# Nutrition and brain development

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All parents want their children to be intelligent and smart. They are more than willing to spend on anything that will make their children "bright kids". In recent years, we have witnessed a number of vitamins and various food supplements being marketed as "food for the brain"; and the number is still growing! How effective are they? Will they really be able to improve or enhance a child's IQ?

We know for a fact that the main determinant of a person's IQ is his genetic make-up. However, studies have shown that there are environmental factors that can affect brain development and behaviour. And nutrition is one of the most important epigenetic factors that can significantly affect brain development and behaviour.

**Normal growth and development of the human brain**

Brain development follows a highly ordered sequence of events that are under strict genetic control but can be influenced by epigenetic factors. Proper development and maturation of the brain is necessary for the acquisition of the full repertoire of integrated functions and behaviours that make us human. And the brain does this through its approximately one billion cells that communicate with each other via very specialized interconnections.

The actions of the brain underlie all behaviour ranging from the simplest acts like walking or eating to complex actions such as thinking, interacting or creating works of art. (Kandell et al., 1995).

**Effects of malnutrition on behavioral and intellectual development**

Disorders of nutrition remain the most common insult affecting the nervous system (Winick, 1976). Approximately 150 million children worldwide are malnourished (UNICEF, 2001). This is an alarming number of our population that are at risk of developing learning and behaviour problems! But how does nutrition affect cognition and behaviour?

As early as the mid 1960's, concepts on how malnutrition experienced in early childhood could affect brain development have been investigated. Animal studies have shown that malnutrition can cause decrease in brain volume, number of neurons, synapses, dendrites and reactive zones. After nutritional rehabilitation, although there was significant "catch up" in brain weight and volume, there was persistent reduction in the number of dendritic and synaptic spines and cortical cells. These structures are important in the cell-to-cell communications. Specifically, the alterations in the hip-pocampus (associated with short term memory) and cerebellum (responsible for fine motor control and balance), are permanent. (Levitsky and Strupp, 1995). Observed problems among malnourished children consist of atten-tional dysfunction and impulsiveness, diminished ability to adapt to stressful situations, susceptibility to affective disorders like anxiety, and diminished motivations and exploratory behaviours. All of these may lead to impaired school performance and social and emotional development.

Plasticity of the brain is nature's way of protecting it from external influ-ences. It allows for adaptation to environmental influences (i.e. undernutrition), but this is dependent on timing, duration and severity of the insult. The greatest effect of malnutrition on brain development is experienced during the time of rapid brain growth. This is the period during which the brain is vulnerable. Insults occurring at this time will have significant negative effects on brain development, cognition, and behaviour.

**Effects of malnutrition on the developing human brain and central nervous system**

The fetal brain undergoes a growth spurt during the third trimester. An infant's brain triples in size during the first year of life from 350 g to 1000 g and continues to develop rapidly during the first 2-3 years of life during which it attains 80% of its adult weight. A significant amount of brain building is happening at this time wherein the foundations for intelligence, vision, and language are established. It has to be emphasized, however, that the groundwork for brain development begins at day one of conception. The prenatal period is the time when the organization, neuronal differentiation, synaptogenesis, glial proliferations, biochemical differentiation of neurons, synthesis of neuro-transmitters and myelination are taking place. If we consider this, then we will be able to understand why insults to the mother at different stages of conception will cause specific deformities and congenital malformations in the fetus. For example, maternal insult incurred during the first 3 months of pregnancy may result in anencephaly, meningocele, and other neural tube defects in the baby. Consequently, fetal insults incurred from the 5th month of gestation onwards may cause mental retardation, Down's syndrome, autism, etc.

Effects of protein-calorie or protein energy malnutrition (PEM) and single nutrient deficiencies on brain development have been studied. Among children who were born small for gestational age, twelve longitudinal studies were conducted and the children were evaluated at ages 9-17 years. All studies showed that babies who are small for gestational age have poorer cognition and school performance compared to babies with normal birth weights (Hack, 1998). Mild prenatal maternal undernutrition can also affect infant behaviour. When early preventive food supplementation trials were conducted among high risk pregnant mothers in endemic areas in Mexico, Guatemala, and Bogota, Colombia, concurrent bene-fits were demonstrated in all the trials (Chavez and Martinez, 1982; Freeman et al., 1980; Waher et al., 1981).

**Vitamin and trace element deficiencies**

Deficiencies in certain micronutrients incurred during the prenatal period have been shown to cause specific neurologic deficits. These micronutrients are: folic acid, iodine, iron, zinc, selenium, copper, magnesium, Vitamins A, C, D, E, B6 and B12 (Scrimshaw and San Giovanni, 1997).

- **Iodine deficiency** is the most significant cause of irreversible mental impairment.
- **Folic acid deficiency** causes neural tube defects, i.e. meningocele and encephalocele; and
  orofacial clefts, i.e. cleft lips and palate.
- **Iron deficiency anemia** is the most common nutritional deficiency worldwide; its highest prevalence is between 6-24 months of age. It has a negative effect on the infant's sleep-waking cycle and on psychomotor and developmental maturation.
- **Zinc** is functionally an essential component of more than 200 enzymes that pervade all metabolic pathways. **Zinc deficiency** causes slowing and restriction of behaviour, lethargy, apathy and decreased growth rate. It is also associated with a compromised host-defense mechanism thereby predisposing the child to recurrent infections.
- **Pyridoxine or vitamin B6** is an essential cofactor in the developing central nervous system. Its deficiency in animals is associated with alteration in the glutamin-ergic neurotransmitter system which is involved in memory and learning.
- **Certain drugs, i.e. anticonvulsants, alcohol, and smoking can deplete folic acid, zinc and iron stores.**
- **Excess and deficiency of Vitamin A** in the mother's diet during pregnancy have been shown to cause malformations of the fetal brain and hydrocephalus.

**Infant nutrition breastfeeding and infant development**

The influence of breastfeeding on cognition and behaviour cannot be overemphasized. Landmark studies have shown a significant neurodevelopmental advantage among breastfed infants.

Results of studies show that school age children have fewer neurological abnormalities (Lanting et al., 1999), better school grades (Rogan and Graden, 1993), better cognitive development up to 8 years of age (Lucas et al., 1992), and better scores in visual acuity up to 3 years of age (Uauy & de Andraca, 1995). Breastfed infants also showed the same developmental advantage even among pre-term and small for gestational age babies (Lucas et al., 1992).

**Conclusions**

- Nutrition plays a major role in the development of the nervous system. Studies have shown that malnutrition causes a variety of cognitive and behavioral deficits over a lifetime. The severity, timing and duration of malnutrition are important determinants of its possible effect on the neurological development of the child. The period of vulnerability consists of the first 45 months, that is, nine months of prenatal life plus the first three years of life.
- Proper nutrition with adequate amounts of necessary micronutrients, protein, and calories, given at the appropriate time may ensure normal brain development. Major catastrophic congenital malformations like neural tube defects, hydro-cephalus, mental retardation, and behaviour problems may be prevented in some instances with proper nutritional supplementation and avoidance of certain lifestyle behaviours such as smoking and alcohol intake among women of childbearing age. Therefore, ensuring an intelligent and smart child starts with a healthy mother.
- Nurturing nutritional well-being and health is a lifelong process, with each phase affecting the next. But in turning the tide of malnutrition, time is of the essence! (Nutrition for Health and Dev., WHO).

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