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The Role of Omega-3 Fatty Acids throughout the Life Cycle: Part 1

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Canadian diets contain relatively high levels of polyunsaturated fats (fatty acids) representing approximately 4-6% of total energy intakes with 90% of the polyunsaturated fatty acids (PUFA) being consumed as the omega-6 PUFA (also known as n-6 PUFA)[1]. These are consumed mostly as linoleic acid via common vegetable oils plus minor amounts of arachidonic acid in animal-based food products. The so-called omega-3 PUFA (n-3 PUFA) typically represent only 10% of the total PUFA intake with approximately 90% of the omega-3 PUFA being consumed (approximately 1.6 gm daily) as the short-chain omega-3 fatty acid known as LNA (alpha-linolenic acid) as found in plant food sources such as soybean oil, canola oil, flax, English walnuts, others. The fish/fish oil-based omega-3 fatty acids represent very minor components (approximately 10%) of the total omega-3 intakes. These long-chain omega-3 fatty acids consist of EPA (eicosapentaenoic acid, 20:5 n-3) plus DHA (docosahexaenoic acid, 22:6 n-3) and are found in varying amounts and ratios in fish/seafood with lesser amounts being consumed in other animal-based foods or processed foods wherein DHA/EPA are added. The metabolic conversion of dietary LNA in the liver to EPA/DHA is both highly variable between individuals and very limited with overall efficiencies in adults (females and males) for LNA to DHA averaging only 3-4%. Thus, the direct consumption of pre-formed DHA/EPA in foods/diets is the most direct means for their provision to the body for health. Typical adult intakes of EPA plus DHA (combined) in Canada range from 100-150 mg/day which reflects very modest fish intakes of approximately one serving every 7-10 days. Much higher intakes are found (approaching 1200 mg/day) in certain countries such as Japan which have very high fish/seafood consumption. The present report will update the reader on recent evidence-based studies which focus on the potential health benefits of DHA/EPA omega-3 when consumed as fish/seafood, fish/algal oils, functional foods, and/or via supplementation in healthy or at risk populations.

Omega-3 Fatty Acids during Pregnancy and Lactation

Docosahexaenoic acid (DHA) is recognized as a physiologically-essential fatty acid in the brain and retina of the eye where it is found in high levels as the predominant member of the omega-3 fatty acids found in the cell membranes therein. The high level of DHA, with its special structural and physical-chemical properties, supports optimal cognitive performance and visual acuity in the brain and retina, respectively, via the mediation of nerve transmission and other critical functions. DHA accumulates in neural and other tissues throughout pregnancy with the last trimester being a particularly active period of growth and neurodevelopment for the infant. DHA continues to accrue at a high rate via lactation during early infant development after birth in nervous and other tissues with the amount of DHA in the brain increasing approximately 30-fold from about 24 weeks of gestation to about 2 years of age[2].

The ALSPAC study[3] found a significantly higher risk of sub-optimal outcomes for various development parameters (verbal IQ, behaviours) up to 8 yrs later in those children from mothers who consumed no seafood as compared to those consuming 340 gms or more per week during pregnancy (340 gms/week estimated to provide an average of approx. 160 mg DHA/day). A recent Spanish study suggested that moderately high intakes of fish during pregnancy may benefit neurodevelopment in children at age 4 years[4]. Daily intake levels of 294 mg DHA as enhanced via supplementation by mothers (versus only 80 mg/day) were found to significantly improve infant visual acuity at four but not six months of age[5]. The PERLIP project (as charged by the European Commission) has recommended that pregnant women should aim to achieve an average intake of at least 200 mg DHA/day[6] which contrasts with an average intake of only 82 mg/day for pregnant Canadian women as directly assessed[7]. Very recently, a randomized controlled trial from Australia reported that DHA supplementation during the last half of pregnancy did not reduce postpartum depression in the mothers or selected measures of cognitive and language development in children as assessed at 18 months[8]. It remains to be determined whether more prolonged supplementation during pregnancy and throughout lactation, particularly in mothers with a low DHA status, may have resulted in beneficial outcomes to the children based on a wide array of cognitive and visual measures.

Omega-3 Fatty Acids during Infancy, Childhood and Adolescence

Some controlled clinical trials in full-term infants have indicated that the presence of DHA in breast milk at higher levels or in infant formula (eg., approx. 0.32% of milk fat which is close to the worldwide human milk level) results in improved cognitive and visual outcomes[9]. A literature review has supported an overall improvement in visual developments in term infants fed formula providing at least 100 mg daily[10] which can be expected by breast milk or infant formula having approx. 0.35% of milk fatty acids as DHA. Recently, the World Association of Perinatal Medicine recommended that lactating women consume at least 200 mg DHA/day[11] while the earlier ISSFAL-supported NIH Workshop advised at least 300 mg DHA/day. Such intakes can be expected to yield levels of approx. 0.30-0.35% DHA in breast milk fat.

The accretion of DHA in the brain progressively increases in the cerebral cortex up to 18 years of age[12]. The evidence for the potential benefits of DHA/EPA supplementation in healthy children older than 2 years of age is generally promising in some studies but not yet conclusive. By supplementing healthy 4-year-old children with 400 mg DHA (or placebo) per day for 4 months, the higher blood levels of DHA which resulted were significantly and positively associated with improved scores on the Peabody Picture Vocabulary Test (a test of listening comprehension for the spoken word in Standard English)[13]. Another recent study on older children (10-12 years of age) which provided 400 or 800 mg supplemental DHA per day for 8 weeks did not find any significant beneficial effect on brain function in healthy children[14]. A formulated functional food (bread spread containing fish flour from a marine source) providing an average intake of 182 mg per day of DHA and EPA combined over 6 months was recently reported to moderately improve the learning ability and memory of children ages 7-9 years[15]. Various studies using DHA and EPA supplementation in attention-deficit-hyperactivity disorder have been inconsistent[16] while preliminary investigations on childhood depression[17] and neurological outcomes in children with phenylketonuria[18] have been encouraging.

Our lab has determined fatty acid intakes in a population of Canadian children aged 4-8 years by direct diet quantitation[19]. Very low intakes of DHA and EPA were found averaging 54 and 38 mg/child/day, respectively. Only 22% of the children met the suggested adequate intake (DHA plus EPA) based on the Dietary Reference Intakes from the Institute of Medicine (Washington, DC) and only 51% met the recommended intakes for long-chain omega-3 fatty acids for children from Australia and New Zealand. The wide 'nutrition gap' between actual versus recommended intakes of DHA and EPA for young children emphasizes the need to recommend increased consumption of appropriate fish and seafood, fortified foods, and possibly supplements containing DHA and EPA.

Summary and Conclusions

The overall evidence-based research to date support the importance of adequate long-chain omega-3 fatty acid intakes (particularly DHA) during pregnancy and lactation to support optimal cognitive and visual development both for the infant and throughout childhood. In addition, direct health benefits to the mother may also be forthcoming from increased intakes of fish/seafood or alternative sources of DHA/EPA including various foods enriched in omega-3 fatty acids or supplementation. Unfortunately, almost all the research to date has not differentiated between those who may be at particularly high risk of omega-3 deprivation for optimal health and others (mother and child) who may have a sufficiently adequate omega-3 status at the physiological level. It is expected that specific recommendations for DHA and/or (DHA plus EPA) intakes in mg/day will be forthcoming from governmental sources in North America, in addition to current target intakes for LNA, in keeping with advisories from international committees and agencies.

Ongoing updates on forthcoming evidence-based research on DHA/EPA omega-3 in health and disease can be freely-accessed via the DHA/EPA Omega-3 Institute at www.dhaomega3.org.

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