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Role of macro and micro nutrients in cognitive function

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Abstract

The importance of proper food and nutrition has increased over time and the lack of it has been linked with causes of many diseases. This has been a topic of continuous research and one of the primary organs that is affected by nutrition is the human brain. Lack of dietary intake during infancy/early-age, obesity, high-fat rich food; or any of such occurrences can trigger an inflammatory response in immune cells primarily in the peripheral ones. This can also impact the moving molecules which control the state of brain and / or affect the brain-blood interface. Blood (carrying antibodies), lymphatic pathways and peripheral pro-inflammatory chemicals can activate brain immune cells (microglia). Either sensitizing or activating microglia may prompt synthesis of complex inflammation causing molecules like interleukin-1beta (IL1-β), IL-6, and Tumour Necrosis Factor alpha (TNF- α) in the brain which are known to influence emotions and cognitive functioning of the brain. An increased inflammation in these areas can affect normal functioning, resulting in memory loss and/or depressive mood tendencies. By modulating central and peripheral immune cell activity, polyunsaturated fatty acids (PUFA), flavonoids, tannic acid, ellagitannin, a good nutrition, stress free life might avoid such unfavourable consequences.

Keywords

Brain, cognitive function, micronutrient, flavonoid, serotonin, PUFA, DHA

Introduction

The brain is one of the most vital and complex organ of the human body that works non-stop every single day. However, to make it work non-stop, it needs bio-molecules that come from food. This implies that brain demands a steady flow of energy and if the brain does not get enough nutrients, it can cause structural or functional change (Spencer *et al*., 2021). As the brain is always 'ON', it needs constant supply of energy throughout life (Nutritional Psychiatry, 2015).

In this context the review is an assessment about how nutrition can affect brain function. This paper essentially aims to cover:

1. Gastrointestinal system and neurotransmitter - serotonin
2. Accelerated brain aging due to imbalance in diet
3. Role and vitality of polyunsaturated fatty acids on cognitive health

4. Cognitive methods centred on effective feeding

1. Gastrointestinal system and neurotransmitter - serotonin

Nutrients derived from diet can affect many brain processes e.g., synaptic transmission, membrane fluidity, regulation of neurotransmitter pathways and signal-transduction pathways (Simeone & Rho, 2009). One such example of neurotransmitter i.e. serotonin is responsible for modulation of sleep, appetite, mood and pain inhibition (Nutritional Psychiatry, 2015). Considering the digestive tract that produces 95% of serotonin and is covered by around hundreds of neurons, the gastrointestinal system does not only perform digestion but also heavily impacts the regulation of emotions. Moreover, the good bacteria present in the intestines, boost the ability to absorb digested food which helps in the activation of neural pathways between the brain and the intestine. If the brain has lower amount of serotonin, it can cause depression. If the brain has serotonin more than our requirements, it can lead to excessive nerve cell activity. Serotonin helps in reduction of depression and regulates anxiety (Irina, 2018).

2. Accelerated brain aging due to imbalance in diet

Acute high-fat food consumption also initiates the hippocampus (regulates learning and memory) to increase the likelihood of neuro-inflammatory response to a moderate immunological challenge, resulting in memory impairment (Gomez, 2008). In an animal experiment done on rat, Gietzen *et al*. (1998) also showed that amino acid imbalanced diet led to alterations in taste pathways and limbic system.

The imbalance observed between the quantum of fat taken in the diet and consumption of omega-3 polyunsaturated fatty acids (PUFA) causes accelerated brain aging. These PUFAs are essential micronutrients for the functioning of the brain. Omega-6 and Omega-3 are examples of the necessary PUFA however it has to be taken in the diet as it is not made by the body itself. In comparison to omega-3 PUFA, omega-6 is present abundantly in the Western diets like butter, sweets, fried foods, red and processed meat, resulting in an imbalanced ratio of these fatty acids, which has negative repercussions on cardiovascular and brain health. In various studies, common characteristics of oxidative stress and inflammation were observed in various degenerative disorders like cardiovascular/ obesity or age related cognitive and motor impairment. Besides it, with the process of aging, cytokines (inflammatory mediators) have more possibility to enter in the brain. This can lead to irreversible age related cognitive and motor impairments. Antioxidant rich fruits and vegetables can have preventive and curative role in reducing these age-related changes. Joseph *et al*., (2009) also documented that reduction in daily calories or ingestion of antioxidant rich foodstuffs (fruits, vegetables, nuts, spices) can support to maintain cognitive functions that otherwise decline with aging process.

3. Role and vitality of polyunsaturated fatty acids on cognitive health

Polyunsaturated fatty acids (PUFA) are majorly of two types - ω-3 and ω -6. These are considered essential fatty acids because these can't be formulated in human body and has to be obtained from external sources like diet or supplements only. Alpha linolenic acid,

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ecosapentaenoic acid (EPA) and Docosahaxaenoic acid (DHA) are three main ω-3 fatty acids. Three main types of ω -6 fatty acids are gamma linolenic acid (GLA), dihomo-gamma linolenic acid (DLHA) and arachidonic acid (AA). Both of these are very important for the normal functioning of our brain and heart. Omega-3 can be obtained from fatty fish, flax seeds, green leafy vegetables and walnuts. Rich sources of ω -6 fatty acids are green leafy vegetables, seeds and nuts.

Low levels of omega-3 PUFA may cause depression by affecting endocannabinoid (neurotransmitter) and inflammatory pathways in brain. These changes in brain's area can cause memory loss due to synaptic phagocytosis in the hippocampus region of the brain (Hibbeln, 1998). Kraguljac *et al*., (2009) found in their study a significant correlation of omega-3 fatty acids administration on treatment of depression. EPA is considered as the most effective organic antidepressant. The most prevalent omega-3 fatty acid in the brain is DHA as part of each cell membrane. An experimental survey was done by Yenfeng *et al*., (2011) where it was observed that the countries (e.g. Japan) as a whole that ate more fish have less annual depression prevalence by about 25%-35% than those who ate Western diets. It was concluded that countries like Japan had diets that not only contained seafood but a high amount of vegetables and fruits and less amount of meat and dairy products. Christine (2020) also documented role of fatty fish as superb source of ω - 3 fatty acids.

DHA (docosa hexaenoic acid) is quite helpful in enhancing synaptic function and cognitive skills of brain that is obtained from fishes. DHA is a significant component of cell membranes in the brain that makes it as an integral part of the structure of brain and simultaneously it is an important part in physiology also of the brain. Role of DHA has been identified in maintaining ionic permeability and functioning of receptors of transmembrane that in turn enhance synaptic transmission and cognitive function of brain.

4. Cognitive methods centered on effective feeding

Bruno *et al*. (2013) did animal study on alzimer's disease and found that β- Alanyl, l-Histidine showed positive effects on cognitive deficit that developed after administering high fat diet in transgenic mouse model. Changing the caloric amount of one's diet might have an impact on cognitive ability. Excess calories, for example, can decrease synaptic plasticity and make cells more vulnerable to harm by generating free radicals that exceed the cell's buffering capacity (Gomez, 2008). Moderate calorie reduction may be helpful by decreasing oxidative damage to cellular nutrients and nucleic acids. It may prove to be beneficial in protection of brain.

Vikas & Anand (2012) presented in their study that parts of brain- hypothalamus, hippocampus, and amygdala were involved in learning and memory system of brain that was associated with the development of lifelong dislike for toxic foods flavours and pleasurable food was linked to reward-related brain circuits. Paleontological data shows

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that food availability and brain size had direct correlation and that even minor dietary variations can have significant implications for survival and reproductive success. Starub *et al*., (2019) worked on economic effect of breastfeeding and its association with childhood cognitive development. A positive co-relation was depicted between breastfed infants & their cognitive development in childhood.

Table 1 Sources of different nutrients & their cognitive function

Nutrient	Sources	Function
DHA	Fish, flax and chia seeds, fruits (kiwi), walnuts	Helps improve the cognitive impairment in elders and brain trauma/injuries
Flavonoids	Cocoa beans/powder, citrus fruits, green tea, dark chocolate	Has proved to be helpful in brain function when taken with exercising
Vitamin D	Milk, cereal grains, fatty fish (liver)	Helps restore information
Choline	Lettuce, chicken, egg yolk, turkey (liver)	Helps enhance memory deficits due to seizures

Conclusion

As a result of the study it can be said that nutrients whether macro or micro are one of the most important factors that affect cognitive function. Saturated fat rich diets and the ones having high on sugar (mostly junk food) show how it declines cognitive productivity, whereas diets containing omega-3 and 6 PUFA help in overcoming depression. Moreover, it can be deduced that characteristics like cooking abilities and energy conservation to upright walking and running all require cooperation with cognitive methods centered on effective feeding. Hence, understanding the connections between nutrition, cognition, and emotion is crucial for identifying mechanisms and methods for deterring or alleviating neurological disorders in people.

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