Chapter 118

The Importance Of Docosahexaenoic Acid (DHA) For Child Development

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ABSTRACT
Long-chain polyunsaturated fatty acids (LMPIC), such as those of the n-3 family, represented by eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), have relevant physiological and biochemical functions in human metabolism and health. DHA, specifically, is a key nutrient for childhood growth and development because of its primary role in the formation and functioning of the central nervous system and retina in humans. DHA is present in important quantities almost exclusively in foods such as seafood (fish, shellfish, micro and macroalgae) and also, in smaller quantities, in meat, milk, and eggs. It is known that the ingestion of aquatic foods during the Middle to Upper Paleolithic period was a watershed in human evolution. In addition to the evolutionary importance of DHA for our species, recent research has established that n-3 PUICLPs are of immense importance in both pregnancy and early childhood, where DHA plays an important role in the development and function of the brain and eyes of infants and children. Deficiency of PUICLs (n-6 and n-3) correlates with impaired cognitive and behavioral performance in children. Thus, nutrition with DHA during pregnancy and lactation represents a critical stage for the child's brain and eye development, and a balanced and varied diet is of utmost importance for the nursing mother, for transmission to the infant through exclusive breastfeeding, or in infant feeding since the introduction of complementary foods. In case these are not the case, supplementation may be necessary, due to the importance of this micronutrient

Keywords: Intants, Child development, Nutritional supplements, omega-3 fatty acids.

1 INTRODUCTION

The fatty acids of the omega 3 series, formed by linolenic, docosahexaenoic acid (DHA), eicosapentaenoic (EPA), and docosapentaenoic (DPA), constitute a group of lipids that have significant functions in the body, being incorporated into the phospholipids of the cell membranes, optimizing their biological function. This optimization occurs particularly in the structure and function of brain cells, glia, and endothelia, strengthening memory and neuroinflammatory control, as well as in the retina, testes, heart, liver, and kidneys. [1, 2-5].

The omega-3 fatty acid is composed of alpha-linolenic acid (ALA). This, through processes of desaturation and elongation, gives rise to two longer chain acids: eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA).[6]

Several benefits of omega-3 intake are reported, such as decreasing inflammatory eicosanoids, cytokines, and reactive oxygen species, preventing and treating cardiovascular disease, inflammatory diseases, infections, and reducing the occurrence of injury, immune changes, and acts to slow cognitive decline. [7-8]

Some studies have attested to the importance of continued human intake of omega-3 polyunsaturated fatty acids for improving the functioning of our bodies in many ways. The results of these, especially those conducted at the end of the 20th century and the 21st century, have promoted very important changes in the way doctors, nutritionists, and even governmental public policies have begun to position themselves in the face of the most different diseases and their prevention, that is, the preventive strengthening of health itself. [9]

Due to the difficulty of the vast majority of the population to obtain these fatty acids directly from food - based on fish from icy deep sea waters that feed on *krills* and algae that contain these oils, or from nuts, seeds and green leaves that have them, but in small quantities and difficult to absorb - the indications of doctors and nutritionists ended up also promoting an exponential increase of manufacturers and brands of omega-3 supplements, whose advertisements bombard us daily these days, occupying the media and social networks.[10]

However, even though they participate in these functions essential to human life, our body is not able to synthesize them: they can only be provided by food! And this is where we identify the serious problem: the ratio of omega-3 to omega-6, which a century ago was 1:1 or 1:2, and for the good of our health should have remained that way, is now 1:20 or even 1:40 due to the scarcity of omega-3 in our diet and the abundance of processed foods and vegetable oils very rich in omega-6 that are now abundantly consumed. But how important is this imbalance for health? The fundamental importance is that omega-3 fatty acids are anti-inflammatory while omega-6 fatty acids are inflammatory, i.e., they contribute to the creation of the inflammatory organ environment favorable for the development of cancer, degenerative diseases such as Alzheimer's, coronary heart disease, depression, bone and joint disease, and many others. [11]

The researches that have been carried out in the last sixty years, especially the most recent ones, have already enlightened us about the relevant biochemical and physiological functions of polyunsaturated docosahexaenoic fatty acids (DHA) in human metabolism and health, with beneficial results to this supplementation in adults and children. Notably for child growth and development, DHA has already been identified as an essential nutrient for the formation and functioning of the central nervous system and retina. However, research shows that precisely during pregnancy and the first years of a child's life, in which DHA is essential for the constitution of, among other things, the brain and eyes, the amount of this fatty acid

found in the maternal organism (in intrauterine passage to the fetus) and, after birth, in the infant up to two years of age, is very small. This situation is even more serious when we observe in some research that DHA deficiency shows a positive correlation with cognitive and behavioral impairment in children. [12-14]

2 CHILD DEVELOPMENT

Development is assessed through a set of skills that most children achieve within an age range. Developmental milestones, such as walking and talking, have a wide range of what is considered normal in the early years. The screening process aims to identify these children quickly and reliably if their level of development is below that accepted as normal for their age and if they need further investigation and additional therapies.

The most widely used developmental screening test for infants and toddlers is that created by Dr. William Frankenburg and his colleagues in Denver, Colorado, 1960. The best known and oldest, the Denver Developmental Screening Test (TTDD) and its revision, the TTDD-R, were again revised, repadronized, and designated as Denver II in 1990. [15]

Development is divided into four groups: Motor development, which includes control of body movements from gross to more delicate and evolves sequentially in children (such as control of the head, torso, turning, sitting and standing); adaptive development, which is the adjustment to new and more complex activities based on previous experiences (more elaborate motor skills that evolve through coordination, perceptions, such as transferring an object from one hand to the other); language development, that of understanding all methods of communication, whether gestural, audible, or verbal, which are manifested from birth through cries, laughter, grunts, and even intelligible verbalizations; and psychosocial development, which represents the child's interaction with others, with the social and cultural environment in which it is inserted, and the beginning of the ability to perform activities independently, such as eating, bathing, brushing teeth, and other activities.[15]

The evaluation through the Denver II test is simple and easy to apply, and can be performed in pediatric offices and clinics, and also in health units, especially in primary health care, all over the world, in order to record an important moment of contact of children and their families with the health team, and also to serve as comparative parameters between the current development and future references.

3 DHA AND EARLY CHILDHOOD DEVELOPMENT - ITS IMPACT ON THE FIRST 1000 DAYS

The brain grows very rapidly during the fetal period and the first years of life. The consensus points out that there is a strong correlation between proper nutrition and cognitive and visual development in children. In addition, it also revealed that DHA, along with arachidonic acid, is the main lipid component of brain tissue and is the basis for brain and visual development in children. [16]

Breast milk contains bioactive substances, such as long-chain polyunsaturated fatty acids (LCAs), which are essential for brain development. In fact, two derivatives of these acids, arachidonic acid (ARA

or omega 6) and docosahexaenoic acid (DHA or omega 3), play essential roles in brain maintenance, growth and development. [17,18]

Breast milk is the best food for infants and should be exclusive use in the first six months of life, and supplementary until two years of age or older, [19,20] so it is important that mothers consume good sources of food, and of supplements, such as sources of omega-3 and 6, to transmit DHA to the infant through breast milk. For infants under 6 months of age who are not exclusively breastfed, it is recommended that prescribed infant formulas contain 0.2% to 0.5% of total lipids in the form of DHA. [21]

The phase that begins while still in intrauterine life, and then extends from birth to the end of the second year of life is considered the main phase of brain development, making up the period of the first 1000 days, so important and worldwide discussed lately. [19]

However, it should be considered that many areas and many synapses in the brain, such as the frontal lobe, will continue to develop throughout childhood and into late adolescence, and this part of the brain contains a high concentration of long chain fatty acids, especially DHA, which is essential for neuronal development. [13] This nutrient accounts for at least 15% of the total fatty acids in the human frontal cortex. At this stage, it is important to consider that DHA is important for capacitation and glucose metabolism, and some of its biologically active metabolites protect tissues from oxidative stress. In addition, it also plays a role in other areas, such as bone development. [19]

4 LONG-CHAIN POLYUNSATURATED FATTY ACIDS (LMPIC) AND LACTATION

In a study on the relationship between the mean concentrations of polyunsaturated fatty acids (alpha-linolenic acid, ALA, and docosahexaenoic acid, DHA), all from the omega-3 family, in samples of breast milk in the first and third months of lactation and the psychomotor development of infants exclusively breastfed until the sixth month of life, a positive association was identified between the concentrations of omega-3 fatty acids (ALA and DHA) in breast milk and infant motor development. Therefore, the authors reinforce the need to provide these nutrients to breastfeeding women. [22]

The Brazilian recommendation for lactating women follows the I Consensus of the Brazilian Association of Nutrology on DHA recommendations during gestation, lactation, and infancy because it recognizes the importance of DHA for the cognitive and visual development of babies. After birth the needs for polyunsaturated fatty acids continue to increase due to body needs, so the same consensus recommends from recent studies, that the amount to be supplemented with DHA for lactating women is 600 mg per day. [21]

Breastfeeding rates have been increasing in Brazil and a new research coordinated by the Federal University of Rio de Janeiro shows how breastfeeding is present in the lives of children up to two years old and their mothers. The National Study on Infant Food and Nutrition (ENANI-2019), commissioned by the Ministry of Health, shows that half of Brazilian children are breastfed for more than 1 year and 4 months. However, we are still far from the World Health Organization's goals for 2030: 70% in the first hour of life,

70% in the first six months, exclusively, 80% in the first year, and 60% by two years of life, the same occurring in the Southeast region, site of the study. And, the use of formulas has a financial cost for the family, as well as for the infant's health, and the situation is even worse when the infant uses fluid or powdered milks.

5 DOCOSAHEXAENOIC ACID - DHA, IN THE COMPOSITION IN BREAST MILK

There is strong evidence that maternal diet influences the content of EPA (eicosapentaenoic acid), DHA (docosahexaenoic acid) and ARA (arachidonic acid), which can be justified and enhanced in the consumption of meat, fish, milk and eggs in the diet. [24,25]

The long-chain polyunsaturated fatty acids are absorbed, transformed into triglycerides by re-esterification pathways, and finally enter the circulation as chylomicrons. Through the action of protein lipase, these chylomicrons are transferred to the mammary gland to finally be transferred to the mother's milk. Also by means of protein lipase, hepatic triacylglycerols are also transported from the liver to the mammary gland in the form of VLDL. Protein lipase activity decreases in adipose tissue and increases in mammary tissue, this occurs during the lactation period and indicates an increased uptake of fatty acids into this tissue. [24,25]

In recent decades, special attention has been paid to aspects of the composition and physiology of the lipid fraction of human milk. The average fat content of breast milk is 3.8g/100ml, but this value can vary widely. The lipids are synthesized by the mammary alveolar cells in the form of fat globules. This synthesis is stimulated by the emptying of the breast and the secretion of prolactin during breastfeeding. The lipid fraction of breast milk is the major source of energy for breastfeeding infants, accounting for 40% to 55% of total energy intake and providing essential nutrients such as fat-soluble vitamins and PUFAs, including n-6 linoleic acids and n-3 alpha-linolenic acid. [24,26]

The mother's diet and the quality of lipids in the diet have a direct influence on the fatty acid profile of the milk. A diet rich in carbohydrates, for example, will favor the synthesis of short and medium chain fatty acids. On the other hand, a diet rich in polyunsaturated fatty acids will, as a consequence, present higher levels of these in breast milk. [26]

In contrast, infants who receive a low-fat milk tend to suckle more often and also for longer, which consequently causes an increase in milk secretion volume. It is possible to positively relate weight gain during gestation and the fatty acid profile of the milk. Thus, the adipose body composition of the mother and the concentration of lipids in the milk is of paramount importance in infant nutrition during the lactation period. [26]

6 DOCOSAHEXAENOIC ACID - DHA, AND NEUROGENESIS

The importance of DHA in the development of the central nervous system (CNS) is one of the best studied areas. DHA plays a role in neurogenesis, neurotransmission, and protection against oxidative stress. The n-3 and n-6 PUFAs are essential for infant brain development; they are involved in many neuronal processes, from effects on membrane fluidity to regulation of gene expression. Brain accumulation of DHA begins in utero and increases quantitatively during the second half of pregnancy, coinciding with the growth spurt of gray matter. Deficits and imbalances in these fatty acids are associated with impairments in cognitive and behavioral performance. Fish intake during pregnancy and higher n-3 PUFA levels at birth are associated with better visual development in babies born at term. [26]

Brain lipids are rich in n-3 and n-6 PUFA, which play key roles in neuronal growth, such as signal transduction and neuromembrane excitability, as well as in gene expression that regulates cell differentiation and growth. Certainly DHA, in addition to its positive effects on infant growth, is also the most numerous polyunsaturated fatty acid in the cones and rods of the retina. About one-tenth of the brain's weight and half of its dry weight are lipid compounds, half of which are phospholipids. The phospholipids of the brain gray matter and the retina, in particular, contain large amounts of DHA and ARA, suggesting the strong relationship that these fatty acids play important roles in visual and neural processing. [27,28]

Breastfeeding, a natural source of DHA, was generally associated with better cognitive performance compared with feeding DHA-deficient formula, even when socioeconomic variables are considered. Furthermore, DHA supplementation by mothers during pregnancy and lactation through consumption of high-DHA foods, fish oil, or capsules results in higher DHA concentrations in breast milk and infant erythrocytes and plasma, which is directly associated with better cognitive development. In conclusion, consumption of PUFA in infancy, and also by the mother during the lactation period, can improve cognitive development. [29]

7 FINAL CONSIDERATIONS

The beneficial effects of essential fatty acids, particularly LFAs, on the health of infants and children are evident. During gestation, the neonatal period, and the first thousand days, the supply of these fatty acids in adequate amounts is critical for proper brain and retinal development and function.

Thus, maternal nutrition plays a key role in the supply of these fatty acids, and a diet rich in source foods must be consumed in order to meet not only the child's needs in each of these stages but also her own. The absence of maternal lactation can produce a lack of these nutrients on the part of the newborn, as well as disturbances in its development. In addition, LFAs play an important role in the prevention of several diseases, such as cardiovascular diseases, colon cancer, immune and inflammatory diseases, among others.

Although some studies have observed advantages in infant development with the use of formula fortified with LAFA, there is no doubt that breastfeeding is the best and most appropriate way to offer these fatty acids to the infant.

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