Abstract: Zinc is essential in the metabolic activities in the body including protein, DNA and RNA synthesis. It plays a role in neurogenesis, maturation, and migration of neurons and in synapse formation. Zinc is high in the hippocampal neurons which is involved in learning and memory. Deficiency of zinc during pregnancy has been related to many congenital abnormalities of the foetal nervous system. Furthermore insufficient levels of zinc in children is associated with lowered learning ability, apathy, lethargy and mental retardation. Maternal deficiency of zinc during lactation has been associated with impairment of infant brain development. Zinc status in mother and child can be assessed by measurement of zinc in plasma; zinc deficiency can be corrected with appropriate diet and zinc supplements.

Zinc Neurobiology and neurophysiology

Zinc acts on glutamate receptors and other voltage-gated ion channels in the brain. It also modulates synapses (a property known as synaptic plasticity). Both of these effects contribute significantly to learning and memory. The highest concentrations of zinc in humans are found in the hippocampus and in the choroid layer of the retina which is part of the brain. All pieces of information are processed by the hippocampus before being stored in the cerebrum hence the hippocampus plays a major role in memory and knowledge and wisdom. Zinc deficiency affects short-term memory more than long-term.
Neurologic impact of zinc deficiency

Since zinc is needed for key enzymes in the developing brain such as DNA polymerase, a critical enzyme in DNA synthesis, hence acute Zinc deficiency impairs brain function in humans. Zinc deficiency in experimental animals during early brain development causes malformations, whereas deficiency later in brain development causes microscopic abnormalities and impairs subsequent functions. A limited number of studies suggest that similar phenomena can occur in humans.

Because zinc is so important to cognitive function, zinc supplementation has also been successful in improving the symptoms of ADHD. Studies show a zinc supplement improves focus and reduces impulsivity in children with ADHD.

Laboratory assessment of zinc deficiency

Zinc status in human subjects can be assessed by measurement of zinc in plasma, erythrocytes, neutrophils, lymphocytes, and hair. Available data indicate that zinc in neutrophils and the assay of activity of alkaline phosphatase in neutrophils may be the best tools for the diagnosis of zinc deficiency. Measurement of zinc in the plasma is simple and readily available in many laboratories. Plasma (or serum) zinc concentration is the most widely used biomarker to determine zinc status. According to Mayo Clinic Laboratories, serum zinc the normal reference range is 0.60–1.20 mcg/mL for children under age 10, and 0.66–1.10 mcg/mL for children 10 years and above including adults.

Nutritional Sources of Zinc

Foods highest in zinc include: 12
- Shellfish: Oysters, crab, mussels, lobster and clams
- Meat: Beef, pork, lamb and bison
- Poultry: Turkey and chicken
- Fish: Flounder, sardines, salmon and sole
- Legumes: Chickpeas, lentils, black beans, kidney beans, etc.
- Nuts and seeds: Pumpkin seeds, cashews, hemp seeds, etc.
- Dairy products: Milk, yogurt and cheese
- Eggs
- Whole grains: Oats, quinoa, brown rice, etc.
- Certain vegetables: Mushrooms, peas, asparagus and beet greens

The following shows the recommended daily allowance of zinc, based on a person’s age and sex: 12

<table>
<thead>
<tr>
<th>Age</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–6 months</td>
<td>2 mg</td>
<td>2 mg</td>
</tr>
<tr>
<td>7–12 months</td>
<td>3 mg</td>
<td>3 mg</td>
</tr>
<tr>
<td>1–3 years</td>
<td>3 mg</td>
<td>3 mg</td>
</tr>
<tr>
<td>4–8 years</td>
<td>5 mg</td>
<td>5 mg</td>
</tr>
<tr>
<td>9–13 years</td>
<td>8 mg</td>
<td>8 mg</td>
</tr>
<tr>
<td>14–18 years</td>
<td>11 mg</td>
<td>9 mg</td>
</tr>
<tr>
<td>19 years and over</td>
<td>11 mg</td>
<td>8 mg</td>
</tr>
</tbody>
</table>

Hambidge et al13 reviewed the effects of inadequately treated maternal acrodermatitis enteropathica on offspring. Some of their infants had brain malformations. Related to these observations, reports from Turkey suggested that low maternal Zn nutrition increased the occurrence of foetal anencephaly. Pregnant and breastfeeding women should consume 11 and 12 mg per day, respectively.15 During pregnancy and breastfeeding, a higher intake of zinc is necessary, because newborns and infants up to 6 months obtain zinc through breast milk. Zinc deficiency can be corrected with appropriate diet and zinc supplements. Plasma zinc concentrations normally respond to zinc supplementation, especially in subjects with a low or moderately low baseline but the neurological deficit caused may not be reversed in children.

Conclusion

Zinc, an essential micronutrient has many critical effects for brain development in childhood and brain function. It is essential for normal brain development in the child as it is required for the formation and function of a variety of proteins, enzymes, hormones, and growth factors that direct stem cell proliferation and differentiation during neurodevelopment. Zinc deficiency is usually due to inadequate dietary intake of major sources including lean meat, shellfish, dairy products and nuts. Zinc deficiency can restrict brain development, impair cognitive function and has been linked to congenital malformations.

Adequate Zinc intake in diet is paramount, however, when necessary zinc supplementation maternal/infancy/childhood may be a crucial intervention to prevent congenital malformations, improve child growth and brain development for optimal brain function and eventual attainment of the full potential of the child.
References


