

A woman with blonde hair in a ponytail, wearing a white lab coat, is holding a baby wrapped in a white blanket. She is looking down at the baby with a gentle expression. The background is a plain, light-colored wall.

Breast Milk and Cognitive Development: The Role of Essential Fatty Acids

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INTRODUCTION

The importance of human milk for the development of infants in early life is well established. Human milk fat is the major energy source of newborn babies, providing 50% of energy content as well as supplying cholesterol and phospholipids which are essential for growth and development. Some fatty acids in human milk have defined functions in the newborn, other than just providing energy, such as long-chain polyunsaturated fatty acids (LCPUFAs) which are essential for brain development.^{1,2} The scope of this article is to review some of the information available in the field of LCPUFAs in the development of brain function in infants.

FAT AND FATTY ACIDS

Dietary essential fatty acids (EFAs) have long been considered part of the lipid supply that is necessary for energy, growth, cellular metabolism and muscle activity.² The parent EFAs are linoleic acid (LA, an n-6 fatty acid) and alpha-linolenic acid (ALA, an n-3 fatty acid). The most important EFAs derived from LA are dihomo-gamma-linolenic acid (DGLA, 20:3n-6), a precursor of series 1 eicosanoids, and arachidonic acid (AA, 20:4n-6), a precursor of series 2 eicosanoids and an important structural lipid. The most important EFAs derived from ALA are eicosapentaenoic acid (EPA, 20:5n-3), a precursor of series 3 eicosanoids, and docosahexaenoic acid (DHA, 22:6n-3), the major LCPUFA in the brain.¹

The essentiality of n-6 and n-3 families of EFAs is explained by the inability of humans to introduce double bonds into fatty acids carbon chains in positions prior to carbon-9.

Terrestrial and marine plants and phytoplankton are the primary source of EFAs in food; fish and the other marine animals are able to elongate and desaturate the parent EFAs to the LCPUFA.^{3,4}

The competitive desaturation of n-3 and n-6 series is of major significance and is controlled by the interaction of hormones and diet. Since the conversion of parent EFAs to their LCPUFA is tightly regulated, the biological and functional effects of providing preformed AA and DHA cannot be replaced by providing equivalent amounts of the precursor fatty acids (ie, LA and ALA). The uniqueness of the biological effects of feeding on human milk and marine foods is based on the direct supply of LCPUFAs, bypassing the controlling steps of desaturation.²

During the past decade, increasing attention has been placed on the effect of n-6 and n-3 EFAs in normal fetal and infant development. The fetus and the placenta are fully dependent on the maternal EFA supply for normal growth and development.^{5,6} The diet before and during pregnancy plays an important role in determining the maternal EFA status, as EFAs are stored in adipose tissue and mobilized when needed. The major deposition of EFAs in the fetus occurs in the third trimester of pregnancy, and the phospholipids in the placental vessels and uterine vasculature are dependent on the EFAs supplied by the mother for eicosanoid formation.⁷ The human placenta selectively transfers the LCPUFAs from the maternal to the fetal circulation to meet the increasing demand of the fetus.

The high concentrations of the LCPUFA, especially AA and DHA, in the brain and the retina suggest their significance in neural function.⁵ DHA reaches levels of up to 40% of total fatty acids in these tissues.^{8,9} In humans, Claidinin *et al* have

shown significant increases in the AA and DHA content of brain phospholipids in the third trimester of pregnancy.⁸ Martinez provided evidence that the accumulation of DHA in the brain continues up to 2 years after birth.¹⁰ The potential for dietary EFA deficiency is an important issue with preterm infants as they do not receive the third trimester supply of DHA and AA. Even full-term infants who are formula fed are at risk of developing DHA deficiency since the formulas do not contain this fatty acid. Several investigators have demonstrated that infants who are breastfed have higher concentrations of DHA in their cortex phospholipids than infants who are fed a cow milk-based formula.¹¹

ESSENTIAL FATTY ACIDS AND THE CENTRAL NERVOUS SYSTEM (CNS)

Development of the CNS

About 70% of the brain cells needed to last an individual's lifespan are formed before birth. In fact, the most active period of brain cell division is in the first few weeks of embryonic development. At this time, the nutrition of the embryo is totally dependent on the mother's health and nutrition as the placenta is not yet developed. At the end of 2 months, the head makes up most of the embryo and directs the first movement of the hands and feet. Then, the placenta takes over and starts pumping nutrients to the fetus. At this stage, the fetal brain uses 70% of the energy derived from the mother. Even after the baby is born, it still uses 60% of the energy from its mother's milk for growth.

Brain growth is unique and distinct from that of other tissues in that it is almost completely developed in a small period of time during early life. Brain growth consists of anatomical physiological and biochemical development of the brain, each occurring at its own pace with critical periods in uterine and early post-natal life.^{12,13} Sometimes the rate of brain