Hair Chromium Concentration in Malnourished and Healthy Preschool Children of Rural Bangladesh

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Introduction

Protein-Energy malnutrition in infancy and childhood is primarily a syndrome of deficiencies of protein and energy but also associated with deficiencies of various essential nutrients. The essentiality of chromium in nutrition and the role of chromium in carbohydrate metabolism were very well documented[1,2]. Recent evidences suggest that chromium may be associated with the Glucose Tolerance Factor (GTF) which potentiates the action of insulin at the receptor sites[3]. Data from the studies in Jordan[4], Turkey[5,6] and Nigeria[4] showed that impaired carbohydrate metabolism due to chromium deficiency as indicated by hypoglycemia and impaired glucose tolerance, is generally encountered in children with protein-energy malnutrition.

In premature infants and those with evidences of intrauterine growth retardation,[7,8] juvenile diabetics[9] as well as insulin dependent diabetic women[10], the hair chromium levels were reported to be significantly reduced. Chromium levels in the tissues of liver of diabetics were also found to be below normal[11]. Indirect evidences from the study by Hambidge et al.[12] strongly support the view that hair chromium level might be used to assess the nutritional status of chromium.

As Chromium deficiency may be a cause of impaired glucose tolerance observed in these malnourished children, and due to widespread prevalence of varying degrees of malnutrition among the preschool children of our country[13], the present study was undertaken as a preliminary study to find out the hair chromium status and fasting blood glucose levels of malnourished preschool children of our country.

Materials and Methods

Different clinical types of fiftythree malnourished children, aged between I and 5 years, were selected purposively for this study. Fourtynine apparently healthy children were selected as control, matching age and socio-economic status with the study population. Screening was done by histories, clinical examination, anthropometric measurements and biochemical tests. Growth chart introduced by National Centre for Health Statistics (NCHS) was used to assess the nutritional status of these children[14], and Well come Classification[15] was used to classify different clinical types of malnourished children. Informed consent was obtained from each parents before study.

Sample collection and preparation

Hair samples cut close to the occipital portion of the scalp with stainless steel scissors, were collected from each of the children, and were kept in clean paper envelops until preparation for analysis. Blood samples were collected from each of the children for the determination of serum total protein and serum total albumin and fasting blood glucose levels. In case of

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malnourished children, hair and blood samples were collected after admission to hospital before any treatment was initiated. Blood for fasting glucose levels were collected in the morning after a 6-7 hour fasting and were kept in test tubes containing a mixture of sodium flouride and potassium oxalate.

To prevent any contamination, all the glasswares were cleaned at first by overnight immersion in a solution of ultraclean powder (Alconox, S-19650, New York, USA). Then they were kept overnight into a mixture of 20% nitric acid and 5% hydrogen peroxide. Finally, they were washed 3-4 times with deionized water and then dried in an oven.

Hair samples were washed according to the procedure described by International Atomic Energy Agency (IAEA)[16] and pellets were made according to the procedures described by Hussain et al.[17], and preserved in a dessicator until irradiated for the determination of chromium.

For preparing serum, blood was allowed to clot at room temparature for about 1 hour and then centrifused at 1000 g for 10 minutes. The clear supernanant was then transfered by a pateur pipettee into another pyrex test tube. All blood and serum samples were kept at 4.C until analysis.

Collection of dietary data

The dietary informations were obtained from their mothers by a trained dietician by a 24 hours dietary recall method along 3 week-days food records and frequency of food intakes and a food weighting on the study day. The amounts of nutrients intakes were calculated from the Food Composition table [18].

Analytical Methods

Chromium levels in hair matrix were determined by Proton-Induced X-ray Emission Spectro-scopic, external beam method [19].

Fasting blood glucose levels were determined by Glucose oxidase method [20]. Serum total protein and serum total albumin were measured by Biuret method[21].

Statistical Analysis

Mean concentration of hair chromium of control children was compared with that of malnourished children by Two sample Student t-test and also by Cochran's modified t-test to allow for inequality of variance. The t-test was also performed following logarithmic transformation to ensure the stability of variance and normality of sample. Anaylsis of variance by one-way classification was done to find out an effect of age on hair chromium level of control children within and between groups[22]. In all analysis, results were considered significant statistically if $P < 0.05$.

Results

Hair chromium levels in control and malnourished children

The mean levels of hair chromium of control children which were arbitrarily subdivided into[4] age groups were 8.5 ± 4.7 (1-2 years); 5.4 ± 5.1 (2-3 years); 4.1± 2.1 ppm (3-4 years); and 4.0 ±1.7 ppm (4-5 years) (Table -I). F-ratio as seen from the table is I.7I, which has indicated that hair chromium levels of these children do not change significantly ($p>0.05$) with age from 1 to 5 years and without any differences in chromium levels in control children between and within groups.

The mean concentrations of hair chromium of control, kwashiorkor, marasmic-kwashiorkor and marasmic children are presented in Table -II. These were 6.3± 3.7 ppm, 4.2 ± I.2 ppm, 3.7 ±1.7 ppm and 3.6 ± I.5 ppm respectively. Significant

differences were found between the chromium levels of control and marasmic-kwashiorkor and marasmic children ($P < 0.05$)., but no difference was found between chromium level of control children and that of children with kwashiorkor ($P > 0.5$).

Table 1. *Hair chromium levels in 4 different age groups of control children.*

Age	No. of children	Hair chromium levels (ppm or microgram/g of dry hair)	F-ratio	P-value
1-2 years	14	8.5 ± 4.7[a]		
2-3 years	11	6.4 ± 5.1		
3-4 years	9	4.1 ± 2.1	1.71	P> 0.05
4-5 years	15	5.0 ± 1.7		(NS)[b]

a. Mean ± S.D.

b. NS means not significant

Table 2. *Hair chromium levels in control, kwashiorkor, marasmic-kwashiorkor, and marasmic children.*

Nutritional status	No. of children	Hair chromium level (ppm or microgram/g of dry hair)	Comparison with control children group[a]
Control	49	6.3 ± 3.7[b]	---
Kwashiorkor	10	4.2 ± 1.2	P> 0.05 (NS)[c]
Marasmic-kwashiorkor	18	3.7 ± 1.7	P< 0.05
Marasmus	27	3.6 ± 1.5	P< 0.05

a. Two Sample Student t-test.

b. Mean ± S. D

c. NS means not significant.

Table 3. *Fasting blood glucose levels in control and malnourished children:*

Nutritional Status	No. of children	Fasting blood glucose levels (mg/100 ml)	Comparison with control children group[a]
Control	49	96.6 ± 20.4[b]	--
Kwashiorkor	10	60.2 ± 19.3	P< 0.05
Marasmic Kwashiorkor	18	58.5 ± 13.6	P< 0.05
Marasmus	27	50.8 ± 10.7	P< 0.05

a. Two Sample Student t-test.

b. Mean ± S.D.

Table 4. *Mean daily intakes of energy, protein, carbohydrate by control and malnourished children.*

Nutrients	Malnourished children	Control children
Energy (Kcal/day)	647.5 ±162.0	1151.3 ± 247
(Kcal/kg/day)	53.8 ± 4.8	96.2 ± 2.1
(Plant origin)	78 - 90%	61 -80%
Protein (g/day)	15.2 ± 4.5	22.8 ± 3.0
(g/kg/day	1.2 ± 0.6	1.72 ± 0.1
(% of total energy)	8%	10%
(Plant orgin, gm)	11.9 ± 4.9	12.4 ± 3.2
(Animal origin, gm)	2.2 ± 0.9	10.4 ± 0.35
Carbohydrate (g/day)	125.2 ± 33.8	222.8 ± 84.8
(g/kg/day)	10.4 ± 2.4	18.2 ± 2.8
(% of total energy)	approx. 80.	approx. 70.

Table 5. *Serum total protein and serum total albumin in control and malnourished children*

Nutritional status	No. of children	Serum total protein (g/100 ml)	Serum total albumin (g/100 ml)
Control	49	6.6 ± 0.7[a]	3.8 ± 0.6[a]
Kwashiorkor	10	3.6 ± 0.4	1.4 ± 0.4
Marasmic kwashiorkor	18	3.2 ± 0.3	1.8 ± 0.7
Marasmus	27	4.2 ± 0.1	2.1 ± 0.8

a. Mean ± S.D.

Fasting blood glucose levels in control and malnourished children

The mean levels of fasting blood glucose of control (86.6 ± 20.4); kwashiorkor (60.2 ± 19.3), marasmic-kwashiorkor (58.5 ± 13.6) and marasmic children (50.8 ±10.7 mg/100 ml) are presented in Table-III.

There were significant differences between the fasting blood glucose levels of control children and those of all three clinical types of malnourished children ($p< 0.05$).

Dietary intakes by control and malnourished children

Mean daily intakes of energy, protein and carbohydrate by control and malnourished children are presented in Table-IV. Intakes of protein and carbohydrate by them supply only 8% and 80% of their total energy requirements according to US Recommended dietary Allowance[2]. Foods of plant origin supply 78-90% at daily energy intate.

Biochemical Values in control and malnourished children

The mean serum total protein of control, kwashiorkor, marasmic-kwashiorkor, and marasmic children are 6.6 ± 0.7, 3.6 ± 0.4, 3.2 ± 0.3, and 4.2 ± 0.1 (g/100 ml) respectively and mean serum total albumin of control, kwashiorkor, marasmic-kwashiorkor, and marsasmic children are 3.8 ± 0.6, 1.4 ± 0.4, 1.8 ± 0.7, and 2. 8. (g/100 ml) respectively (Table-V).

Discussion

The results of this study has showed that age has no significant effect on hair chromium levels of control children from 1-5 years of age, which confirms those reported by Hambidge et al.[12]. Hair chromium levels of children with either marasmic-kwashiorkor or marasmus was found to be significantly lower than that of control children but no significant difference was found in hair chromium levels of kwashiorkor children compared to control children. The present study also confirms that fasting blood glucose level, an indicator of impaired carbohydrate metabolism encountered in all the clinical types of protein-energy malnourished children were significantly lower, when compared to that of control children.

Hair chromium levels of children with marasmic-kwashiorkor and marasmus were

found to be significantly lower than that of control children but showed no significant difference between hair chromium levels of kwashiorkor and control children. The results of the studies reported from Turkey [5,6], Jordan,[4]. and Nigeria[4] also showed evidences that children with protein energy malnutrition may suffer from chromium deficiency.

It is well-known that disorders of carbohydrate metabolism such as low fasting blood glucose levels, impaired glucose removal rates occur in children with chromium deficiency, commonly encountered in protein -energy malnutrition [4-6]. This study has showed that reduced fasting blood glucose levels found in these marasmic-kwashiorkor and marasmic children were probably due to chromium deficiency as evidenced by low hair chromium levels in these children. But low fasting blood glucose level found in kwashiorkor children of this study could not be explained by chromium deficiency as mean hair chromium level of these children has showed no significant difference when compared to that of control children. However, presence of severe infections, hypothermia and many other unknown metabolic factors might probably play roles in causing low fasting blood glucose levels in these children[23]. Carter et al.[24] have showed no significant relationship between chromium and low fasting glucose levels seen in children with kwashiorkor in Egypt. Ample amounts of chromium were found in some of the foodstuffs consumed by these children prior to admission to the hospital and variable, but sometimes quite large amounts in therapeutic agents employed.

Toepfer et al.[25] and Carter et al.[26] reported that edible portions of most of the grains and cereals contain ample amounts of chromium. In this present study, foods consumed by the control malnourished children were not analyzed for chromium contents but analysis of dietary data showed that malnourished children usually consumed 78-90% of plant origin foods. As a part of their daily dietary intakes and these cereals probably contain sufficient amounts of chromium. Children with kwashiorkor of this study, prior to admission to hospital probably consumed ample amounts of chromium compared to marasmic-kwashiorkor and marasmic children through their daily diets and drinking water.

It is not yet absolutely confirmed if hair chromium concentration is a valid, indicator of total body chromium or of chromium nutritional status. This study indicates that protein-energy malnutrition has a very significant effect on hair chromium content with consequent impaired carbohydrate metabolism and raises questions concerning the adequacy of chromium nutrition during protein-energy malnutrition. However a meaningful interpretation of the results need more data on this aspect.

Summary

Chromium conentrations in hair of fiftythree different types of malnourished and fourtynine control children of I-5 years of age, and their fasting blood glucose levels were determined. Age was found to have no significant effect on hair chromium levels ($P>0.05$). This study has showed that hair chromium levels of children with marasmic-kwashiorkor and marasmus were significantly lower than that of control children ($P<.05$) but has showed no significant difference in the hair chromium levels between control and kwashiorkor children ($P>0.05$). This study has also showed that fasting blood glucose level in all the three types of malnourished children is significantly lower ($P<0.05$) than that of control children. This study indicated that protein-energy malnutrition has a very significant effects on hair chromium

contents with consequent impaired carbohydrate metabolism and raised the questions concerning chromium malnutrition during protein-energy manutrition.

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