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Brain booster foods for children

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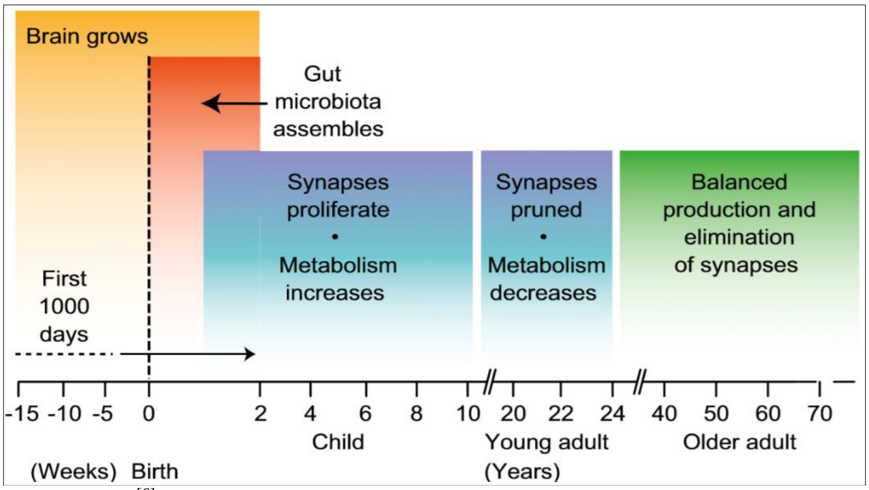
Abstract
About 95% of brain volume development takes place by 6 years. As growth occurs, volume of the grey matter decreases and white matter increases with the 100-fold increase for the signal transmissions. Human brain is composed of 60% fat mainly as docosahexaenoic acid (DHA) for the normal functioning. Brain cells rich in phospholipids facilitate the transport of neurotransmitters which improves processing speed, visual-motor coordination, attention, and executive function up to 70%. The intake of ω – 3/6 fatty acids should be in the ratio of 9:3:1 with eicosapentaenoic, docosahexaenoic and γ – linolenic acid improved erythrocyte fatty acid ω – 3 profile thereby enhancing the neuro cognitive functions. The vulnerable early years of growth affected by malnutrition decreases the number of brain cells, myelin production and alters the functioning of neurotransmitters leading to cognitive impairments, learning disorders and schizophrenia. So the supplementation of brain booster foods helps to improve the normal functioning of the brain in individuals.

Keywords: DHA, mothers milk, B-vitamins, high fibre, GABA

Introduction
In adults 25% of body weight is brain and consume 20% of energy intake whereas in children it is 5-10% of body weight and accounts to 50% of metabolic rate. At the age of 2-3 years, the gut microbiota of child is similar to that of adults. Microbiota helps in expression of genes for neurons, astrocytes, oligodendrocytes and microglia along with aiding in immune function and vascular permeability of the brain. Proper maintenance of gut microbial helps to improve the cognitive functioning of the brain (Gordon *et al*., 2015) [6].
DHA is an important constituent of brain and retinal cells, playing a pivotal role in the foetal brain development along with preventing life style diseases like atherosclerosis, dementia and Alzheimer's (Anandan *et al*., 2016) [12].
Environmental factors play an important role in the origins of some child mental health disorders as well as a range of subclinical neurodevelopmental deficits. The developing brain is particularly vulnerable to toxic chemical exposures and this sensitivity is greatest in utero and throughout early childhood. Even exposure to low levels of toxic chemicals can have significant adverse effects on brain development and behavioural function being extremely costly to individuals and society (Rahu and Margolis, 2016) [14].
The vulnerable early years of growth affected by malnutrition decreased the number of brain cells, myelin production and alters the functioning of neurotransmitters leading to cognitive impairments, learning disorders and schizophrenia. The lack of nutrient supply to white matter injury it and tends to activate microglia, free radical attack and excitotoxin (Bel *et al*., 2015) [9].

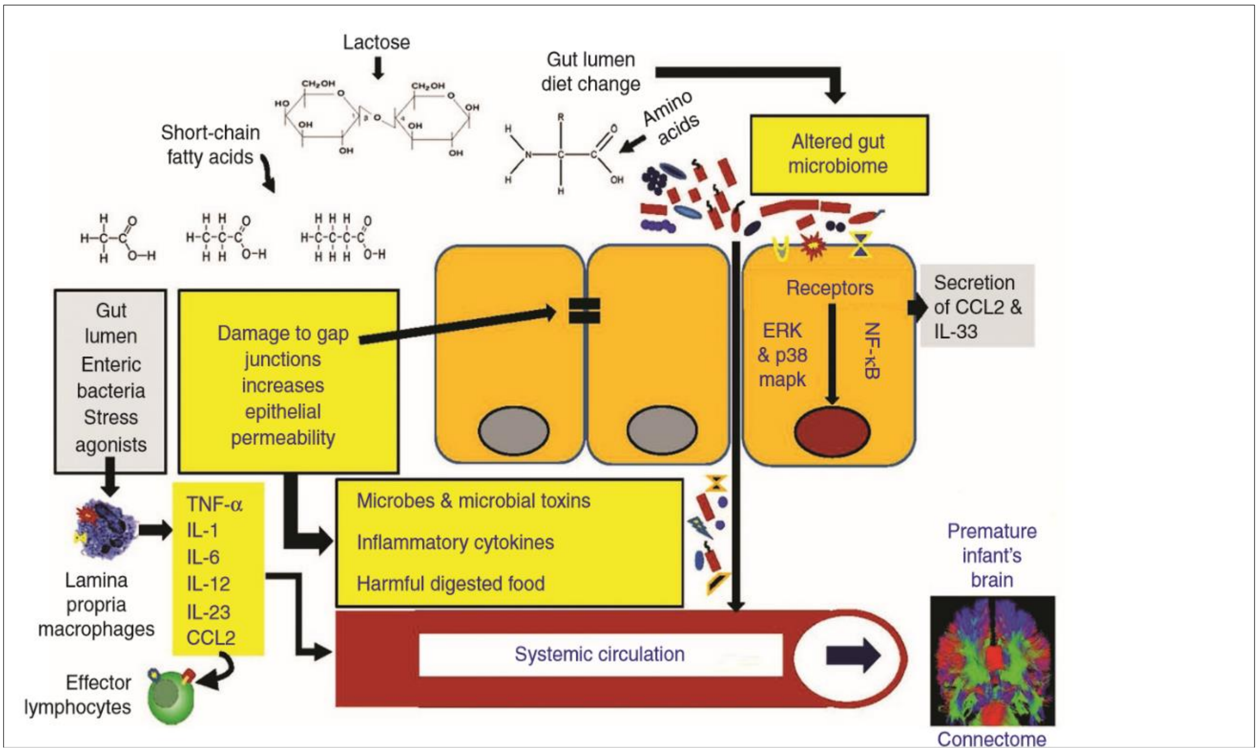
Brief history of findings
The total cerebral volume reaches 95% of its size by 6 years and reaching a peak at age 10.5 years in girls and 14.5 years in boys, with subsequently slight decline through the second and third decades of an individual (Giedd *et al*., 2015) [5].
Growth of gut microbiota takes place during in the 2-3 years of life. The growth rates of the brain and human body increase most rapidly during the first 1000 day after conception Dendritic spine density and brain glucose uptake are sustained well after the first one thousand days. Although the brain's oxygen consumption is higher during this period, it is not nearly as high as the increase in glucose uptake (Gordon *et al*., 2015) [6].



Gordon *et al*., 2015 [6].

Fig 1: Development of brain during first 1000 days after birth

Recent advances in metagenomics implicate the gut microbiota and diet as key modulators of bidirectional signalling pathways between the gut and brain for the neurodevelopmental and psychiatric disorders in adults. Recent clinical studies show that intestinal dysbiosis preceded late-onset neonatal sepsis and necrotizing enterocolitis in intensive care babies. Moreover, strong evidence links late-onset neonatal sepsis and necrotizing enterocolitis in long-term psychomotor disabilities of very-low-birth-weight infants. The notion of the gut–brain axis thereby supports that intestinal microbiota can indirectly harm the brain of preterm infants. These messengers initiate neurologic disease in preterm infants (Niklas *et al*., 2015) [16].



Niklas *et al*., 2015 [16].

Fig 2: Loss of gut barrier protection and increased permeability

Neurovascular coupling mechanisms helps to maintain steady oxygen levels in the individuals disruptions in it leads to hypoxia and neurodegeneration. The cognitive and motor functions decreases which leads to Parkinson's, Alzheimer's and Huntington's diseases. Oxygen plays an important role in maintaining the neuronal plasticity, hypoxia leads to learning and memory dysregulation (Claudianos *et al*., 2018) [19].

Glutamine helps for the improvement of gastrointestinal barrier integrity and helps for the stimulation of lymphocyte proliferation, monocyte function and Th1 cytokine response which reduced the systemic infections (Coeffier *et al*., 2002) [4].

Probiotics helps in the reduction of systemic inflammation, bacterial translocation and necrotizing enterocolitis. It also helps to maintain the gastrointestinal mucosal integrity and enhances the innate immunity responses (Martin and Walker, 2008) [11]. Selenium helps in the reduction of systemic infections by immunostimulant effects by proliferation of activated T-cells, improved B-cell function and natural killer cell activity (Rayman, 2012) [15].

Prebiotic oligosaccharides helps to reduce the bacterial translocation by increased gastrointestinal integrity to promote the growth of bifido bacteria and decreased the pathogens in gut (Esch *et al*., 2013) [7].

Mother's milk is the best source of nutrition to infants and aids in the maintenance of GI tract, immune functions and brain development. Breast milk contains linolenic and α – linolenic acids which are converted to arachidonic, eicosapentaenoic and docosahexaenoic acids important for regulating growth, inflammatory responses, immune function, vision, cognitive development and motor systems for new borns. (Blackburn *et al*., 2016) [10].

Mother's nutritional stores impact the development of neuro functions in offspring. Vitamin D stores impact the mental and psychomotor functions of children. Iron stores of mother impact the gross motor functions but not on fine motor skills is new born children (Fall *et al*., 2016) [17].

Iron plays an important role in the regulation of dopaminergic activity as its lower levels are associated with the pathogenesis and symptoms of ADHD. Iron deficiency influences cognitive, motor, social and emotional functions of young children. It has been found that decreased iron concentration in the brain is associated with alterations in the conduction of cortical fibres, changes in serotonergic and dopaminergic systems along with formation of myelin (Huang *et al*., 2017) [18].

High fibre diet impacts the brain as it is fermented in colon and produce short chain fatty acid 'butyrate'. Sodium butyrate helped to protect the neurons from Parkinson's disease, improved learning and memory in toxicity induced dementia, aided in plasticity and regeneration of brain cells. G-protein receptors of butyrate were found in microglia of brain which acts as anti-inflammatory agent. The dietary sources of butyrate through sources of high fibre diets lowers the risk of brain disorders (Bultman *et al*., 2016) [3].

The B-vitamins perform essential cellular functions along with acting as co-enzymes in catabolic and anabolic enzymatic reactions. Their collective effects are particularly on numerous aspects of brain function like energy production, DNA/RNA synthesis and repair, of genomic and non-genomic methylation, synthesis of numerous neurochemicals along with signalling molecules. Vitamins B_9, B_{12}, B_6 that are the most prominently involved in homocysteine metabolism and are essential for optimal physiological and neurological functioning in young children (Kennedy, 2016) [8].

Vitamin B_{12} and folate dependent enzyme methionine synthase (MS) played a major role in brain development. There was 10-fold decrease in methyl cobalamin in older adults and in fetal brain as well as, levels of inactive cyanocobalamin were high. In autistic and schizophrenic persons, MeCbl and AdoCbl levels were low which decreased the activity of MS and homocysteine levels are elevated. The decreased Vitamin B_{12} levels increased the antioxidant requirement leading to neuropsychiatric problems due to free radical formation (Abdolmaleky *et al*., 2016) [20].

Magnesium is an essential ion involved in energy metabolism and protein synthesis plays important physiological role in brain and heart. Its supplementation is important in treating depression and hypomagnesemia is linked to T-cell deficiency (Bindles *et al*., 2015) [1]. Copper plays a major role in CNS development and function and it has effect on brain synapses. It acts as a blocking agent for glutamate receptors and enhances neurotransmission by the PDS95 protein and increases α-amino-3-hydroxy-5-methyl-4-isoxazolepropionic acid at post synaptic cleft (Bush *et al*., 2014) [13].

Gamma aminobutyric acid (GABA) serves as the main inhibitory neurotransmitter in the human cortex. The increase in brain GABA might be caused by an L-arginine mediated increase in nitric oxide, which can affect blood brain barrier permeability. GABA food supplements on brain and cognition might be exerted through blood brain barrier passage or more indirectly via effecting enteric nervous system. The increased GABA can cause flushing, depressed mood, drowsiness in the morning, electric shock sensation to whole body, malaise and nausea (Colzato *et al*., 2015) [2].

Future perspectives:

The neuroimaging helps to include the progress in neuroimaging of mapping developmental trajectories and its mechanism at macro and micro level of group and individual levels to predict the cognitive behavioural features.

Conclusion

Development of brain tends to occur at the early age of the individual. By the age of two years, 75% of the brain development takes place by the age of 6 years 95% of development takes place. Proper nutrition should be provided for the neurological development of an individual, neuroprotective foods should be consumed which are rich in omega fatty acids as 70% of brain is composed of fatty acids. Foods like fatty fish, broccoli, avocados, berries, coffee, turmeric, pumpkin seeds, dark chocolate, nuts, oranges, oatmeal, apples, plums, eggs, greek yogurt and green tea can be included in diets to provide a variety of nutrients that boost brain functioning, help in development of new brain cells and reduce occurrence of depression.

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