteers of Mysore city and surrounding villages. In addition, their food habits and blood sugar level were also collected for interpretation. Significant difference in the mean elements concentration between vegetarian & non-vegetarian and between diabetes & non-diabetes for urban and rural groups were computed. It is observed from the results that food habit of Mysore subjects had altered their element contents in blood (Cd and Pb) of rural non-vegetarian, nails (Cd, Cr, Mn and Zn) and teeth (Zn) of urban vegetarian; whereas, urinary and hair element levels were not affected. In the present study, the rural vegetarian subjects had lower levels of Cd-B and Pb-B than non-vegetarian rural subjects. It is reasoned for such difference that especially intake of a high fiber diet apparently lowers uptake of metals from intestine. Further, as the higher Pb and lower Zn levels have been observed in urban diabetes, it is viewed that higher Pb from environment and lower Zn from food intake are the casual factors related to diabetes. Thus, it is evident from the present study that food habit affects/changes the elements level and causes elements imbalance leading to altered element metabolism, which may be one of the causal factor for diabetes.

KEY WORDS: Diabetes, trace elements, ICP-AES, non-vegetarian, Mysore subjects & bio-samples.

INTRODUCTION

The definition of nutritional requirement has been fixed for a population but there is considerable variability of requirement among individuals. Age related variables such as, in uterus, infancy and the elderly, gender, pregnancy and lactation, genetical variation, acquired disorders of homeostasis and interaction between the essential trace elements determine the nutritional requirement of individual. For example, Zn is essential for the development of the

neural tube during embryonic [1]. Heavy metals have many significant biological roles in metallo-enzymes and are required at trace levels by all living organisms. However, they prove to be hazardous even when the concentrations of these metals are slightly increased above the trace quantity needed for nutritional requirement and physiological interactions.

It is found that particular food items become a source for certain elements. Reference [2] reported that cereals represent the primary source of Cu (35%), Fe (30%) and Mg (27%). In the case of non-vegetarian food, beef and pork shoulder were the best source of Fe and Zn [3], and the muscles of rainbow trout were good source of Se. Consequently, the food habit (i.e. vegetarian/ non-vegetarian) of an individual may have association with the changes in body element levels and may form the causal factor for multi-element exposures. Such altered status of elements may causes metabolic imbalance and leads to chronic health disorders such as diabetes and hypertension etc. Thus, it is obvious that there is a need of assessing either low concentration of essential trace elements or high concentration of non-essential, potentially toxic elements in the subjects with chronic health hazard such as diabetes. Such assessment of human exposure to trace elements can be done by biological monitoring which is a scientific technique based on sampling and analysis of individuals tissue or fluid. Incidentally, the present study aims to find out the influence of food habit on body levels of trace elements (Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn) and in turn it's effect on physical health of Mysore subjects.

MATERIALS AND METHODS

Subjects

The residents from Mysore city (M=60 & F=44) and surrounding villages (M=40 & F=32) who visited various hospitals in Mysore for consultation during the sampling period are the subjects (total: M=100 & F=76).

Sampling

With the approval of ethical committee five biological samples namely 1. whole-blood, 2. urine, 3. scalp hair, 4. fingernail and 5. permanent tooth samples were collected from subjects when visited to the Kamakshi Hospital, Bassappa Memorial Hospital, Vickram Hospital and J.S.S Dental College Hospital, Mysore. However, All the five samples could not be collected from same group and the collected blood, urine, scalp hair and fingernail samples were not equal in number because some people refused to donate nail and hair samples in view of their orthodox nature and tradition.

Preparation of sample for element analysis

Washing

As reported elsewhere [4] the tooth, scalp hair and fingernails were washed with double distilled water to completely remove loosely adhering external metals associated with fat, sweat and dirt without altering endogenous content of elements of the sample [5].

Drying

Washed samples were dried in hot air oven at 50^{o} C and 3 hr time was required to achieve a constant weight indicating complete desiccation of the samples [6].

Digestion

Dried samples were wet acid digested with addition of HNO_3 and $HClO_4$ in 4:1 ratio in Kjeldhal digestive unit following the procedures reported by others [6]. Blood sample was digested as it is and urine was not digested since it is in liquid form. Simultaneously, few blank and quality control samples were digested for every 20 samples.

Element analysis

Concentrations of Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn in whole blood, urine, scalp hair and fingernail samples were measured with Inductively Coupled Plasma-Atomic Emission Spectrometer (ICP-AES), model JY-IYON-2002–2 and the levels of Cr, Cu, Fe, Ni, Pb and Zn were measured in tooth samples with Flame-Atomic Absorption Spectrometer (F-ASS) model - AAS 6 VARIO (make - Analytic jena). Due to the non-availability of specific lamps, the amount of Cd, Co and Mn were not measured in tooth samples.

Quality control studies

The quality assurance in element analysis is taken care of by adopting 1) use of Certified Reference Material (CRM) – human hair powder as external quality control sample, 2) an in-house reference material as internal quality control sample and 3) participating in the inter laboratory quality control programme [7].

RESULTS AND DISCUSSION

In each group of subjects (rural & urban Mysore) the mean element concentrations for food habit and blood sugar level were computed for each biological sample. With use of 'student-t test' sample-wise comparison of elements level between subgroups of food habit (vegetarian & non-vegetarian) and blood sugar level (diabetes & non-diabetes) were made to find significance of the difference between the subgroups and the results were discussed as follows:

Comparison of element levels of blood between subgroups of rural & urban subjects

As reported by reference [8] it is found from the table 1 that diet is an important source of element exposure, which is evident from the levels of Cd-B and Pb-B being higher in non-vegetarian subjects than in vegetarian rural subjects from Mysore district. In support, other studies showed that Se-B was influenced by dietary habits [9]. The fish consumption was considered responsible for elevated Hg-B in Austrian subjects [10]. In contrast, no correlation was observed between blood elements and dietary habits of Turkey people [11]. Between diabetics and non-diabetics only Cu-B level differed and that too in villagers only. Reference [12] observed greater level of Cu-P in diabetics than controls. Likewise, reference [13] found significantly higher Cd-B in diabetics and opined that the toxic metal may play a role in the development of diabetes.

Comparison of element levels of teeth between subgroups of rural & urban subjects

Research findings revealed that food is an important source of teeth elements. Reference [14] observed that greater intake of seafood and use of fluoride dentifrices are possible reasons of higher F-T and Mg-T concentrations in the Japanese individuals. In the present study, the higher Zn-T levels which were observed in urban vegetarians substantiated the view of food as a source of element exposure (table 2).

Table 1. Comparison of element levels of blood between subgroups of rural & urban subjects

Subgroups		N	Mean concentration of elements in blood (ng/ml) ± SD							
			Cd	Co	Cr	Cu	Fe	Ni	Pb	Zn
Rural subjects	Vegetarians	20	1.41± 1.19	2.38± 1.31	3±3	228± 177.6	2395.7 ±1303	5.0± 3.22	7.80± 7.40	446.0 ±228. 8
	Non vegetarians	52	3.07± 1.44*	3.65± 1.18	6.38± 6.37	92.31 ±85.3	3640.6 ±1160. 6	13.0± 12.32	24.23 ±15.9 *	371.0± 146.5
	Non diabetics	32	2.45± 1.85	3.11± 1.47	4.25± 4.09	57.5± 55.9	3124.8 ±1462. 3	8.63± 8.33	16.00 ±17.4 7	331.0 ±165. 9
	Diabetics	40	2.73± 1.34	3.45± 1.24	6.40± 6.36	188.0± 184.2*	3430.8 ±1209. 6	12.50 ±12.0 5	22.60 ±14.7 5	440.6 ±163. 7
Urban subjects	Vegetarians	60	3.33± 1.14	3.89± 0.92	8.93± 8.68	145.3 ±109. 2	3879.3 ±919.0	13.33 ±8.17	40.27 ±37.9 5	412.2 ±149. 8
	Non vegetarians	44	3.69± 1.63	4.19± 1.24	8.55± 5.92	79.1± 73.3	4173.9 ±1195. 3	11.82 ±7.58	29.00 ±24.3 7	413.6 ±173. 0
	Non diabetics	52	3.66± 1.59	3.97± 1.25	7.92± 7.15	174.6 ±162. 8	3943.0 ±1218. 0	10.85 ±8.32	38.23 ±25.4 7	388.0 ±175. 6
	Diabetics	52	3.29± 1.09	4.07± 0.87	9.62± 8.03	160.0 ±156. 5	4064.9 ±854.7	14.54 ±7.10	32.77 ±50.7 8	437.6 ±137. 7

Note: Significance: * -P ⊆ 0.05, N – Number of samples, SD- Standard Deviation.

Table 2. Comparison of element levels of teeth between subgroups of rural & urban subjects

Subgroups		N	Mean element concentrations of teeth (µg/g) ± SD					
			Cr	Cu	Fe	Ni	Pb	Zn
Rural subjects	Vegetarians	16	15.09± 1.07	3.32± 0.58	61.98 ±11.6 3	17.34 ±0.86	51.41 ±22.8 8	143.92 ±21.63
	Non vegetarians	52	15.54± 6.14	3.53± 0.68	63.08 ±15.5 1	19.46 ±6.32	40.84 ±13.8 6	136.56 ±21.50
	Non diabetics	44	14.69± 5.44	3.57± 0.71	62.84 ±16.6 4	18.75 ±6.50	41.46 ±16.0 8	138.77 ±23.04
	Diabetics	24	18.08± 6.80	3.33± 0.42	63.32 ±7.83	20.68 ±4.04	44.11 ±9.78	128.04 ±8.74
Urban subjects	Vegetarians	28	20.19± 7.38	4.47± 4.78	81.23 ±19.7 5	28.80 ±9.45	65.36 ±7.42	176.06 ±51.02 *
	Non vegetarians	20	21.80± 9.56	2.64± 0.85	71.43 ±22.6 7	26.61 ±13.6 8	72.63 ±27.6 7	155.05 ±28.51
	Non diabetics	24	22.47± 8.74	2.37± 1.09	80.82 ±27.9 4	30.02 ±14.4 3	56.97 ±7.07	181.74 ±55.46
	Diabetics	24	19.26± 7.57	5.04± 6.10	73.48 ±11.0 6	25.76 ±6.39	72.81 ±24.7 4*	152.87 ±21.34

Note: Significance: * -P ⊆ 0.05, N – Number of samples, SD- Standard Deviation.

From the present observation of higher Pb-T in diabetes, it may be stated that the diabetes may be associated with the tooth element level (Pb-T). Similarly, increased concentration of Pb-T was reported in diabetic patients from Mysore [15].

Comparison of element levels of urine between subgroups of rural & urban subjects

It is observed from the table 3 that insignificant difference of urinary element levels between vegetarian and non-vegetarians shows that the food habits (vegetarian/non-vegetarian) did not affect the urinary elements of Mysore district subjects. In support, reference [16] found that food-Zn level did not show any effect on Zn-U level of the subjects from Spain. On the other hand, other studies showed significant influence of food habits on urinary element level [17].

Table 3. Comparison of element levels of urine between subgroups of rural & urban subjects

Sub group		N	Unit	Mean elements concentration in urine (in µg/l and µg/g cr) ± SD								
				Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Zn
Rural subjects	Vegetarians	16	µg/l	0.13± 0	0.16±0	0.19±0	0.12±0	0.16±0	0.06±0	0.27±0	0.22±0	0.21±0
			µg/g cr	9.66± 8.69	11.83± 10.7	13.71±12.8	8.46± 7.29	11.68± 10.6	4.32± 4.05	17.41± 13.6	14.34± 11.0	12.33± 10.02
	Non vegetarians	20	µg/l	0.10± 0.04	0.18± 0.02	0.16± 0.04	0.08± 0.05	0.16± 0.01	0.08± 0.02	0.37± 0.18	0.24± 0.05	0.71± 0.61
			µg/g cr	10.84± 10.8	14.31± 14.4	15.26± 13.4	9.21± 12.1	13.75± 12.8	5.62± 5.24	23.90± 18.9	17.97± 16.7	30.02± 28.08
			µg/g cr	10.68± 10.1	13.08± 12.5	15.28± 14.9	9.36± 8.42	13.12± 12.4	4.81± 4.74	18.40± 15.6	15.33± 12.8	15.83± 11.39
	Non diabetics	12	µg/l	0.14±0	0.16±0	0.19±0	0.12±0	0.16±0	0.06±0	0.26±0	0.22±0	0.15±0
			µg/g cr	17.33± 15.3	20.21± 17.2	23.69± 20.6	15.26± 12.8	19.80± 17.5	7.42± 6.58	30.73± 23.4	25.38± 19.3	19.64± 17.73
	Diabetics	24	µg/l	0.11± 0.04	0.18± 0.02	0.16± 0.03	0.09± 0.05	0.17± 0.01	0.07± 0.02	0.36± 0.17	0.23± 0.05	0.65± 0.69
			µg/g cr	6.81± 7.80	9.71± 8.74	10.02± 10.1	5.68± 5.82	9.34± 8.93	3.85± 3.19	16.16± 10.6	11.85± 9.02	23.42± 26.43
Urban subjects	Vegetarians	52	µg/l	0.10± 0.04	0.17± 0.01	0.16± 0.04	0.16± 0.25	0.16± 0.01	0.07± 0.02	0.41± 0.24	0.21± 0.06	0.36± 0.27
			µg/g cr	4.59± 3.84	6.88± 4.03	6.63± 4.89	5.82± 7.73	6.63± 3.93	2.91± 1.49	14.09± 6.7	8.66± 6.0	11.63± 7.38
	Non vegetarians	32	µg/l	0.13± 0.03	0.17± 0.01	0.18± 0.04	0.10± 0.04	0.17± 0.02	0.06± 0.01	0.34± 0.10	0.26± 0.10	0.41± 0.21
			µg/g cr	7.59± 10.3	9.30± 10.8	9.95± 12.6	6.30± 9.86	10.45± 14.2	3.32± 4.83	14.55± 16.3	12.91± 16.7	17.60± 20.5
	Non diabetics	36	µg/l	0.13± 0.03	0.17± 0.01	0.18± 0.02	0.11± 0.03	0.16± 0	0.06± 0.01	0.31± 0.07	0.24± 0.04	0.23± 0.16
			µg/g cr	6.41± 3.91	8.52± 4.49	8.83± 5.10	5.40± 3.56	8.09±4.38	3.22± 1.79	14.68± 6.15	11.51± 6.36	9.45± 5.23
	Diabetics	48	µg/l	0.10± 0.05	0.17± 0.01	0.16± 0.05	0.15± 0.26	0.17± 0.02	0.08± 0.02	0.43± 0.25	0.23± 0.10	0.49± 0.23**
			µg/g cr	5.23± 9.23	7.26± 10.2	7.20± 10.1	6.45± 8.84	8.08± 10.1	2.95± 3.87	13.95± 13.8	9.35± 10.92	17.24± 18.7

Note: Significance: **-P ⊆ 0.01, N – Number of samples, SD- Standard Deviation.

The concentration of Zn-U was alone found higher in diabetic urbanites, whereas, no impact of blood sugar level in urinary element concentration was observed in the rural subjects. This may be due to the fact that the urbanites taking higher levels of mineral rich food with regularity in taking supplementary mineral medicine showed more urinary excretion of the elements than the villagers.

Comparison of element levels of scalp hair between subgroups of rural & urban subjects

Although diet is expected to affect the levels of hair elements, the present study indicated no significant difference in scalp hair element levels between vegetarians and non vegetarians (table 4). This may be due to taking non vegetarian food occasionally or in lesser frequency by the non-vegetarians and the food habits of non vegetarians may be more or less similar to the vegetarians (i.e. mixed diet). Reference [18] supported this observation by stating that there was no significant difference in the mean hair element levels between non vegetarians and vegetarians from Bombay.

Table 4. Comparison of element levels of scalp hair between subgroups of rural & urban subjects

Subgroups		N	Mean elements concentration of scalp hair (µg/g) ± SD							
			Co	Cr	Cu	Fe	Mn	Ni	Pb	Zn
Rural subjects	Vegetarians	12	4.68± 2.42	0.46± 0.32	1.86± 1.25	5.15± 2.34	1.20± 0.54	0.57± 0.25	0.82± 0.29	91.00± 4.54
	Non vegetarians	28	3.55± 1.02	0.31± 0.11	5.82± 9.02	3.96± 1.13	1.11± 0.54	0.41± 0.21	0.71± 0.52	98.32± 15.58
	Non diabetes	16	2.78± 0.62	0.35± 0.10	1.90± 1.72	3.18± 0.67	1.06± 0.41	0.44± 0.19	0.98± 0.65	100.78 ±21.72
	Diabetes	24	4.63± 1.51*	0.35± 0.24	6.45± 9.65	5.08± 1.52*	1.19± 0.59	0.47± 0.26	0.58± 0.20	93.02± 3.18
Urban subjects	Vegetarians	48	4.68± 3.24	0.67± 1.31	5.01± 6.05	5.69± 4.51	2.47± 2.77	0.99± 0.47	1.23± 0.90	115.67 ±37.09
	Non vegetarians	32	3.03± 2.47	0.26± 0.09	2.18± 1.65	3.42± 2.57	0.95± 0.52	0.36± 0.14	0.91± 0.41	97.56± 11.17
	Non diabetes	32	3.13± 2.97	0.78± 0.62	5.63± 5.39	4.25± 4.21	2.93± 2.89	1.08± 1.03	1.31± 1.01	116.82 ±46.15
	Diabetes	48	4.61± 3.01	0.33± 0.17	2.71± 1.82	5.14± 3.02	1.10± 0.58	0.51± 0.30	0.96± 0.50	102.83 ±12.53

Note: Significance: * -P $\subseteq$ 0.05, N – Number of samples, SD- Standard Deviation.

However, in the present investigation, higher levels of Co-H and Fe-H were found in diabetes than in non diabetic villagers, whereas no change in element levels in urbanities. This

may indicate that higher levels of Co-H and Fe-H may be a responsible factor for diabetic condition.

Comparison of element levels of fingernails between subgroups of rural & urban subjects

Table 5 shows that increased nail levels of Cd, Cr, Mn and Zn which may be due to the vegetarian diet in urban subjects from Mysore. Reference [19] reported high As, Mn, Pb, and Ni in the nail levels and opined that it may be form food. While reference [20] found that the concentration of Hg-FN was correlated with the number of fish meals of subjects from the Province of Rome. However, reference [21] observed no difference in Se-TN levels between vegetarians and non vegetarians from Oxford.

Table 5. Comparison of element levels of fingernails between subgroups of rural & urban subjects

Subgroups		N	Mean elements concentration in fingernails (µg/g) ± SD								
			Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Zn
Rural subjects	Vegetarians	20	2.17± 1.93	8.11± 2.90	2.20± 2.10	10.8 ±15.0	30.18 ±12.59	7.03 ±6.54	3.17± 5.61	2.73 ±2.21	169.70 ±109.7
	Non vegetarian	20	0.98± 0.47	4.24± 3.49	0.83± 0.37	5.63 ±4.40	16.67 ±9.42	3.10 ±1.26	1.11± 1.39	1.06 ±0.56	110.94 ±57.16
	Non diabetics	16	0.74± 0.4	5.46± 3.41	0.66± 0.20	4.52 ±2.95	20.04 ±10.42	2.53 ±1.11	1.49± 1.27	1.09 ±0.55	88.73 ± 60.25
	Diabetics	24	2.13± 1.69	6.65± 4.04	2.08± 1.89	10.7 ±13.6	25.67 ±14.44	6.76 ±5.82	2.58± 5.23	2.44 ±2.13	174.71 ±90.85
Urban subjects	Vegetarian	52	1.56± 1.4*	2.97± 3.68	1.48± 1.42*	7.95 ±9.09	13.71 ±8.42	5.06 ±3.85*	3.18± 3.02	2.07 ±1.34	147.69 ±127*
	Non vegetarian	28	0.54± 0.36	2.38± 2.99	0.42± 0.18	2.83 ±2.96	12.28 ±8.67	1.58 ±0.80	0.34± 0.52	2.51 ±1.73	53.50 ± 39.58
	Non diabetics	32	0.70± 0.38	2.68± 2.53	0.52± 0.23	1.99 ±2.41	12.45 ±6.89	1.97 ±0.99	0.40± 0.60	2.02 ±0.61	197.74 ±121 *
	Diabetics	48	1.96± 1.6*	3.51± 3.45	1.98± 1.6**	12.4 ±9.0 **	14.33 ±10.6	6.64 ±5.6 **	4.87± 4.1**	3.72 ±2.40*	59.37 ± 56.95

Note: Significance: * -P ⊆ 0.05; **-P ⊆ 0.01, N – Number of samples, SD- Standard Deviation.

Further, urban diabetic subjects from Mysore had significantly higher fingernail levels of Cd, Cr, Cu, Mn, Ni and Pb and lower level of Zn than the non diabetics. This observation was ascertained by reference [22] from their findings of positive correlation between diabetes and nail levels of Cr, Mn, and Ni. Whereas, reference [23] found no difference in these element levels between control and diabetic subjects from urban New Delhi.

It is observed from the present study that trace elements either in excess of toxicants (Pb, Cd, As, Hg etc.) or deficiency of essential nutrients (Cr, Zn, Mn, Cu, etc.) are found related to ill health including diabetes [24]. The change in tissue concentrations of elements is an indicator of health condition of human being [25]. Reference [26] indicated that diabetic females from New Delhi had lower level of Zn-H and hypertensive females had lower levels of Cr-H and Zn-H.In the present investigation the rural diabetics had higher levels of Co-H and Fe-H, but urban diabetics showed lower levels of Zn-FN, and higher levels of Cd-FN, Cr-FN, Cu-FN, Mn-FN, Ni-FN, Pb-FN and Pb-T. The main finding of our study is that the existence of some positive correlation between traces elements and human diabetes.

In our study, the rural vegetarian subjects had lower levels of Cd-B and Pb-B than non-vegetarian rural subjects. It is reasoned for such difference that especially intake of a high fibre diet apparently lowers uptake of metals from intestine. In support, reference [9] and [27] opined that Se-B levels were influenced by dietary habits and fish consumption and reference [10] found that fish consumption elevated Hg-B in Austrian population. Further, reference [28] reported that consumption of spinach, seaweed, organ meats and shellfish tended to be positively correlated with urinary element concentrations and consumption of various forms of potatoes tended to be negatively correlated. When higher Pb and lower Zn levels in urban diabetes have been observed, it is viewed that higher Pb from environment and lower Zn from food intake are the casual factors related to diabetes.

CONCLUSION

It is evident from the present study that food habit (i.e. vegetarian/ non-vegetarian) affects/changes the elements level and causes elements imbalance leading to altered element metabolism, which may be one of the causal factor for diabetes.

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