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Review Article

Effects of Essential Fatty Acids on Brain Health

Nida Adeel[1*]; Ammar Ijaz[2]; Rimsha Saleheen[3]; Azama Shabbir[4]; Sadaf Tahir[5]; Ayesha Farooq[6]; Ayesha Ashraf[7]; Iqra Rasheed[7]; Aqsa Rasheed[8]; Zohaib Ahmed[9]

[1]Department of Biosciences, COMSATS University Islamabad, Pakistan

[2]Faculty of Health and Well-being, University of Bolton, Bolton BL3 5AB, United Kingdom

[3]MSPH- NS: Master of Science in Public Health (Nutritional Sciences) School of Public Health Dow University of Health Sciences

[4]Department of Food Science and Human Nutrition, faculty of Bio-sciences, University of Veterinary and Animal Sciences, Lahore

[5]Faculty of Food Nutrition & Home Sciences, University of Agriculture Faisalabad

[6]Department of Physiology at Nur International University Lahore, Lahore, Pakistan

[7]Department of Diet and Nutritional Sciences, University of Lahore, Lahore, Pakistan

[8]Department of Allied Health Sciences Cardiac Perfusion Technology, Postgraduate Institute of Gulab Devi Lahore, Pakistan

[9]Department of Human Nutrition and dietetics, Agriculture University Peshawar, KPK Pakistan.

***Corresponding author:** **Nida Adeel**
Department of Biosciences, COMSATS University Islamabad, Pakistan.
Email: arifkamal191312@gmail.com

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Abstract

Aim: The human brain is comprised of approximately 60 percent fat, highlighting the important role of fatty acids in sustaining brain integrity and functionality. Essential Fatty Acids (EFAs) are necessary for health maintenance but cannot be synthesized endogenously and must therefore is sourced from veggies and fruits intake. Research has indicated that imbalances in dietary fatty acid consumption are associated with diminished brain performance and a variety of diseases.

Methodology: Brain development predominantly concludes by the age of five to six years, during which EFAs, particularly fatty acids like omega-3, are integral to both fetal and postnatal brain development. De Hexenoic Acid (DHA), a specific fatty acid omega-3, is indispensable for the optimal maturation of the retina and visual cortex. Empirical evidence suggests that increased DHA intake is correlated with improvements in visual acuity and cognitive development.

Results: Beyond their structural roles, EFAs function as critical messengers in the production and operation of neuronal transmitters and components of the defense system. The cell membranes house phospholipid reservoirs that are mobilized to produce specific lipid messengers in response to neuronal activation or injury. These lipid messengers are involved in managing pathways that can worsen neurons damage or promote neuronal protection.

Objective: Objective of the article is to provide an advanced perception of the role EFAs play in maintaining brain control and performance and to examine the neuronal psychiatric disorders potentially influenced by EFAs. As scientific exploration continues to uncover the mechanisms by which fatty acids impact brain function, ensuring proper dietary intake or supplementation of EFAs becomes paramount in the quest for optimal health.

Keywords: Human brain; The fatty acids omega-3; Essential fatty acids

Introduction

Our human brain is approximately 60% fat. It's likely that doctors disregarded this knowledge because they imagined that dietary fat had little impact on the brain integrity and functioning. We now possess distinct knowledge. According to recent research, fatty acids are among the most critical molecules that govern the health and functioning of your brain. EFAs, also known as Polyunsaturated Fatty Acid (PUFAs), are essential for overall health. Because the body cannot produce EFAs, they must be absorbed through dietary sources. PUFAs are split into two categories: omega-6 and omega-3.

While the body changes the primary fatty acid omega-3 and Alpha-Linolenic Acid (ALA), to Docosahexaenoic Acid (DHA) and Eicosatetraenoic Acid (EPA) by means of a series of metabolic processes involving the microsomal enzyme system, the primary omega-6 fatty acid, Linoleic Acid (LA), is converted to arachidonic acid [9]. These long-chain metabolites are precursors to a number of prosta glandins, thromboxane, leukotrienes, and prostacyclin, which have a major impact on the immune system, neurotransmitter systems, and circulation to the brain [21].

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Phospholipids, which contain unsaturated atty acids (FAs), are integral components of cell membranes. The dietary FAs determine the types of FAs incorporated into cell membranes. Phospholipids composed of saturated fats have a different structure and are less fluid compared to those containing EFAs. Both LA and ALA directly impact neuronal membrane fluidity by reducing cholesterol levels in the neuronal membrane. Lower cholesterol levels increase membrane fluidity, facilitating normal cellular functions and reducing susceptibility to injury and death [7]. The consequences of these effects on cellular function are not limited to the entire levels of EFAs but are influenced by the respective proportions of fatty acids omega-3 and fatty acids omega-6 unsaturated fatty acids in cell membranes. This equilibrium has an impact on cellular activity and may have a role in the etiology of long-term illnesses such cancer, osteoporosis, cardiovascular disease, and inflammatory and autoimmune disorders [2].

The myelin sheath and the neuronal membrane contain extremely high concentrations of FAs and lipids. FAs make up around 50% of the synaptic membrane, whereas lipids make up roughly 70% of the myelin sheath. Compared to the protein part, which is particularly stable, the portion of lipids has a comparatively rapid turnover rate. For axons in the brain and spinal cord to function properly, the myelin sheath must remain intact. Numerous nervous system functions can disintegrate as a result of myelin breakage or lesions.

During this phase, a myelination, demyelination, or demyelanation may occur if EFAs are not accessible or are metabolically inhibited [14]. A significant delay in the myelination process, as well as impairments related to learning, motor function, vision, and hearing, would result from an EFA shortage that manifests during the postnatal period [18]. This review aims to provide a fresh perspective on how EFAs affect the integrity and function of our brains as well as a reminder of the clinical situations in which the neurons might be affected by them.

Nutritional Sources of EFAs

Food-Based origin of EFAs edible oils like sunflower, safflower oil, sesame oil, and corn oils are the main nutritional sources of omega-6 Fatty Acids (FAs). Fish oil, green leafy vegetables, fatty cold-water fish (salmon, mackerel, sardine, and mackerel), jojoba or canola oil, the oil of peanuts, walnuts oil, and green leafy vegetables are all good sources of fatty acids omega-3. The production of critical brain lipids and messengers that control a variety of bodily activities depends on these EFAs. Our bodies lack the basic elements needed for proper cell activity in the absence of EFAs [21].

Historically, human diets had an fatty acids omega-6 to fatty acids omega-3 ratio estimated to be roughly 1:1. Today, this ratio has shifted dramatically to approximately 15:1-17:1. The production of long-chain DHA and EPA by the body from shorter-chain precursors is impacted by this shift in addition to dietary imbalances that lower fatty acid Omega-3 intake. The alteration of dietary ALA to EPA and DHA is extremely low; metabolic biochemists have found that only approximately 5% of ALA is transformed to these two compounds [12]. This altered ratio of FAs has significant implications for brain function. For instance, studies of the brain tissue of individuals with multiple sclerosis have shown very low levels of important fatty acids such as DHA [11].

Additionally, it discovered that blood contained very little omega-3 FA storage and that blood had very little of it. When Australian physicians examined the blood of patients suffering from moderate to severe depression, they discovered that the omega-3 FA level was abnormally low and that the balance of EFAs had been drastically changed [1]. Blood levels of omega-3 FA and DHA were shown to be lower in those exhibiting indications of hyperactivity and attention deficit disorder, according to Purdue University researchers [17]. Each of these observational studies linked imbalanced dietary intake of FAs to illnesses and compromised brain function in certain genetically susceptible individuals.

Methodology

The data is collected from previous review articles and from published papers, google scholar, PubMed and science hub. All the provided information is authentic, and research based.

EFAs and the Development of the Brain

By the age of five or six, the majority of brain development is over. 70% of an adult's brain weight is present at birth, 15% grows throughout infancy, and the remaining 15% grows during preschool years [3]. Both during the prenatal and postnatal stages of brain development, the EFAs—in particular, the Omega-3 —are crucial. Omega-3 and Omega-6 FAs have a major role in the formation of integration of nerve cell relationships, the appearance of genes governing progression of cells and growth, and neuron growth. For the retina and optical brain to develop to their full capacity and to potentially improve mental and visual acuity, dietary DHA is essential [19]. Furthermore, the supply of EFA from the mother is crucial for the growth and development of the fetus and placenta. Infants who receive DHA supplements exhibit markedly enhanced intellectual and psychomotor development evaluations, and breastfed children show even higher benefits. Cognitive and behavioral deficits are linked to decreased DHA levels, and these deficits are particularly important during brain development [16]. According to these results, there is a greater chance that children will realize their full potential if the FA balance is maintained during infancy. Restoring FA balance may also have therapeutic advantages for kids who struggle with behavior, learning, or other brain-related issues. It is crucial to make sure nursing mums' diets contain enough ALA and DHA to do this.

EFAs' Role in Brain Functions and Structures

The brain is predominantly made up of fat, making Essential Fatty Acids (EFAs), which are derived from the diet, crucial for nearly every brain structure and function. The brain contains minimal amounts of Linoleic Acid (LA) and Alpha-Linolenic Acid (ALA), instead favoring Docosahexaenoic Acid (DHA) and Arachidonic Acid (AA). These two fats are considered essential for brain health. During fetal development, it is transferred from the mother to support the growing brain, and it is also present in breast milk to aid further brain development in infants. By the age of one, children typically produce sufficient acids on their own, reducing the dietary need for acids in adults. Elevated levels of acids in cell membrane lipids can lead to the production of inflammatory substances such as prostaglandin, trienes, and thromboxane. Over the past two decades, research has highlighted the importance of DHA as the primary long-chain omega-3 fatty acid in the brain. Although the body can convert the essential fatty acid into acids, this process is often inefficient. Therefore, there is a dietary need for preformed that cannot be sufficiently met by other fatty acids, indicating that DHA may be conditionally essential for brain health [23].

EFAs are important transmitters in the body as well as to their function in brain building. They play a part in immune system molecules and are important in the creation and activity of brain transmitters through neurons. Omega fatty acid deficiency has been shown to cause disruptions to the cholinergic MS corticolimbic pathway and a decrease in the density of dopamine vesicles in the cortex. The intricate relationship between Omega-3 and Omega-6 fatty acids and their effects on different immunological components is largely explained by the ratio of Omega-3 to Omega-6 fatty acids.

Numerous theories are being put out regarding how EFAs modulate their immune-related roles in a variety of illnesses, including schizophrenia and Alzheimer's. These include modifications to membrane fluidity that may affect cytokines' ability to attach to their specific receptors on the cell membrane; Prostaglandin production is an indirect process through which prostaglandins, which are PUFA derivatives, influence cytokine function; lipid peroxidation alleviates tissue damage induced by free radicals; PUFA's impact on signal transduction pathways, mRNA activity, and gene expression control [10].

The fatty acids that comprise the structure of cell membranes act as messengers when stimulated by signals. Neuronal membranes contain pools of phospholipids that serve as reservoirs for synthesizing specific lipid messengers in response to neuronal activation or injury [23]. These messengers play crucial roles in indicating cascades that can either enhance neuronal breakdown or provide neuroprotection.

Cyclooxygenase activity aids in the synthesis of prostaglandins. The production of prostaglandin H2, a short-lived precursor, is the first stage of the Arachidonic Acid (AA) cascade. From there, different prostaglandins involved in diverse physiological and neurological processes are synthesized [13]. Membrane EFAs generate PGE1, PGE2, and PGE3 prostaglandins. In addition to having anti-inflammatory qualities and boosting immunological function, PGE1 impacts the release of chemicals from nerve cells that are involved in sending nerve signals. As an example, PGE2 causes swelling, increased sensitivity to pain, and increased blood viscosity. It is a highly inflammatory chemical. Relative to PGE2, leukotrienes are likewise produced from AA and are implicated in inflammatory processes. The fatty acid PGE3, which is produced from chemicals, boosts immunity and has some anti-inflammatory effects.

It is thought to work by inhibiting blood accumulation of platelets and lowering blood vessel spasms to offset the effects of the strong inflammatory PGE2. EPA and DHA can also lower the amount of AA in cells, which in turn lowers the amount of highly inflammatory mediators made from AA. This shows how these kinds of fatty acids can control the synthesis of inflammatory messengers. Another possible mechanism by which the membrane DHA supports the protection of Brain. It is the forerunner and supports the oxidation products that are known as docosanoids today, some of which are strong anti-inflammatory starters [10].

Important Fatty Acids and Mental Performance

Explored the unsaturated composition of mental health, it's reasonable to consider that individuals with imbalanced fatty acid (FA) levels may experience altered mental performance. It [5] recently described positive impact on child brain development associated with maternal seafood intake exceeding 340 grams per week during pregnancy. They found that maternal seafood intake below this threshold was linked to an enhanced risk of young scoring in the lowest quartile for verbal intelligence quotient. Furthermore, there was a negative correlation found between poor maternal seafood intake and prosocial behavior, fine understanding abilities, connections, and socializing progress scores.

Furthering investigation [8] highlighted the beneficial impact of human milk on neurodevelopment. When comparing children who did not receive milk from their mothers in the initial days of life to those who did, the IQ scores of the former group were much higher at 7.5-8 years of age. A dose-response association was noted, with higher IQ scores following in the wake of consuming a larger percentage of the milk of your mother in the diet.

In Addition, in suggests that EFAs, particularly EPA and DHA, can benefit cognitive function in healthy individuals. A double-blind randomized controlled trial with 33 healthy volunteers aged [4]. Over a 35-day period, participants consumed either 4 grams of fish oil per day or 4 grams of olive oil as a placebo. The group receiving showed significant improvements in various mood parameters such as vigor, anger, anxiety, fatigue, depression, and confusion.

Participants showed increased sustained attention and fewer errors on attention tests, and measures of attention and response time also improved significantly.

EFAs and Neurological Disorders:

The role of DHA and EPA in dementia and moderate cognitive impairment Relatively high DHA and EPA intake has been associated with a lower relative risk of dementia onset or development, according to epidemiological research conducted over the previous ten years. 5,386 people 55 years of age or older were assessed for dementia as part of a longitudinal cohort research that was reported. Using a semi-quantitative food frequency questionnaire, dietary practices were assessed. After 2.1 years, the assessment was repeated. Eating fish was negatively correlated with the incidence of dementia and more precisely, with the chance of getting Alzheimer's disease.

Extended cohort studies offer objective insights in analyzing blood content or tissue for specific nutrients. It is studied in Framingham Heart Study, a cohort of 900 men and women without dementia at the start were monitored over an average of 9 years to track the onset of all-cause memory loss and Alzheimer's disease (Schaefer EJ, 2006). During the study period, 90 new cases of memory loss, including Alzheimer's disease, were identified. Blood samples collected and follow-ups were analyzed for essential acids in the plasma phospho lipid fraction. After adjusting for other factors, individuals in the highest of plasma phospholipid DHA levels had approximately half the relative risk of developing all-cause memory loss.

In Another randomized controlled trial involving 170 patients with moderate Alzheimer's disease [4]. Participants received either 1.5 g DHA and 0.7 g EPA daily or a placebo for half year, followed by all patients receiving the DHA/EPA supplements for an additional six months. While no significant differences in cognitive decline were observed between groups after the initial six months, a subgroup analysis of patients with minimal severe cognitive impairment showed a significantly slower decline. A slowing of decline was noted in the group after switching to

DHA/EPA supplementation for the next half year. These findings suggest that individuals experiencing mild Alzheimer's disease progression may benefit from a combined dietary additive having both deHA and EPA.

Omega-3 fatty acids have been linked to a lower incidence of dementia and an improvement in cognitive function, according to a recent systematic review [6]. The evidence that is now available suggests that there may be a link between Omega-3 acids and a lower risk of memory loss, even though it is not strong enough to draw conclusions about how fatty acids Omega-3. Essential fatty acids affect cognitive performance during normal aging or how dementia is diagnosed or treated.

In patients with borderline personality disorder, Omega-3 supplementation may also be effective in treating borderline personality disorder. The trial was double blind and placebo controlled. Individuals on ethyl-EPA had much less aggressiveness and less serious mental illness [25].

Conclusion

While the clinical research for brain activity is less extensive to studies on circulatory benefits, the existing evidence strongly indicates their significance for intelligence, behavior, temper, early brain development, and overall mental accomplishments. As we continue to unravel how fatty acids influence the brain, there is potential to profoundly impact our individual lives and society through informed dietary adjustments.

Even while studies on the benefits of blood circulation have been conducted more extensively than those on brain function, the information that is currently available clearly shows the importance of brain function for cognition, behavior, mood, the earliest stages of brain and general mental performance. Knowing more about how fatty acids affect the brain may allow us to make informed dietary changes that have a significant impact on both society and each of our individual lives.

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