

FATTY ACIDS --- BRAIN STRUCTURE AND FUNCTION

Studies on Fatty Acids in the Brain ...

Bourre JM. Importance of Exogenous Saturated Fatty Acids During Brain Development and Mylenization in mice. Ann. Biol Anim Biochem and Biophys, 19(1B), 1979. ----- Many studies by this researcher show that exogenous (dietary) stearic acid (generally the most common saturated fat in meat, fish, poultry, eggs and cheese) is essential for synthesizing the membranes of nerve cells and astrocytes. The research also shows that both the saturated and monounsaturated fatty acids are synthesized in the brain, but the brain only synthesizes approximately 60% of what it needs. Exogenous sources are required.

Bourre JM. Roles of Unsaturated Fatty Acids in the Brain at Various Ages and During Aging. J Nutr Health Aging. 2004. ----- This noted researcher, who studied lipid metabolism of the brain for decades, concludes that from conception through old age, the human brain needs dietary sources of Arachidonic Acid (meat, fish, poultry, eggs, and cheese) as well as Alpha Linolenic Acid (--- animal sources (egg yolks in particular) are more effective than plant sources).

Many studies show “benefits” from omega 3 supplementation; some show harmful effects as well. Some show that the purported benefits are enhanced by concomitant antioxidant supplementation, and others show that the damage done by omega 3 fatty acid supplementation is mitigated to some degree by antioxidant supplementation. Even the studies showing benefits to the brain from omega 3 fatty acids confirm the NUTRI-SPEC stance on these PUFAs in the following ways:

- All the benefits of omega 3 supplementation derive from the parent oil, alpha linolenic acid (ALA), not from the highly catabolic EPA and DHA.
- All those benefits occur simply because the omega 3 fatty acids (the ALA, or the DHA and EPA derived from ALA) block the damaging effects of omega 6 fatty acids.
- Quantitatively speaking, the amount of ALA required to confer benefits is truly miniscule, and really only yields benefits to the extent that damage from omega 6 HOHUM PUFAs needs to be mitigated. The amount of DHA produced from ALA in the brain is a miniscule fraction of the miniscule quantity of ALA that is useful.

- There is zero evidence in the literature that either DHA or EPA are in any way dietarily “essential”. Furthermore (and this is critical for you to understand), there has never been a study showing that any human being has a deficiency in the capacity to convert ALA to DHA and EPA as needed.

ALA deficiency (of the truly miniscule amount that is useful):

- alters the structure and function of membranes
- induces minor cerebral dysfunctions
- alters the course of brain development
- perturbs the composition of physicochemical properties of brain cell membranes, neurons, oligodendrocytes, and astrocytes
- causes neurosensory and behavioral upset
- perturbs the visual and cerebral abilities of infants
- decreases the level of cerebral vascularization
- causes depression, dementia, and Alzheimer’s disease
- the frontal cortex and pituitary gland are particularly severely affected
- behavior disorders include mainly those associated with habituation and adaptation to new situations
- can be corrected more effectively with animal phospholipids than with plant phospholipids (--- n-3-rich egg yolk extracts. Egg yolk fatty acids are 1.2% ALA.)
- decreases the perception of pleasure, both by altering the efficacy of sensory organs, and by affecting certain cerebral structures
- impairs hearing, vision and smell
- is particularly severe during gestation since organization of neurons is almost complete several weeks before birth
- causes a reduction of phosphatidylethanolamines

The brain is the organ with the highest level of lipids (other than adipose). Brain lipids, formed from fatty acids, participate in the structure of membranes. 50% of the fatty acids in the gray matter are polyunsaturated, and 1/3 are ALA, and thus are of dietary origin. Recuperation of ALA deficiency in the brain is extremely slow in contrast with other organs.

- Increasing ALA:
 - causes a decrease in pro-inflammatory PGE2 and PGF2-alpha that are formed from an excess of omega 6 fatty acids
 - causes an increase in insulin responsiveness
 - causes decreased protein degradation by altering muscle membrane composition, glucose transport, and metabolism of muscle protein.
- Adequate ALA in the diet confers increased resistance to certain neurotoxic agents, for example lead.
- Vitamin E is a membrane stabilizer. Vitamin E deficiency in the brain causes a decrease in palmitic and other Saturated Fatty Acids, and a toxic increase in DHA.
- A ratio of n-6/n-3 is optimal at 8. This ratio is required to maintain adequate Arachidonic Acid concentration in the liver. Other tissues maintain adequate Arachidonic Acid on a lower n-6/n-3 ratio. Neurotoxic damage is done by either low ALA or high Linoleic Acid. A ratio of n-3/n-6 of 0.28 or higher suppresses excess Arachidonic Acid in the lung and plasma phospholipids, and the capacity of tissues to synthesize Prostaglandins (both good and bad PGs).
- The brain is an organ with a very high concentration of lipids, and they are directly involved in the functioning of membranes. The speed of recuperation from Fatty Acid imbalances is extremely slow for brain cells, organelles, and micro vessels, in contrast with other organs. A decrease in ALA in brain membranes results in a 40% reduction in the Na-K-ATPase of nerve terminals, and a 20% reduction in 5'-nucleotidase. Membrane fluidity is significantly decreased. A diet low in ALA induces alterations in the electro-retinogram in the young, and impedes learning behavior. A deficiency of ALA or an excess of Linoleic Acid has the same effect on brain membrane structure and function. (The ratio is the critical consideration.)

- In MS patients there is an elevated RBC membrane zinc level. Plasma lipids in MS patients contain less sphingomyelin, but more phosphatidyl serine, and the cholesterol/phospholipid ratio is 40% higher in the plasma from MS patients. In RBCs, phosphatidyl inositol is lower and cholesterol per milligram protein is significantly lower than normal. n-3 FA are lower in plasma from MS patients, and Linoleic Acid is lower in RBC ghosts. It is concluded that altered levels of cholesterol in plasma and RBCs from MS patients may contribute to increased RBC membrane zinc. It is uncertain whether the abnormal lipids are the cause or the result of MS.
- Alzheimer's disease is characterized by elevated Linoleic Acid and reduced Arachidonic Acid and EPA in the brain, indicating abnormalities in delta-6-desaturation. There is also a decrease in DHA, which also suggests delta-6-desaturase abnormalities.
- Major depression: higher Arachidonic Acid/EPA ratio in both serum cholesteryl esters and phospholipids, and a significantly increased n-6/n-3 ratio in cholesteryl esters. There is also lower ALA in cholesteryl esters and lower total n-3 PUFA in cholesteryl esters, and significantly lower EPA in serum cholesteryl esters and phospholipids.
- Stroke: lower palmitic acid in serum phospholipids, and higher 20-, 22-, and 24-carbon saturated Fatty Acids; higher Arachidonic Acid; higher DHA. Assuming that serum phospholipids represent tissue phospholipids, it is concluded that the tissue membranes of stroke patients may be considerably more fluid than those of normals.
- Schizophrenia: symptoms are decreased by ALA supplementation (tardive dyskinesia also benefits from ALA supplementation). Arachidonic Acid and DHA are low and plasma lipid peroxides are high. It is possible that increased oxidative stress may be one of the mechanisms of reduced Arachidonic Acid and DHA. Supplementation of PUFAs (along with high doses of protective antioxidants) may improve the condition. The decreased PUFA in both brain and peripheral membranes is consistent with the hypothesis of myelin-related dysfunction in schizophrenia. Membrane defects induced by decreased PUFAs in phospholipids can significantly alter a broad range of membrane functions, and thus behavior. It has been repeatedly shown that in both the brain and peripheral tissue there is increased phospholipid breakdown and decreased levels of various PUFA, particularly Arachidonic Acid. [The dietary source of Arachidonic Acid is meat, fish, poultry, eggs and cheese.]

There are also immune changes in some patients with schizophrenia, particularly in the activities of several cytokines known to be altered in autoimmune dysfunction. Immune system abnormalities include a shift from a Th1 (cellular) to a Th2 (humoral) immune response. The hyperactive inflammatory response system could induce enhanced tryptophan breakdown. In the plasma of Sz patients, Th1 IFN-gamma was significantly higher, and Th2-specific IL-4 was significantly lower. Th1-related IL-2 was lower but TNF-alpha and Th2-related IL-6 were higher. Plasma tryptophan concentrations were lower and were negatively correlated with positive symptoms score.

Indications are that a hyperactive pro-inflammatory response inducing a change in tryptophan metabolism is related to the development of Sz. Acute exacerbations of Sz are associated with increased Th1-related TNF-alpha and with reduced Th2-related IL-4. The contradictory reports on Th1/Th2 balance in Sz relate to the variable Th1/Th2 ratio at different times in the progression of the disease. It may be that Sz is characterized by increased monocytic cytokines and a decrease in both Th1 and Th2 cytokines. Thus, there is evidence of an inflammatory syndrome in Sz, which refutes the popular hypothesis of a Th2 dominance.

An absent niacin skin flush response is typical of Sz, and does not differ between bipolar individuals and controls. 49% of Sz, but only 7.5% of controls and 11.1% of bipolar patients did not show a flush response. The absence of a niacin skin flush demonstrated impaired Arachidonic Acid-related signal transduction. In another study, only 2 out of 21 Sz patients showed a flush, compared with 15 out of 20 controls. The absence of a flush indicates a Fatty Acid deficiency, particularly Arachidonic Acid.

- The liver is critical in providing less metabolically active tissues, particularly the brain, with long-chain ALA, Linoleic Acid, and their derivatives, secreted in VLDL. Dietary ALA inhibits delta 6 desaturation of Linoleic Acid. The desaturation products of ALA, EPA and DHA, inhibit delta 6 desaturation of Linoleic Acid and delta 5 desaturation of DGLA. Insulin and thyroxin are necessary to delta 6 and delta 5 desaturation activities, whereas other hormones such as glucagon, epinephrine, ACTH, and glucocorticoids inhibit desaturation.

RE: One popular Health Food Industry Guru and his comments on fish oil in relation to the brain --- typical of all the charlatans capitalizing on the fish oil craze. (--- We will refer to this doctor as “Dr. FO”, for “Dr. Fish Oil”.)

1. Appearing on the Wizard of Oz show immediately categorizes Dr. FO as a cartoon character, not a credible doctor.
2. I had Dr. FO brought to my attention several years ago in association with his earlier book. I remember looking at it then and seeing a monstrous conglomeration of both excellent information and non sequiturs. --- But in any case, if the book got people to eat less carbs, that is fine.
3. The brain protein he is referring to is BDNF --- Brain-Derived Neurotrophic Factor. Production of that brain protein is activated by exercise. It is stimulated to a certain extent by what people call aerobic exercise, but is stimulated even more by high intensity exercise. It is one of the main reasons why regular exercise has such a beneficial effect on mood and on cognitive function.

----- The downside of BDNF is that an excess of it will cause seizures, and will also exacerbate immune-reactive diseases such as eczema. Excess BDNF is also associated with a tendency to drug addiction and psychological dependence.

Still --- the amount of BDNF stimulated by intense exercise is entirely beneficial to the overwhelming majority of people.

4. The problem with Dr. FO's presentation is that he is offering a non sequitur. BDNF is not made from fish oil nor any of the fatty acids in fish oil. Neither is the activity of BDNF on the hippocampus (and other parts of the brain that it most affects) stimulated in any way by the destructive catabolic fatty acids in fish oil (EPA and DHA).

Like nearly all charlatans, Dr. FO is no dummy. He realizes he can dazzle people with a truth about BDNF and neurogenesis in the brain derived from intense exercise, and then switch gears, and by use of a non sequitur make people believe they can achieve the same benefits of high intensity exercise from swallowing a pill (in this case, fish oil).

5. To make sure I had not missed something regarding fish oil (EPA and DHA) and BDNF, I just did a search of the entire National Institute of Health database for studies showing that fish oil somehow improves either the production or the function of BDNF. There are absolutely none.

--- There is one study in the entire database done on rats with metabolic syndrome, since it is known that in humans metabolic syndrome (insulin resistance) is associated with cognitive decline. The researchers wanted to find out if they could improve the cognitive function of mice with metabolic syndrome by omega 3 fatty acid supplementation. The researchers did find

a statistically significant increase in BDNF in the rats given a broad-spectrum omega 3 fatty acid supplement what was primarily alpha-linolenic acid (ALA) (as found in flax oil and egg yolks). However, when fish oil was given alone, there were absolutely no benefits.

There was one other study done on rats that were run through a forced swimming test over and over and over again until they developed the rat model of depression. The researches wanted to see if that depression could be prevented by omega 3 fatty acid supplementation. The researchers specifically tested for the level of BDNF in these rats and found that the EPA and DHA supplementation did not increase it in the least.

6. So --- all Dr. FO has done is jump on the fish oil bandwagon as so many other nutrition gurus have done over the last 10-15 years.
7. As we have stated repeatedly, all the clinical benefits derived from omega 3 fatty acid supplementation are ...
 - a) derived from the parent oil, alpha-linolenic acid (ALA), not from the highly catabolic EPA and DHA
 - b) simply because the omega 3 fatty acids block the damaging effects of omega 6 fatty acids.
 - c) achieved as well by restricting dietary intake of Linoleic Acid

--- Furthermore, there has never been a single study showing that any human beings have a deficiency in conversion of ALA to the minuscule amounts of EPA and DHA that are needed. This is a critical point, and is one more way of demonstrating that supplementation with EPA and DHA is never necessary. And to the extent omega 3 supplementation may be beneficial, those benefits can be derived entirely from dietary sources of ALA --- such as egg yolks.