Nutrition and Cognition

Nutritionis been defined as food at work in the body. Nutrition includes everything that happens to food from the time it is eaten until it is used for various functions in the body.

Cognition includes the mental processes involved in acquiring knowledge and the integration of these processes into numerous responses such as learning, decision-making, concentration and memory. The cognitive domains include: knowledge (ability to recall data/information e.g. recite alphabet), comprehension: ability to understand the meaning of what is known, application, analysis, synthesis, evaluation

Optimal nutrition is critical for brain function throughout life and especially important is early-life experience: in adults, the incidence of numerous diseases is related in part to early nutrition. Both pre-natal and post-natal nutrition affect health and disease in later life, and these effects can even be passed between generations.

Considerable evidence also suggests that both maternal and infant nutrition have a critical role in brain function and cognitive performance later in life. Prenatally, there is a positive association between maternal intake of micronutrients such as folate, vitamin B12, omega-3 polyunsaturated fatty acids and iron, and cognitive outcomes in children. Maternal supplementation with multiple nutrients may be especially beneficial, although considerably more research is needed in this area. Postnatally, breast milk is linked with enhanced neurodevelopment, and may exert its beneficial effects in part via long-chain polyunsaturated fatty acids and insulin-like growth factors

Moreover, a better diet quality score during the first 3 years of life has a positive effect on verbal and non-verbal cognitive ability at 10 years of age. Especially important are recent results from a 40-year longitudinal study: moderate to severe malnutrition during infancy is associated with elevated incidence of impaired intelligence quotient and academic skills in adulthood, even when physical growth is rehabilitated.24 This demonstrates that an episode of malnutrition during the first year of postnatal life carries significant risk for long-term cognitive function.

The first 1,000 days of life - the time spanning roughly between conception and one’s second birthday - is a unique period of opportunity when the foundations of optimum health, growth, and neurodevelopment across the lifespan are established. Yet too frequently in developing countries, poverty and its attendant condition, malnutrition, weaken this foundation, leading to earlier mortality and significant morbidities such as poor health, and more insidiously, substantial loss of neuro developmental potential.
At least 200 million children living in developing countries fail to meet their developmental potential. Along with under-nutrition, concomitant influences of infectious disease, environmental hazards, societal and household violence, all contribute to this loss of potential. Unlike many other influences that are tremendously difficult to change, nutrition is something we can control. Interventions based on the knowledge of these critical windows have the potential to exert a profound global impact, as correction of nutritional deficits alone has been estimated to have the power to increase the world’s intelligence quotient by 10 points.

**Sensitive periods of brain development**
While the human brain continues to develop and change throughout life, the most rapid period of brain growth and its period of highest plasticity is in the **last trimester of pregnancy** and the first two years of life. The human brain at 5 months post-conception is a smooth, bi-lobed structure that looks somewhat like a coffee bean. By 9 months, i.e. term birth, it has gyri and sulci indicative of significant complexity, looking far more like the walnut-like adult brain. At birth, rapidly developing brain areas include the hippocampus and the visual and auditory cortices. In the first postnatal year, there is rapid growth of the language processing areas as well as early development of the prefrontal cortex that will control "higher processing" such as attention, inhibition, and flexibility.

The first 1,000 days are characterized by rapid rates of neuronal proliferation (cell numbers), growth and differentiation (complexity), myelination, and synaptogenesis (connectivity). Thus, this time period harbors the greatest opportunity to provide optimal nutrition to ensure normal development and also the time of greatest brain vulnerability to any nutrient deficit.

While all nutrients are important for brain development and function, optimal overall brain development depends on providing sufficient quantities of key nutrients during specific sensitive time periods in these first 1,000 days. The brain is not a homogenous organ, but instead consists of multiple separate regions, each with a unique growth trajectory, that ultimately interconnect to make the complex organ that drives behaviour. Thus, there is not a single common growth trajectory or single sensitive period. Rather, the different regions (e.g., the hippocampus, striatum, cortex) and processes (e.g., myelination) of the brain exhibit growth trajectories that span and peak at different times, each time period (and region) having specific nutrient requirements. A critical nutrient at one time period may have little or no effect in another epoch. While the brain requires all nutrients for growth, certain nutrients, including protein, polyunsaturated fatty acids, iron, zinc, copper iodine, choline, folate and vitamins A, B6, and B12 are particularly critical. Of these, iron, exemplifies the necessity of adequate nutrition at specific times of brain growth to ensure full developmental potential.

Iron deficiency is the most common nutritional deficiency in the world. Globally, an estimated 47% (293 million) of all preschool-aged children and 42% (56 million) of all pregnant women are anemic, with approximately half attributable to iron deficiency. The periods of peak brain iron requirement and therefore of highest risk of iron deficiency-induced neurobehavioral impairment are: 1) the fetal/neonatal period and 2) infancy/toddlerhood (6 months to 3 years). The developing brain at these time points requires iron for proteins that regulate myelin production, neurotransmitter synthesis, and neuronal energy production. These processes in turn support speed of processing in the brain, as well as behaviours such as affect and emotion and learning and memory. Iron supplementation during these key periods of peak iron need, particularly during pregnancy, has proven to be an effective deterrent of later neurodevelopmental impairment. In a recent study in China, children born to mothers with iron deficiency anemia in late pregnancy had a significantly lower mental development index score than children of non-iron-deficient mothers at 12, 18, and 24 months of age. This deficit, however, was corrected in children of mothers who received iron and folic acid supplementation throughout pregnancy, but not in children whose mothers who had received folic acid alone or a multiple micronutrient supplement that contained half as much iron.

Plasticity versus vulnerability: Based on what is now known about the magnitude of brain development in the first 1,000 days, it is not surprising that the roots of some of the human’s most complex behaviors are laid down very early in life; well before there is obvious behavioral expression of those areas. Indeed, one of the most striking aspects of developmental nutritional neuroscience is the finding that early life deviation from expected trajectory due to a nutrient deficiency can affect brain function in adulthood, long after repletion of the nutrient. While the young brain is enormously plastic in its ability to recover from early insults and, hopefully, it is never too late to at least partially correct a deficit, the window of opportunity does narrow with advancing age. The science suggests that it is far better policy to build the brain right in the first place through nutritional deficit prevention programs than to depend on replacement therapy once a deficit has occurred. Feeding the fetal, newborn, and young child brain is one of the best ways we can achieve this goal.

**Roles of B vitamins in Brain Development**

1. **Thaimine (**vitamin B1): This is important to nerve function. Thiamin deficiency can lead to confusion, poor coordination and fatigue. It is found in grains, nuts, seeds and pork.
2. **Riboflavin**: A deficiency of vitamin B2, also known as riboflavin, can cause burning eyes and eye fatigue. As a result, a child may show resistance to reading because of visual disturbances from a vitamin B2 deficiency.  Riboflavin also calms and maintains a healthy nervous system. Milk, yogurt, cheese, almonds, hard boiled eggs and spinach are great sources of riboflavin.
3. **Niacin**: Vitamin B3 or niacin is essential for skin health and overall support of nervous and digestive systems. It is found in all protein-containing foods; niacin is heat stable and can withstand cooking. Dementia, diarrhea and dermatitis are all common symptoms of vitamin B3 deficiency.
4. **Vitamin B6**: Pyridoxine or vitamin B6 influences brain process and development by helping with the development of neurotransmitters. In some cases memory loss can be improved through increased intake of vitamin B6 rich foods or supplementation (under a physician’s direct supervision). Good food sources of pyridoxine are bananas, brewer’s yeast, legumes, eggs and sunflower seeds .
5. **Biotin** (vitamin B7): Biotin is needed for every metabolism. By eating foods rich in biotin like cauliflower, egg yolks, peanuts and mushrooms, a biotin deficiency can be avoided and thereby reduce the likelihood of symptoms like hallucinations, and depression.
6. **Folate (**vitamin B9): It is naturally occurring in fruits, vegetables, beans and sunflower seeds. Folic acid is a synthetic form of folate and is used to fortify many grains to ensure proper nutrition. Folate deficiency in children can slow growth rate, causes increased irritability and lead to behavioral disorders.
7. **Vitamin B12 (cobalamin)**: It is found in meat and dairy products. Adequate intake of vitamin B12 ensures proper neural transmission speed and DNA replication. Without this essential nutrient, children may exhibit symptoms like reduced cognitive performance. Severe deficiency can lead to permanent damage like memory loss and dementia .