ROLE OF POLYUNSATURATED FATTY ACIDS: OMEGA 3 AND OMEGA 6 IN BRAIN AND NEURAL DEVELOPMENT IN CHILDREN

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Introduction

- Infant growth and development begins in the womb and continues at a rapid pace during the first months and years of life.
- Breastfeeding provides optimal nutrition for this infant growth and development, especially when the mother’s nutrition itself is optimal.
Role of Breast Milk in Child development

• According to World Health Organization, breast milk is the best in feeding infants.
• It contains nutrients, antibodies, enzymes among other important elements.
• The human breast milk contains essential fatty acids (EFAs) which are healthy fats. Particularly, it consists of Polyunsaturated fatty acids; omega 3 and omega 6 which are beneficial for the infant’s growth and development.
• They play an important role in the infant brain, visual, behaviour and nerve development thereby dictating the child’s cognitive ability/ intelligence, visual ability and overall performance in the long run.
Essential fatty Acids in Breast milk

The fat content of breast milk is of great importance to infant development especially when it comes to the omega-3 fatty acid docosahexaenoic acid (DHA), and the omega-6 fatty acid metabolite arachadonic acid (AA) which are both concentrated in the infant brain during the last trimester and first few months of life.

What Support can this mother get???
Concentrations of Essential fatty Acids in the Brain

• The principal omega-3 fatty acids in the Central Nervous System is DHA required for brain development in synthesis of membrane phospholipids that occurs with neurogenesis.
• It represents 10–20% of the total fatty acid composition in brain grey matter, with lower amounts in white matter.
• The rod and cone outer segments, on the other hand, are a highly specialized series of membrane disks in which DHA represents about 35% of the total fatty acids.
• Arachidonic acid (AA) and eicosapentaenoic acid (EPA) comprise of a smaller percentage. Overall, omega-3 fatty acids comprise approximately 60% of the weight of the brain.
Concentrations of DHA

• The concentration of DHA increases significantly in CNS tissue in the perinatal period.

• Fatty acids are used as fuel for brain metabolism and help control chronic inflammatory processes involved in degenerative brain disorders. DHA is important in protecting brain health.

• According to Mind Boosters author Dr. Ray Sahelia, There's a reason why fish is known as brain food. It is a rich source of docosahexaenoic acid (DHA). DHA’s instrumental function of brain cell membranes is important for the transmission of brain signals.

• By making cell membranes more fluid, omega-3 fatty acids improve communication between the brain cells. As a result, lack of omega-3 in the body can cause a communication breakdown in the brain.
Essential fatty Acids in CNS

• The central nervous system is highly enriched in long-chain polyunsaturated fatty acid (PUFA) of the omega-6 and omega-3 series.

• The presence of these fatty acids as structural components of neuronal membranes influences cellular function both directly, through effects on membrane properties, and also by acting as a precursor pool for lipid-derived messengers.

• An adequate intake of omega-3 PUFA is essential for optimal visual function and neural development. DHA in retina and postsynaptic membranes is crucial for adequate functioning of embedded proteins, i.e. rhodopsin for vision and postsynaptic receptors for neurotransmission.

• Deficiency in omega-3 fatty acids in neural membranes can lead to impaired G-protein-coupled receptor signalling, which can have profound effects on neurotransmission.
Omega-3 Fatty Acids

• Omega-3 fatty acids continue to be essential to infant brain development after birth, and research shows babies who are breast fed receive higher levels of the important fatty acid than those fed formula, since baby formula mostly does not contain any omega-3 at all.

• According to Phyllis A. Balch, CNC and Dr. James F. Balch in Prescription For Nutritional Healing, “Breastfed infants have been found to be more intelligent than formula-fed infants and to achieve higher academic levels in adult life.”
omega-3 fatty acids and Foetal development

• Consumption of omega-3 fatty acids during pregnancy is critical to fetal development. They are required during the prenatal period for the formation of synapses and cell membranes.

• A study published in The Journal of Nutrition in 2007 found that the maternal diet affects the brain DHA status of offspring.

• It suggests that a maternal diet containing insufficient amounts of omega-3 polyunsaturated fatty acid can lead to greater risk of decreased accretion of brain DHA in infants.
Omega-3 fatty acids and Maternal Nutrition

• The DHA status of the newborn and breast-fed infant depends on the maternal intake of DHA and varies widely.
• Epidemiological studies have linked low maternal DHA to increased risk of poor child neural development.
• Intervention studies have shown improving maternal DHA nutrition decreases the risk of poor infant and child visual and neural development.
• Sufficient evidence is available to conclude that maternal fatty acid nutrition is important to DHA transfer to the infant before and after birth, with short and long-term implications for neural function
ALA and DHA in breast milk of women in Congo and Burkina Faso (at 5 mo)

Rocquelin G et al., 2003
**Dietary Sources of Omega 3 & 6**

**Sources of Omega 3**
- Oily fish such as sardines, fish oils, oilseeds, nuts, soybeans, green leafy vegetables.

**Sources of Omega-6**
- Sunflower oil, Corn oil, Sesame oil, Hemp oil (best balance of omega 6:3), Pumpkin oil, Soybean oil, groundnut oil and Wheat germ oil.

**Fish oil capsules**
# Fatty ac Composition of fat sources

<table>
<thead>
<tr>
<th>Source of Oil</th>
<th>Sats %</th>
<th>MUFAs %</th>
<th>PUFAs %</th>
<th>n-6 PUFA%</th>
<th>n-3 PUFA%</th>
<th>Chol (mg)</th>
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<tbody>
<tr>
<td>Canola</td>
<td>7.10</td>
<td>58.90</td>
<td>29.60</td>
<td>20.30</td>
<td>9.30</td>
<td>0</td>
</tr>
<tr>
<td>Corn</td>
<td>12.70</td>
<td>24.20</td>
<td>58.70</td>
<td>58.00</td>
<td>0.02</td>
<td>0</td>
</tr>
<tr>
<td>Sunflower</td>
<td>10.30</td>
<td>19.20</td>
<td>65.70</td>
<td>65.70</td>
<td>0.01</td>
<td>0</td>
</tr>
<tr>
<td>Rapeseed</td>
<td>6.80</td>
<td>55.50</td>
<td>33.30</td>
<td>22.10</td>
<td>11.10</td>
<td>0</td>
</tr>
<tr>
<td>Soya</td>
<td>14.90</td>
<td>43.00</td>
<td>37.60</td>
<td>34.90</td>
<td>2.60</td>
<td>0</td>
</tr>
<tr>
<td>Olive</td>
<td>13.50</td>
<td>73.70</td>
<td>8.40</td>
<td>7.90</td>
<td>0.60</td>
<td>0</td>
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<tr>
<td>Veg solid fat</td>
<td>25.00</td>
<td>44.50</td>
<td>26.10</td>
<td>2.50</td>
<td>1.60</td>
<td>0</td>
</tr>
<tr>
<td>Animal fat Lard</td>
<td>39.20</td>
<td>45.10</td>
<td>11.20</td>
<td>10.20</td>
<td>1.00</td>
<td>95</td>
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<tr>
<td>Milk fat</td>
<td>50.49</td>
<td>23.43</td>
<td>3.01</td>
<td>1.83</td>
<td>1.18</td>
<td>219</td>
</tr>
</tbody>
</table>

Source: Ricardo Uauy MD, PhD Annuals of Nutrition Metabolism Vol. 55 No. 1-3, 2009
Recommended dietary intakes for total fat and essential fatty acids (FAO/WHO 2008)

<table>
<thead>
<tr>
<th></th>
<th>Infants and young children (6–24 mo)</th>
<th>Pregnancy and lactation*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fat in food supply</td>
<td>Gradual reduction to 35% E, depending on physical activity</td>
<td>20–35% E</td>
</tr>
<tr>
<td>Omega-6 PUFA</td>
<td>3.0–4.5 %Energy (AI) (LA only)</td>
<td>2–3 %Energy (AI) (LA only)</td>
</tr>
<tr>
<td>Omega-3 PUFA</td>
<td>0.4–0.6 %Energy (AI) (ALA only)</td>
<td>0.5–2 %Energy (AMDR) (ALA + other omega-3 PUFA)</td>
</tr>
</tbody>
</table>

*Recommended intake for healthy adults; AMDR, acceptable macronutrient distribution range; U-AMDR, upper value for AMDR; AI, adequate intake (range); PUFA, polyunsaturated fatty acids.
Omega-3 Fatty acids and Cognitive development

• Breast milk is rich in omega 3 fatty acids. It contains eicosapentaenoic acid (EPA), DHA docosahexaenoic acid (DHA) and Linolenic acid.

• Omega-3 fatty acids are highly concentrated in the brain and are important for cognitive (brain memory and performance) and behavioral function.

• Infants who do not get enough omega-3 fatty acids from their mothers during pregnancy are at risk for developing cognitive, vision and nerve problems.
Effect of DHA supply on brain activation in healthy children (functional MRI)

- 33 healthy boys (age: 8-10 years) randomized to receive placebo, 400 mg DHA/d or 1200 mg DHA/d for 8 weeks
- Continuous performance task (one digit CPT-IP)
- fMRI neuroimaging during completion of the cognitive test
- DHA-% in RBC increased twofold in the 400 mg/d group and threefold in the 1200 mg/d group
- No significant group differences or improvements in the one digit CPT-IP

Scientific Opinion on Dietary Reference Values for fats, including saturated fatty acids, polyunsaturated fatty acids, monounsaturated fatty acids, trans fatty acids, and cholesterol

**Adequate intake (AI) per day**

**Adults**: 250 mg EPA plus DHA

**Pregnancy/Lactation**: Adult AI plus 100-200 mg DHA

**Infants/young children** (6 - 24 mon): 100 mg DHA
Breastfeeding effects on child IQ depend on fatty acid desaturase genes

5934 children at ≈8 years (ALSPAC): children homozygous for less common variant (GG): largest difference between any breastfeeding and excl. formula feeding on IQ

Lower LC-PUFA synthesis: +4.3 IQ points benefit from breastfeeding (provides LC-PUFA)

Dr. van Kauferen's Kinderzulassung
Omega-3 fatty Acids and Neurological development

- DHA is a central component of the nervous system and promotes neurological development, particularly with regard to the eyes and to fundamental cognitive function.
- Studies suggest that a baby born to a mother with high levels of Omega-3 fatty acids in her system will more likely have advanced cognitive faculties and an increased attention span (a fundamental non-verbal indicator of intelligence in very early childhood).
- These effects have been measured up to age four, suggesting that there are long-term benefits of Omega-3 fatty acid consumption during pregnancy and nursing.
Essential Fatty Ac Intake 0-36 months in the Gambia

FAO (1994) recommendation = 600 mg/kg

FAO (1994) recommendation = 50 mg/kg

FAO (1994) recommendation = 40 mg/kg (including associates)

FAO (1994) recommendation = 20 mg/kg

Modified from Prentice and Paul 2000
Impact of LNS (Nutributter) on infant growth in Ghana (Adu-Afarwuhu et al. 2007)

Length-for-age z-scores of intervention (SP, NT, NB) and non-intervention (NI) groups

SP = Sprinkles
NT = Nutritabs
NB = Nutributter
NI = Non-intervention

Age (mo)

Growth reference: WHO
Child Growth Standards 2006
Omega-3 fatty acids and Oxygen uptake

• Omega-3 fatty acids are used to form cell walls. They help improve circulation and allow red blood cells to properly take oxygen.

• Without sufficient omega-3 fatty acids, mental abilities can suffer, vision will be poor, immune system function is diminished, heartbeat can become irregular and growth can be retarded.
Attention deficit/hyperactivity disorder (ADHD)

- Children with attention deficit/hyperactivity disorder (ADHD) may have low levels of certain essential fatty acids (including EPA and DHA). In a clinical study of nearly 100 boys, those with lower levels of omega-3 fatty acids had more learning and behavioral problems (such as temper tantrums and sleep disturbances) than boys with normal omega-3 fatty acid levels.

- However, studies examining whether omega-3 fatty acids help improve symptoms of ADHD have found mixed results. A few studies have found that omega-3 fatty acids helped improve behavioral symptoms, but most were not well designed. One study that looked at DHA in addition to stimulant therapy (standard therapy for ADHD) found no effect.

- More research is needed, but eating foods that are high in omega-3 fatty acids is a reasonable approach for someone with ADHD.
Pregnancy and lactation

• The brain begins to form in the first month after conception. A congenital brain defect usually occurs due to an interruption in the normal growth of the nervous system.

• Adequate intake of omega-3 fatty acids docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) can increase gestation length and improve infant cognitive and visual performance.

• Omega-3 fatty acids reduce the incidence of preterm births.
During Pregnancy

- During pregnancy, most DHA supplied to the fetus originates from maternal sources, either from diet or mobilization of fat stores, and is transferred across the placenta. ALA transferred across the placenta may also be converted to DHA in the foetal compartment.
Postpartum

• The secretion of DHA in human milk is readily increased by increasing the lactating mother's intake of DHA from fish, or other sources.

• **DHA levels in breast milk depend on maternal dietary ingestion of omega-3s.** The benefits of breastfeeding in providing omega-3s for neonatal neural and brain growth when eating a diet high in omega-3s should be promoted.

• Adequate maternal intake of n-3s has been correlated with improved neonatal visual development, central nervous system functioning, and improved childhood intelligence scores.
Deficiency Symptoms

- Symptoms of omega-3 fatty acid deficiency include fatigue, poor memory, dry skin, heart problems, mood swings or depression, and poor circulation.

- Although rare, deficiency symptoms of omega 6 are skin problems (itching, eczema, dry patches), hair that is thin and weak, nails that crack and break and behavioural changes.
Osteoporosis

• Some studies suggest that omega-3 fatty acids may help increase levels of calcium in the body and improve bone strength, although not all results were positive.

• Some studies also suggest that people who don’t get enough of some essential fatty acids (particularly EPA and gamma-linolenic acid [GLA], an omega-6 fatty acid) are more likely to have bone loss than those with normal levels of these fatty acids.

• In a study of women over 65 with osteoporosis, those who took EPA and GLA supplements had less bone loss over 3 years than those who took placebo. Many of these women also experienced an increase in bone density.
Omega 3& 6 Ratios/ Balance

• The ratio should be in the range of 2:1 - 4:1, Omega-3 fatty acids help reduce inflammation, and most omega-6 fatty acids tend to promote inflammations. Unfortunately, our diets put us at ratios between 20:1 to 50:1.

• This is attributed to the high intake of omega-6 rich foods, such as processed food and meats, and lower intakes of omega-3 rich foods.

• This dietary imbalance is implicated in the development of chronic diseases, such as coronary artery disease, arthritis, cancers, and other inflammatory disorders.
Omega-3 fatty acid supply (% energy) in 13 countries ranked by GDP

Malawi
Ethiopia
Bangladesh
Burkina Faso
Ghana
India
Vietnam
Bolivia
Indonesia
Guatemala
China
South Africa
Mexico

AI - 6-24 mo
AMDR - Pregnancy and lactation
2.0
Conclusion/Recommendation

- In conclusion, the role of (n-3) fatty acids in brain development and healthy brain aging is emerging as a field of intense scientific study and of considerable public health importance.

- The evidence to show low rates of conversion of ALA to DHA and the demonstrated importance of DHA for brain function provide strong evidence that DHA is important for human brain development.

- The events in which DHA fulfils its essential roles, including neurotransmission, neurogenesis, and protection from oxidative stress are relevant throughout the lifespan and to maximizing cognitive potential in development and minimizing its loss with aging.

- **A concerted effort is needed to better understand (n-3) fatty acid requirements to support optimal brain development and function and to elucidate those dietary conditions and diet-gene, or diet-disease, interactions that pose risk of inadequate brain DHA (Innis, 2007).**
Asante sana