

## **Dietary omega 3 fatty acids and the developing brain**

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### **FROM ABSTRACT**

The omega-3 fatty acids are essential dietary nutrients and one of their important roles is providing the fatty acid with 22 carbons and 6 double bonds known as docosahexaenoic acid (DHA) for nervous tissue growth and function.

Inadequate intakes of omega-3 fatty acids decrease DHA and increase omega-6 fatty acids in the brain.

Decreased DHA in the developing brain leads to deficits in neurogenesis, neurotransmitter metabolism, and altered learning and visual function.

Western diets are low in omega-3 fatty acids, including the 18 carbon omega-3 fatty acid alpha linolenic acid found mainly in plant oils, and DHA, which is found mainly in fish.

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.

Thus, 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.

Consideration of omega-3 fatty acid to include brain development, optimizing omega-3 and omega-6 fatty acids in gestation and lactation, and in fatty acid nutrition support for intravenous and formula-fed neonates is important.

### **THIS AUTHOR ALSO NOTES:**

"The long chain omega-3 fatty acid with 22 carbons and 6 double bonds known as docosahexaenoic acid (DHA) is the most abundant omega-3 fatty acid in the mammalian central nervous system, and is specifically concentrated in membrane lipids of brain grey matter and the visual elements of the retina."

The retina and brain levels of DHA are altered by the dietary omega-3 and omega-6 fatty acid supply.

Low levels of DHA increase the risk of poor visual and neural development in infants and children and increase the risk of dementia and cognitive decline in older individuals.

Variations in fatty acid metabolism, "contribute to poor central nervous system (CNS) functioning in infants and children, and do so with long-lasting sequelae."

Animals are unable to form omega-3 or omega-6 fatty acids and "must obtain these fatty acids from their diet."

DHA is the major omega-3 fatty acid that forms the structural matrix of brain grey matter and retinal membranes.

"DHA accumulation in the brain and retina, as in other organs, depends on the amount and types of omega-3 fatty acids in the diet, and on dietary intake of omega-6 fatty acids which interact and compete with omega-3 fatty acids in the fatty acid metabolic pathway."

"Synthesis of DHA occurs in phytoplankton and animals, but not plants. This means that DHA is absent from foods of plant origin, including vegetable fats and oils, grains, nuts and seeds." **[Important]**

"DHA is present in animal tissue lipids, with the richest dietary source being fatty fish."

Common oils such as corn oil, safflower oil, sunflower oil and olive oil all contain < 1% omega-3 fatty acids.

The 18-carbon omega-6 fatty acid, linoleic acid is abundant in modern food supplies, with over 50% of all the fatty acids in soybean, corn, safflower and sunflower oils being omega-6.

Once obtained from the diet, the 18-carbon long omega-6 is metabolized to arachidonic acid.

"Lipid nutrition with very high omega-6 fatty acids and low in omega-3 fatty acids do not support biochemical and functional development of the central nervous system."

"DHA for brain growth and development is provided by placental transfer of omega-3 fatty acids before birth and in breast milk after birth, meaning that consideration of the effect of the maternal diet and metabolism must be considered."

The conversion of 18-carbon long (plant derived) omega-3 to DHA is low in adults and infants. **[Important]**

Supplementation with 18-carbon long (plant derived) omega-3 during pregnancy does not increase DHA in maternal or newborn infant.

Higher amounts of 18-carbon long (plant derived) omega-3 in infant formula does not increase circulating levels of DHA.

In current western diets, human milk, and infant formulas, omega-6 levels exceed 3%. When levels exceed 3%, DHA will be low unless DHA is supplemented.

"The types of fats in human diets has changed remarkably over the last century, driven in part by efforts to lower plasma cholesterol by replacing dietary saturated fatty acids with vegetable oils rich in omega-6."

"High intakes of DHA and EPA (from fish and other sea-foods) are associated with decreased risk of poor child performance on standardized IQ tests."

Studies show that in pregnant women, high levels of omega-6 contributes to low circulating levels of DHA. Consequently, both inadequate intakes of omega-3 fatty acids or excessive intakes of omega-6 are important.

"Human milk fat DHA varies among and within populations, from < 0.1% to over 1.0% DHA, explained largely by differences in the intake of preformed DHA, usually from fish and other sea-foods. Women following vegan and vegetarian diets usually have 0.1% or less DHA in their milk fat." **[Very Important]**

In the last 3 decades, "human milk DHA decreased by 50% to less than 0.2% milk fat."

"The amount of DHA in human milk is increased by increasing the maternal intake of DHA."

Human milk omega-6 varies from 6 to 30% milk fatty acids, depending on the maternal intake of omega-6.

"In the 1970s, human milk had an average of 7% omega-6 compared to the current average of 12 to 16% omega-6, an increase explained by the increased consumption of omega-6 rich vegetable oils."

Mammal synaptic membranes should be 35% DHA.

The decreased DHA in the brain of animals fed an omega-3 deficient diet in development is accompanied by altered metabolism of several neurotransmitters, including dopamine and serotonin, resulting in deficits in behavioral tasks of learning, leading to functional consequence.

"The potential for adverse effects of inadequate fatty acid nutrition during development to have lasting effects on neural functions, and the nature of those effects will depend on the stage in development, duration and severity of the dietary insult."

"Inadequate DHA alters brain development through effects related to membrane structures."

"Even short-term omega-3 fatty acid restriction is sufficient to cause early morphological and biochemical changes in the embryonic brain." **[Important]**

"Omega-3 fatty acid deficiency decreases the mean cell body size of neurons in the hippocampus, hypothalamus and parietal cortex, and decreases the complexity of cortical dendritic arborization."

Inadequate maternal omega-3 fatty acid nutrition among women has implications for infant neural development.

Infants fed low levels of DHA have lower visual acuity and language development during the first 14 months after birth than infants fed breast milk with higher levels of DHA.

High omega-6 fatty acids and low DHA "contributes to poor infant neural development."

Increased maternal or infant circulating levels of DHA at birth is associated with better infant neural and visual development.

"DHA nutrition in gestation and lactation has long-term benefits to mental and motor skill development in early childhood, consistent with epidemiological evidence to link maternal omega-3 fatty acid intakes in pregnancy to decreased risk of poorer IQ scores in young children."

"In conclusion, while there is no doubt that DHA is a critical component of brain membrane lipids, the possibility that western diets poor in omega-3 fatty acids and rich in omega-6 fatty acids contribute to poor CNS development and function is becoming increasingly recognized."

## KEY POINTS FROM DAN MURPHY

- 1) The omega-3 fatty acids are essential dietary nutrients, and docosahexaenoic acid (DHA) is required for nervous tissue growth and function.
- 2) Decreased DHA in the developing brain leads to deficits in neurogenesis, neurotransmitter metabolism, and altered learning and visual function.
- 3) Western diets are low in omega-3 fatty acids, including the 18-carbon omega-3 fatty acid alpha-linolenic acid, found mainly in plant oils, and DHA, which is found mainly in fish.
- 4) The DHA status of the newborn and breast-fed infant depends on the maternal intake of DHA.
- 5) Low maternal DHA increases the risk of poor child neural development.
- 6) Improving maternal DHA nutrition improves infant and child visual and neural development.
- 7) 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.
- 8) "The long chain omega-3 fatty acid known as docosahexaenoic acid (DHA) is the most abundant omega-3 fatty acid in the mammalian central nervous system, and is specifically concentrated in membrane lipids of brain grey matter and the visual elements of the retina."
- 9) Low levels of DHA increase the risk of poor visual and neural development in infants and children and increases risk of dementia and cognitive decline in older individuals.
- 10) Animals are unable to form omega-3 or omega-6 fatty acids and "must obtain these fatty acids from their diet."
- 11) DHA is the major omega-3 fatty acid that forms the structural matrix of brain grey matter and retinal membranes.
- 12) "Synthesis of DHA occurs in phytoplankton and animals, but not plants. This means that DHA is absent from foods of plant origin, including vegetable fats and oils, grains, nuts and seeds." **[Important]**
- 13) "DHA is present in animal tissue lipids, with the richest dietary source being fatty fish."
- 14) Common oils such as corn oil, safflower oil, sunflower oil and olive oil all contain < 1% omega-3 fatty acids.

- 15) The 18-carbon omega-6 fatty acid, linoleic acid, is abundant in modern food supplies, with over 50% of all the fatty acids in soybean, corn, safflower and sunflower oils being omega-6.
- 16) Once obtained from the diet, 18-carbon long omega-6 is metabolized to arachidonic acid.
- 17) "Lipid nutrition with very high omega-6 fatty acids and low in omega-3 fatty acids do not support biochemical and functional development of the central nervous system."
- 18) The conversion of 18-carbon long (plant derived) omega-3 to DHA is low in adults and infants. **[Important]**
- 19) Supplementation with 18-carbon long (plant derived) omega-3 during pregnancy does not increase DHA in maternal or newborn infant.
- 20) Higher amounts of 18-carbon long (plant derived) omega-3 in infant formula does not increase circulating levels of DHA.
- 21) In current western diets, human milk, and infant formulas, omega-6 levels exceed 3%. When levels exceed 3%, DHA will be low unless DHA is supplemented.
- 22) "The types of fats in human diets has changed remarkably over the last century, driven in part by efforts to lower plasma cholesterol by replacing dietary saturated fatty acids with vegetable oils rich in omega-6."
- 23) "High intakes of DHA and EPA (from fish and other sea-foods) are associated with decreased risk of poor child performance on standardized IQ tests."
- 24) Studies show that in pregnant women, high levels of omega-6 contributes to low circulating levels of DHA. Consequently, both inadequate intakes of omega-3 fatty acids or excessive intakes of omega-6 are important.
- 25) "Human milk fat DHA varies among and within populations, from < 0.1% to over 1.0% DHA, explained largely by differences in the intake of preformed DHA, usually from fish and other sea-foods. Women following vegan and vegetarian diets usually have 0.1% or less DHA in their milk fat." **[Very Important]**
- 26) In the last 3 decades, "human milk DHA decreased by 50% to less than 0.2% milk fat."
- 27) "In the 1970s, human milk had an average of 7% omega-6 compared the current average of 12 to 16% omega-6, an increase explained by the increased consumption of omega-6 rich vegetable oils."

- 28) The decreased DHA in the brain of animals fed an omega-3 deficient diet in development is accompanied by altered metabolism of several neurotransmitters, including dopamine and serotonin, resulting in deficits in behavioral tasks of learning, leading to functional consequence.
- 29) "The potential for adverse effects of inadequate fatty acid nutrition during development to have lasting effects on neural functions, and the nature of those effects will depend on the stage in development, duration and severity of the dietary insult."
- 30) "Inadequate DHA alters brain development through effects related to membrane structures."
- 31) "Even short-term omega-3 fatty acid restriction is sufficient to cause early morphological and biochemical changes in the embryonic brain." **[Important]**
- 32) "Omega-3 fatty acid deficiency decreases the mean cell body size of neurons in the hippocampus, hypothalamus and parietal cortex, and decreases the complexity of cortical dendritic arborization."
- 33) Infants fed low levels of DHA have lower visual acuity and language development during the first 14 months after birth than infants fed breast milk with higher levels of DHA.
- 34) High omega-6 fatty acids and low DHA "contributes to poor infant neural development."
- 35) Increased maternal or infant circulating levels of DHA at birth is associated with better infant neural and visual development.
- 36) "DHA nutrition in gestation and lactation has long-term benefits to mental and motor skill development in early childhood, consistent with epidemiological evidence to link maternal omega-3 fatty acid intakes in pregnancy to decreased risk of poorer IQ scores in young children."
- 37) "In conclusion, while there is no doubt that DHA is a critical component of brain membrane lipids, the possibility that western diets poor in omega-3 fatty acids and rich in omega-6 fatty acids contribute to poor CNS development and function is becoming increasingly recognized."