ABSTRACT

This case control study was carried out in the department of Anatomy in cooperation with Department of Pediatrics and Department of Biochemistry, Institute of Medical Sciences Banaras Hindu Varanasi during the period from October 2009 to July 2012. The aim of the study was to explore the status of serum zinc; copper and Iron level in Indian children living in eastern Uttar Pradesh with Protein Energy Malnutrition (PEM) as a means to monitor the possibility of management of these children as each of these mineral deficiencies produce typical deficiency syndromes. A total of 250 children from five months to five years were included in this study. One hundred and ninety three of these subjects had different grades of PEM; of these children sixty five children belong to mild, sixty to moderate and sixty eight to severe group. Fifty seven remaining children who were healthy well-nourished were recruited as controls. Cases were again categorized into three subgroups. These were Marasmus (n=54), Kwashiorkor (n=18) and Marasmic Kwashiorkor (n=34). Serum zinc, iron and copper levels were determined by Atomic Absorption spectrophotometric method. Statistical analysis was done by using Statistical Package for the Social Sciences (SPSS) window package. Among the different groups of children mean±SD (Standard Deviation) of serum zinc in PEM Marasmus (0.03 ± 0.04 mg/dl), Kwashiorkor (0.05±0.07 mg/dl) and Marasmic Kwashiorkor (0.04± 0.06 mg/dl) were all significantly lower (p<0.001) than in control group (0.76 ± 0.13 mg/dl). Similarly mean ±SD of serum copper in PEM Marasmus (0.09±0.26 μg/dl), Kwashiorkor (0.10±0.03 mg/dl) and Marasmic Kwashiorkor (0.10±0.25) were all also significantly lower (p<0.001) than in control group (0.27 ± 0.01 mg/dl). Whereas mean±SD of serum Iron in Marasmus (1.74 ± 0.18 mg/dl) Kwashiorkor (1.87 ± 0.20 mg/dl) and Marasmic Kwashiorkor (1.84± 0.19) were all significantly increased (p< 0.001) than in control group (0.68 ± 0.14 mg/dl). It is evident from the study that serum zinc and copper level significantly decrease in children with PEM whereas serum iron level was significantly increased in malnourished children.

INTRODUCTION

Nutrition in the developing world is in a sorry state. The designation micronutrient traditionally has referred to the trace minerals and vitamins of low molecular weight essential to human health. The micronutrient do not serve as energy stores they are important in cellular metabolism and are related to enzyme systems where they act either as cofactor for metal ion activated enzymes or as specific constituents or as specific constituents of metallo-enzymes, bodily functions and in protection of the body against oxidative damage.

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Iron, zinc, copper, manganese, selenium, molybdenum, cobalt, chromium and iodine are generally considered to be the essential trace elements which functions as components of metallo-enzymes and as cofactors for enzymes. The understanding of adequate trace element nutrition is a key factor in designing a better nutrition that protects humans from infections. Although micronutrients deficiencies are common in developing countries (Muller et al., 2001), the levels of these micronutrients are rarely determined in malnourished children. The present work aims to evaluate trace elements in patients with malnutrition in an attempt to throw light on the possible role of these trace elements as protective agents and that their deficiencies associated with the manifestations of P.E.M.

MATERIAL AND METHODS

The study was conducted in the Department of Biochemistry & Department of Pediatrics, Institute of Medical Sciences, Banaras Hindu University, Varanasi. Two hundred fifty children of age between 6 months to 5 years were selected. These children were examined for malnutrition, diagnosed and classified according to nutrition subcommittee of IAP in 4 grades with various percentages of expected body weight for age. Total malnourished children were 193 and the remaining 57 children apparently looking normal & healthy and presenting no clinical and anthropometric sign or symptoms suggestive of any form of malnutrition were used as control group to compare with.

The children were classified using the standard value 100% as 50th percentile of the standard NCHS growth standard. Normal > 80% of standard wt for age, Group-I =71-80%, Group -II =61-70%, Group -III = 51-60 % and Grade IV = <50%. According to this classification 193 children were of strictly defined malnutrition cases, of these children sixty five belong to grade 1, sixty to grade 2 and sixty eight to grade 3 and 4. The cases of grade 2 and grade 3 and 4 were further classified into Marasmus, Kwashiorkor and Marasmic Kwashiorkor. Anthropometric measurements of height, weight, mid upper arm circumference and chest circumference were taken.

Statistical analysis: Statistical analysis was performed by SPSS 11.5 software. Subjects with malnutrition were compared with non-malnourished controls. Means and standard error of means were calculated, and differences between means were.
assessed by one way analysis of variance (ANOVA). The strength of association between pairs of variables was assessed by Pearson correlation coefficients. The level of significance was set at P<0.05.

**OBSERVATION AND RESULTS**

**Table-1: Anthropometric measurement in cases of malnutrition and controls**

<table>
<thead>
<tr>
<th>Anthropometric Measurement</th>
<th>Control (n=57)</th>
<th>Grade-1 (n=65)</th>
<th>Grade-2 (n=60)</th>
<th>Grade-3 &amp; 4 (n=68)</th>
<th>F* value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (kg)</td>
<td>12.09±3.04</td>
<td>9.44±2.28</td>
<td>8.11±1.77</td>
<td>6.75±2.04</td>
<td>75.39</td>
<td>≤0.001</td>
</tr>
<tr>
<td>Age (months)</td>
<td>29.52±15.90</td>
<td>30.8±15.3</td>
<td>27.7±13.9</td>
<td>26.2±17.6</td>
<td>1.22</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>87.80±12.03</td>
<td>88.7±10.95</td>
<td>83.97±10.69</td>
<td>80.9±13.52</td>
<td>7.001</td>
<td>≤0.001</td>
</tr>
<tr>
<td>Head Circumference (cm)</td>
<td>47.40±2.18</td>
<td>47.7±1.78</td>
<td>46.80±2.10</td>
<td>46.8±2.48</td>
<td>2.507</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Mid Arm Circumference (cm)</td>
<td>14.90±0.89</td>
<td>13.9±0.86</td>
<td>12.04±1.14</td>
<td>10.9±0.97</td>
<td>263.7</td>
<td>≤0.001</td>
</tr>
<tr>
<td>Chest Circumference (cm)</td>
<td>48.52±3.59</td>
<td>49.02±3.16</td>
<td>48.10±3.10</td>
<td>47.7±4.35</td>
<td>1.80</td>
<td>&gt;0.05</td>
</tr>
</tbody>
</table>

**Table-2: Serum Cu, Zn & Fe of different groups of malnourished and normal children.**

<table>
<thead>
<tr>
<th></th>
<th>Control (n=57)</th>
<th>Grade-1 (n=65)</th>
<th>Grade-2 (n=60)</th>
<th>Grade-3 &amp; 4 (n=68)</th>
<th>F value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cu mg/dl</td>
<td>0.27±0.01</td>
<td>0.21±0.08</td>
<td>0.14±0.01</td>
<td>0.08±0.01</td>
<td>755.8</td>
<td>≤0.001</td>
</tr>
<tr>
<td>Zn mg/dl</td>
<td>0.76±0.13</td>
<td>0.54±0.08</td>
<td>0.17±0.03</td>
<td>0.01±0.02</td>
<td>1427</td>
<td>≤0.001</td>
</tr>
<tr>
<td>Fe mg/dl</td>
<td>0.68±0.14</td>
<td>0.93±0.10</td>
<td>1.49±0.16</td>
<td>1.89±0.14</td>
<td>1134</td>
<td>≤0.001</td>
</tr>
</tbody>
</table>

**Table-3: Serum Cu, Zn & Fe of different groups of PEM children and control.**

<table>
<thead>
<tr>
<th></th>
<th>Control (n=57)</th>
<th>Marasmus (n=54)</th>
<th>Kwashiorkor (n=18)</th>
<th>Marasmus &amp; Kwashiorkor (n=34)</th>
<th>F value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cu mg/dl</td>
<td>0.27±0.01</td>
<td>0.09±0.26</td>
<td>0.10±0.03</td>
<td>0.10±0.25</td>
<td>755.8</td>
<td>≤0.001</td>
</tr>
<tr>
<td>Zn mg/dl</td>
<td>0.76±0.13</td>
<td>0.03±0.04</td>
<td>0.05±0.07</td>
<td>0.04±0.06</td>
<td>789.02</td>
<td>≤0.001</td>
</tr>
<tr>
<td>Fe mg/dl</td>
<td>0.68±0.14</td>
<td>1.74±0.18</td>
<td>1.87±0.20</td>
<td>1.84±0.19</td>
<td>635.05</td>
<td>≤0.001</td>
</tr>
</tbody>
</table>

Number in parentheses show no. of samples analyzed
F* One way Analysis of variance (ANOVA)
p≤ 0.05 (Student-Neumen Keuls multiple range test)

**RESULTS**

Subjects with malnutrition were compared with non-malnourished controls. Means and standard deviation were calculated and difference between means were assessed. The strength of association between pairs of variables was assessed. The level of significance was set at P<0.05. The mean age, HC, CC between malnourished and control group was comparable. The weight, height, MAC levels were significantly reduced in malnourished children.
There is a significant decrease of the serum level of zinc, copper in all groups of malnutrition compared with the control group. The plasma free iron levels were significantly increased in children with malnutrition.

**DISCUSSION**

The results of this study revealed significant decrease in serum zinc level in all groups of patients compared with control group. This is in accord with previous studies.²³ There was significant decrease in serum level of copper in malnourished children compared with control group. Also, serum copper level is significantly lower in marasmus compared with the control which are in agreement with that reported by Ashour et al., (1999)⁵ and Ibrahim (1990)⁶.

The low level of serum copper in marasmic children may be due to reduction in ceruloplasmin in marasmic children, which, is attributed to its excessive loss or destruction or inability to synthesis leading to lack of copper transport to the liver.⁷ Another contributing factor that may lead to copper deficiency in marasmic cases is repeated bouts of acute and chronic diarrhoea and malabsorption which are common with marasmus.⁸ Copper and zinc deficiency has been attributed to losses, inadequate intake and poor bioavailability.⁹ Copper deficiency has been found in children with diarrhea,¹⁰ in patients receiving long term parenteral nutrition¹¹ phytate which is present in most foods of plant origin can hinder zinc absorption.¹²

Excess zinc levels induce the synthesis of the intracellular ligand metallothionine (MTO) in enterocytes, which then binds zinc. The excess zinc bound to MTO then is excreted in the faeces through enterocyte shedding. However, copper, with its higher affinity for MTO, displaces zinc and also is excreted, reducing the amount of copper delivered to the enterocyte.¹³ On the other hand copper with its higher affinity for metallothionine binds preferentially and therefore sequestered, making it unavailable for absorption.¹⁴ The concentrations of the two elements were lower in malnourished children in the present study The mechanism by which both copper and zinc lower levels occurred simultaneously is not known, as both elements exhibit antagonistic relationships.¹⁵ It might be an indication that both were present at lower levels in the diet of malnourished children Copper and zinc contents of diet in a given population depends on the soil contents of these elements.¹⁶

Mean plasma iron concentrations in our malnourished children were significantly increased than those of control. In malnourished children, plasma iron concentrations were reported to be either normal or overloaded.¹⁷ This may be a consequence of an increased transferrin saturation and hence the reduction in the capacity to deal with an iron overload.¹⁸ It is possible that free iron or loosely bound iron acts as a redox catalyst, particularly as the synthesis of transferrin and other iron-binding protein are impaired.¹⁹ In addition, low plasma level of ceruloplasmin in PEM children may decrease the binding of iron with transferrin. The low concentrations of iron binding proteins may explain the elevated levels of Fe in children with malnutrition

**CONCLUSION**

Malnourished children in our environment are copper and zinc deficient with associated anemia. Supplemental copper and zinc should be part of nutritional rehabilitation of malnourished children in order to achieve optimal results and avoid clinical complications associated with zinc and copper deficiencies. However, fortification of food with zinc and copper remains the best way to prevent deficiencies in those at risk. However, iron supplement in severe malnutrition may aggravate clinical condition as there may be already iron overload in these groups of patients contributing more to existing oxidative stress of PEM.

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*M. Khare et al.*

**Serum Micro-Minerals Levels in Protein Energy Malnutrition in Indian Children**

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REFERENCES


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