Essential Fatty Acid Needs During Pregnancy and Lactation

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Key messages

- The endogenous synthesis of both docosahexaenoic acid (DHA) and arachidonic acid (ARA) in early life may be insufficient, and the rate of membrane DHA incorporation depends mostly on maternal transfer and dietary supply (i.e., breastfeeding).
- DHA content in breast milk is very dependent on the mother's diet and can be very low in populations living on a primarily plant-based diet with no or limited fish intake.
- In countries with low socioeconomic status, the availability of DHA and ARA in the food supply among pregnant women, infants and young children is significantly lower than the minimum recommended intake proposed by international organizations.

Fatty acids: biological meaning and worldwide consumption

Long-chain polyunsaturated fatty acids (LC-PUFA), including docosahexaenoic acid (DHA) and arachidonic acid (ARA), are incorporated into membrane phospholipids, and their presence can influence cellular structure and function.[1] The omega-3 (n-3) LC-PUFA DHA is especially important for the brain and retina, where it rapidly accumulates during the early years of life[2] and plays an important role in the development of visual and cognitive function.[3] The omega-6 (n-6) LC-PUFA ARA is also rapidly accreted by the infant brain but, in addition, it is also widely distributed throughout other vital organs and tissues within the body. It is increasingly being recognized that both DHA and ARA are important precursors and messengers for a variety of biological processes, particularly in relation to cerebral, cardiovascular and immune functions.[4] These lipid mediators play crucial roles in the prevention or treatment of common chronic diseases that may lead to significant morbidity and mortality.[5]

There are two key components that may influence DHA and ARA status. First, there is the contribution of endogenous synthesis from the essential precursor 18-carbon n-3 and n-6 fatty acids, linoleic acid (LA) and α-linolenic acid (ALA), respectively; second, there is the contribution from preformed DHA and ARA sources in the diet.[5] Endogenous synthesis is directed through a metabolic pathway where the n-3 and n-6 fatty acids compete for a shared desaturation and elongation enzyme system. As a consequence, the balance in the intake of the essential 18-carbon n-3 and n-6 precursors can influence the levels of DHA and ARA derived from endogenous synthesis.[6] Moreover, it is now recognized that this metabolic pathway is relatively inefficient in converting n-3 and n-6 precursor fatty acids to DHA and ARA respectively, especially in early life, when organ development is at its peak.[7]

Studies have shown that the endogenous synthesis of both DHA and ARA in early life may be insufficient[8,9] and that blood and tissue concentrations decrease rapidly after birth if exogenous supplies are inadequate.[2,3,10]

In addition to substrate competition, the efficiency of the Δ5- and Δ6-desaturase steps is also dependent on the genotype of fatty acid desaturase system (FADS) 1 and FADS2, both located on chromosome 11, and which encode Δ5- and Δ6-desaturase enzymes, respectively.[6]

Concerning the supply from diet, animal-source foods, including meat, poultry, egg, milk and fish, are important sources of n-6 and n-3 fatty acids. In particular, seafood, mostly marine species, is the only food group that has a significant content of n-3 LC-PUFA (e.g., eicosapentaenoic acid [EPA] and DHA). Different populations may have different intakes of n-3 LC-PUFA based on the access to coastal areas and therefore on the type of fish species that are available for consumption.[11]

LC-PUFA may be derived from fatty fish that live in cold saltwater (like the sardines depicted here) or from algae.

Following extensive researches in Western countries, scientific interest in the beneficial effects of an optimal dietary fatty acid composition in low-income countries has recently grown, especially concerning vulnerable population groups such as pregnant women, infants and young children. Indeed, in low-income countries, the major staple foods are represented by cereals that all have a low essential fatty acid content, especially if refined.[11] On the other hand, legumes and oils thereof, such as soya bean products, in spite of high contents of anti-nutrients such as polyphenols, phytate and certain oligosaccharides, may be an important source of precursor LC-PUFA LA and ALA in population groups without access to animal-source foods.[12–15]

As a result, in many low-income countries, more than 50% of the PUFA intake comes from vegetable oil, and the most balanced ratios between LA and ALA are found in soybean oil and canola, or rapeseed oil.[11]

> "Interest in the beneficial effects of an optimal dietary fatty acid composition in low-income countries has recently grown"

Essential fatty acids in pregnancy

The accumulation of DHA in the brain takes place during the brain growth spurt in the intrauterine and neonatal period up to two years of age, and the high levels of DHA in the brain are maintained throughout life.[16] Due to the lack of *de novo* PUFA synthesis, the rate of membrane DHA incorporation in early life – in the brain as well as in other tissues – depends on direct maternal transfer, and then dietary supply (i.e., breastfeeding) and endogenous LC-PUFA production.[17] The DHA accumulation in the brain during the third trimester of pregnancy is substantially higher (in % of fatty acids [FA%]) than the overall body deposition rates, whereas brain incorporation of ARA is more in line with that which occurs in other tissues.[18] Fetal LC-PUFA accumulation occurs mainly during the last trimester, in which weight increase becomes more rapid and growth is accompanied by a deposition of fat tissue, which begins around the thirtieth week of gestation.[19]

The intrauterine PUFA supply occurs via transfer of non-esterified PUFA mainly derived from the maternal circulation across the placenta. The overall fat concentration in maternal plasma increases throughout pregnancy, and placental fat transport is driven by a concentration gradient, as the fetus has substantially lower fat concentrations, including the concentration of DHA and ARA.[18]

The n-3 fatty acids EPA and DHA help sustain pregnancy duration. In particular, for high-risk pregnant women, n-3 fatty acid intake seems to have an important effect on reducing spontaneous premature births.[20] A high ratio of n-6 to n-3 fatty acids will result in increased proinflammatory eicosanoid production (i.e., prostaglandin E_2 [PGE_2] and prostaglandin F_2 [PGF_2]). These metabolites have been associated with the initiation of labor and preterm labor. Including more EPA in the diet may lead to a reduction in the production of proinflammatory eicosanoids and increased production of prostacyclin (PGI_2), which may promote myometrial relaxation. n-3 LC-PUFA downregulate the production of prostaglandins PGE_2 and PGF_2, and may thereby inhibit the parturition process.[21,22] This results in an increased birth weight and intrauterine LC-PUFA accretion. In infants born preterm the progressive accumulation of LC-PUFA in fetal tissues is truncated at the end of pregnancy, and accumulation is also strongly limited in growth-retarded fetuses.[23]

At present, there are conflicting data regarding the impact of n-3 fatty acids on the length of gestation.[24,25] However, the amount of n-3 fatty acids derived from the recommended amount of seafood intake or daily supplementation to optimize fetal brain development may have the added benefit of reducing the risk of preterm birth in high-risk populations (i.e., women with a history of preterm birth or women with low baseline n-3 fatty acid intake).[26]

Major depressive disorder affects 10% to 20% of perinatal women. Pregnancy-related and postpartum depression have been shown to affect child attachment, cognitive development, and behavior.[26] Research by Makrides and colleagues has demonstrated that increased intake of LC-PUFA during pregnancy reduces the risk of depressive symptoms in the postpartum period.[27] Polyunsaturated fatty acids have been shown to decrease proinflammatory cytokine production, which is elevated in depressed patients.[28] n-3 fatty acids are transferred from the mother to the fetus during pregnancy, thereby depleting maternal stores. Because many women remain reluctant to take antidepressant medication while they are pregnant or breastfeeding, it has been postulated that increasing intake of omega-3 fatty acids from the diet and supplements could theoretically prove beneficial and protective of maternal affect.[26]

"Research has demonstrated that increased intake of LC-PUFA during pregnancy may reduce the risk of depressive symptoms in the postpartum period"

Essential fatty acids during lactation and complementary feeding period

Breast milk is the most important source of PUFA during the first two years of life, but the breast milk DHA content is very dependent on the mother's diet and can be very low in populations living on a primarily plant-based diet with no or limited fish intake.[11]

Post-natal accumulation of LC-PUFA in infant tissues is supported by maternal transfer of PUFA through breast milk, and blood levels of LC-PUFA in breastfed infants remain higher than maternal levels for some time postnatally.[29,30]

With respect to the functional effects of LC-PUFA supplementation in infancy, the most accepted developmental effect is an increased rate of visual acuity development.[31] However, little is known regarding the persistency of this effect on vision and the potential effects that this early visual deficit may have on cognitive development. Overall, meta-analyses of the randomized controlled trials that have investigated the effect of LC-PUFA supplementation on neurodevelopmental outcomes throughout the first two years of life have not shown any clear benefit of LC-PUFA addition to infant formula on development of term or preterm infants.[32–34]

The meta-analyses looking at the developmental effects of maternal n-3 LC-PUFA supplements in pregnancy and lactation have suggested some effects on neurodevelopment based on a few studies.[35,36] However, at the current stage, this does not provide any definite proof that an increase in the early DHA supply improves the mental development of infants.

Interestingly, in a small Danish trial of maternal fish oil supplementation during lactation, treatment-gender interactions were found on blood pressure at 7 years of age.[37] Blood pressure is not normally defined as cognitive outcome, but it can nevertheless be affected by the central nervous system in response to anxiety. As was the case with cognitive outcomes, boys and girls in the fish oil group were found to have comparable diastolic and mean arterial blood pressures, whereas girls had higher blood pressures than boys in the control group.[37] The intervention was also found to level out gender differences in energy intake and physical activity at 7 years of age.[37] Accordingly, these results indicate that early DHA intake could also have long-term health consequences, which might be mediated by effects in the brain and lifestyle choices.

Influence of genetic polymorphisms

The influence of FADS polymorphisms on LC-PUFA status introduces new variables to be considered in the evaluation of the effects of FADS genotype on development and health of young children. Several studies have shown that infant FADS genotype, examined by use of different individual Single Nucleotide Polymorphisms (SNPs), modifies the effect of breastfeeding on IQ-like neurodevelopmental outcomes in childhood,[38,39] while other studies did not find any significant interaction.[40,41]

In lower-income developing countries the LC-PUFA content of traditional complementary foods is low, and consequently these infants may be vulnerable to LC-PUFA deficiency, especially if they are not receiving breast milk.[11] This vulnerability may be further increased if the maternal LC-PUFA diet is insufficient, starting at the stage of transplacental transfer of LC-PUFA during pregnancy, leading to an early reduction of the LC-PUFA status of the infant at birth.[42] Moreover, maternal diet relates to the LC-PUFA content of breast milk, especially DHA, and low maternal DHA status is associated with low levels of DHA in breast milk.[43]

"In the vast majority of developing countries, the DHA and ARA intakes among pregnant women, infants and young children may be significantly lower than current recommendations"

This suggests that in the vast majority of developing countries, the DHA and ARA intakes among pregnant women, infants and young children may be significantly lower than current recommendations proposed by various international organizations (i.e., Dietary Reference Values by the European Food Safety Authority [EFSA] and the Food and Agriculture Organization of the United Nations [FAO] for the European and the global populations, respectively, which are provided in **Table 1**).[44,45] This has potential significant public health implications, and future policies on dietary DHA and ARA need to reflect the specific needs of the world's most vulnerable populations.

TABLE 1: Dietary Reference Values (DRV) for essential fatty acids (EFSA 2010, FAO 2010) [44,45]

	Infants and children		Pregnancy and lactation	
	EFSA	FAO	EFSA	FAO
ARA	No DRV	No DRV	No DRV	No DRV
DHA	AI 7–24 mo: 100 mg/day	0–6 mo: 0,1–0,18 En%	RI: 100–200 mg/day	200 mg/day
		0–6 mo: 0,1–0,18 En%		
EPA+DHA		2–4 y: 100–150 mg/day	RI: 250 mg/day	300 mg/day
		4–6 y: 150–200 mg/day		
		6–10 y: 200–250 mg/day		

AI: Adequate Intake Energy

En%: Energy %

RI: Reference Intake ranges for macronutrients. These are expressed as a proportion of daily energy intakes, to reflect intakes that are adequate for maintaining health and are associated with a low risk of chronic disease. For example, the reference intake range set for dietary fat is 20–35% of total daily energy intake.

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