Short review

Dietary omega-3 fatty acids for women

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Abstract

This review details the specific needs of women for omega-3 fatty acids, including alpha linoleic acid (ALA) and the very long chain fatty acids eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). Omega-3 fatty acid (dietary or in capsules) ensures that a woman’s adipose tissue contains a reserve of these fatty acids for the developing fetus and the breast-fed newborn infant. This ensures the optimal cerebral and cognitive development of the infant. The presence of large quantities of EPA and DHA in the diet slightly lengthens pregnancy, and improves its quality. Human milk contains both ALA and DHA, unlike that of other mammals. Conditions such as diabetes can alter the fatty acid profile of mother’s milk, while certain diets, like those of vegetarians, vegans, or even macrobiotic diets, can have the same effect, if they do not include seafood.

ALA, DHA and EPA, are important for preventing ischemic cardiovascular disease in women of all ages. Omega-3 fatty acids can help to prevent the development of certain cancers, particularly those of the breast and colon, and possibly of the uterus and the skin, and are likely to reduce the risk of postpartum depression, manic-depressive psychosis, dementias (Alzheimer’s disease and others), hypertension, toxemia, diabetes and, to a certain extent, age-related macular degeneration. Omega-3 fatty acids could play a positive role in the prevention of menstrual syndrome and postmenopausal hot flushes.

The normal western diet contains little ALA (less than 50% of the RDA). The only adequate sources are rapeseed oil (canola), walnuts and so-called “omega-3” eggs (similar to wild-type or Cretan eggs). The amounts of EPA and DHA in the diet vary greatly from person to person. The only good sources are fish and seafood, together with “omega-3” eggs.

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1. Introduction

The two fatty acids, the fundamental member of the omega-6 family, linoleic (LA, 18:2(n-6)) and alpha-linolenic acid (ALA, 18:3(n-3)) are physiologically essential and complementary, but they compete as substrates for desaturases. Not only is the intake of ALA far too low, but also its conversion to longer chain fatty acids is reduced because it has to compete with the larger quantities of LA for the same enzymes. Indeed, polyunsaturated fatty acids are dramatically involved in human health and pathologies [1], the ratio omega-6/omega-3 being important [2]. Interestingly, dietary omega-3 fatty acids content is largely below the recommended quantities.

Holman [3] was the first to describe a young girl with neurological signs due to a lack of ALA who was successfully treated with oral ALA; this was later confirmed by treating another girl [4] aged 7 with linseed and cod liver oils. It has been known for several years that a lack of dietary omega-3 fatty acids is offset in tissues by an increase in their contents of omega-6 fatty acids, particularly 22:5 omega-6.

2. Methods

Systematic review of all pertinent original publication, not all of which are included in MedLine.
3. The length of pregnancy

3.1. Eating fish

Women living in the Faroe Islands consume more fish oil than those living in Denmark, and their babies (weighing 141 g more) are born after a pregnancy that is 5.7 days longer [5]. Eating a diet of eggs that provides 133 mg DHA during the third trimester lengthens pregnancy by 6 days [6]; this increases the amount of omega-3 fatty acids in the plasma phospholipids of both the mother and the baby without resulting in an uncomfortably longer pregnancy. A diet containing fatty fish also reduces hypertension in pregnant Eskimo women [7], and may well prevent preeclampsia [8], perhaps because it competes with the ARA derivatives that are involved in this disorder. Some studies indicate that vegetarians are more prone to premature births, and that Caesarean sections are more likely. The average pregnancy is 5.6 days shorter [9], while the birth weights are slightly lower.

3.2. Fish oils

A dietary supplement of fish oil that has a high DHA content but little EPA is good for increasing the DHA in tissue, but may be bad for omega-6 fatty acids [10]. However, a daily intake of 500–1000 mg of a DHA/EPA mixture (enriched milk or capsules) increases the omega-3 fatty acid status of the fetus [11]. A pregnant mother taking an oral supplement of 200 mg DHA per day has increased plasma DHA, which is good for fetus development [12]. The concentrations of DHA and ARA in the maternal blood and cord blood are correlated; the concentrations of omega-3 fatty acids in the fetal blood are greater than in the maternal blood. Little is presently known of the role of the placenta, whether it has specific transfer systems or whether it can produce DHA from ALA.

4. Providing for the fetus

There are several lines of experimental evidence showing that omega-3 fatty acids are most important as structural elements in the developing nervous systems of the fetus and newborn, and that this is linked to the mother’s food. The initial experimental studies were on the differentiation and function of brain cells in primary culture [13] and on membranes of brain cells and organelles [14]. ALA is the first dietary component that experiments in a range of disciplines, including chemistry, physical chemistry, biochemistry, enzymology, toxicology, physiology, electrophysiology, vision and behaviour have shown to influence brain structure and function [15]. This led to the demonstration that adding omega-3 fatty acids to baby formula, to make it more like mother’s milk, influences the visual, cerebral and intellectual capacities of newborn babies, as assessed by the neural and intellectual development quotients and neuromotor activity. The pregnant woman and her fetus each has specific requirements. The fetus uses most of the portion of dietary omega-3 fatty acids supplied to it for its developing brain. The brain also has the highest lipid concentration of all tissues, except adipose tissue.

4.1. ALA

The importance of dietary ALA for the development and function of the retina and brain has been clear since 1997. There is a direct relationship between the dietary intake of ALA and its concentration, and that of its derivative DHA, in the tissues of both mother and fetus.

4.2. DHA

The concentration of DHA in the plasma phospholipids and erythrocytes of the mother begins to increase very early in pregnancy, regardless of the diet. This increase is the result of an early change in the maternal metabolism to supply the needs of the rapidly proliferating cells, particularly those of the brain of the fetus [16]. A dietary supplement of DHA increases the maternal DHA and limits the decrease during the last trimester in which there is a preferential transfer from the mother to the fetus [17]. The overall DHA status decreases during pregnancy [18], and this could be severe in a multiple pregnancy [19].

5. Adipose tissue and lactation

The fatty acids in milk are derived directly from the diet or indirectly from a body pool [20], particularly adipose tissue, depending on the nature of the dietary fatty acids [21]. The amounts of DHA and ARA in the brain and the liver exceed the dietary intake and thus require the use of this reserve [22]. There is also a correlation between certain fatty acids in adipose tissue and those in the milk of lactating women [23]. Ingesting fish oil increases the DHA and EPA contents of adipose tissue [24].

6. Composition of human milk

Several studies have shown the importance of breast-feeding, and some have emphasized the provision of polyunsaturated fatty acids, especially omega-3 fatty acids. The cerebral and overall DHA status of breast-fed babies is better than that of infants fed formula lacking DHA [25]. Human milk contains considerable concentrations of both DHA and ALA and these concentrations are not greatly influenced by the metabolism of the mammary glands. Instead, they depend on the blood plasma concentrations, which in turn are linked to the dietary intake. This is well illustrated by the link between the consumption of fatty fish and fish oil capsules and the DHA in the milk [26,27]. Eating eggs enriched in omega-3 fatty acids also increases the amounts of ALA and DHA in mother’s milk [28]. A diet containing linseed oil, which has a high ALA content, increases the ALA and EPA in the milk and erythrocytes of lactating women, but not DHA [29]; this is in contrast with situation in experimental
animals, suggesting that the limiting step of desaturase activity varies from one species to another.

6.1. Disorders

Some disorders, such as diabetes, alter the composition of mother’s milk; ALA accounts for only 0.87% of total fatty acids in the milk of diabetics, much lower than the normal figure of 2.3%, while DHA accounts for only 0.11%, compared to 0.3% in the milk of normal women [30].

6.2. Special diets

Although the diets of vegans and vegetarians contain reasonable amounts of ALA, it is unlikely that enough is converted to DHA to satisfy the needs of pregnancy and lactation, particularly as these diets contain large amounts of competing omega-6 fatty acids. The milk of vegetarians, defined as those whose diet includes eggs and milk, contains more ALA (that is found in plants), while the quantities of DHA are either normal [31] or low, with 2.6 times less DHA and 2.7 times more ALA [32]. The amount of DHA is usually reduced [33]. The tissues of their offspring have above normal concentrations of LA and ARA, but subnormal DHA [34]. While the ALA (and LA) concentrations in the milk of women on a macrobiotic diet are generally higher, they should try to consume at least one serving of fatty fish per week [35]. Thus dietary fish or any seafood, or supplements, are advisable, and prudent for pregnant and lactating women: the mental performance of children born to mothers who take cod liver oil during these periods is above normal when measured at the age of 4 years [36].

7. The special requirements of neurosensory organs

7.1. Vision

DHA is important for the retina (the highest DHA contents of all body tissues), the brain, photoreceptors, neurotransmission, rhodopsin activity, the development of rods and cones neuronal connections and the maturation of cerebral structures [37,38]. As a result omega-3 fatty acids may well be important for preventing age-related macular degeneration, and perhaps certain retinopathies [39]. There is no doubt that supplements of omega-3 fatty acids, generally taken as fish oil, improve infant visual acuity [40].

7.2. Hearing

A lack of omega-3 fatty acids damages hearing, particularly the cerebral response; it also leads to premature aging of the auditory nervous system [41]. The DHA content of the milk of a lactating rat modulates the auditory system of her pups [42]. The evoked auditory potentials of human babies fed formula supplemented with long chain polyunsaturated fatty acids or mother’s milk for the first 16 weeks of life develop particularly rapidly [43]. Consequently, omega-3 fatty acids are important dietary components for preserving hearing throughout life.

8. Diabetes

Children given cod liver oil during the first year of life seem less likely to develop type I diabetes, perhaps because of the anti-inflammatory action of very long chain omega-3 fatty acids [44]. In addition, omega-3 fatty acids may be beneficial for diabetic women during pregnancy, helping to prevent their children developing long-term metabolic abnormalities linked to macrosomia [45]. These are some debates as to how effective omega-3 fatty acids are at preventing the development of type 2 diabetes insulin resistance and obesity [46]. There could be a link between obesity, BMI (body mass index), and the tissue concentrations of ARA in children rather than with omega-3 fatty acids [47]. Experiments have shown that omega-3 fatty acids influence body weight and glucose metabolism [48].

9. Breast and colorectal cancers

9.1. Breast cancer

Nutritional factors are one of the preventable causes of 20–60% of breast cancers, depending on the geographic region [49]. Ecological studies have found a negative correlation between the risk of developing breast cancer and fish consumption [50,51]; this has been confirmed by measurements of fish consumption [52]. A Chinese prospective study found that eating fish reduces the risk, but other studies are not in agreement. Most studies have found no effect of EPA, but a link between DHA and reduced risk. One case–control study found that the risk was 70% lower when there was a high concentration of DHA in the mammary gland adipose tissue [53]. Another cohort study showed that the highest concentrations of DHA in erythrocytes were linked to a 52% reduction in the risk of developing breast cancer [54]. Excess omega-6 fatty acids seems to increase the risk of breast cancer metastasis, while omega-3 fatty acids have the opposite action. Thus the omega-3/omega-6 fatty acid ratio is of prime importance [49]. A case–control study of non-menopausal women found that the risk of developing breast cancer was 50% lower in those women with the lowest omega-6/omega-3 ratio than in the group with the highest ratio [55]. ALA may also have a positive effect. One case–control study in three [56] and one of two cohorts [57] found that the risk of breast cancer was 30% lower in women taking ALA. And this can be as high as 60% in women with high concentrations of omega-3 fatty acids in their mammary adipose tissue [58]. However, there should always be a good intake of antioxidants to restrict the peroxidation of fatty acids [58], as these peroxide derivatives are genotoxic and cytotoxic. A cohort study on postmenopausal women showed a lower incidence of breast cancer in those with a high intake of vitamin C and beta-carotene. But this was true only for women with a high intake of polyunsaturated fatty acid [59].
9.2. Colorectal cancer

Not taking into account genetic predisposition to this cancer, it is estimated that 90% of the risk is due to environmental factors, principally foodstuffs [49]. Epidemiology has implicated dietary fat in mortality associated with colorectal neoplasia [60]. Several studies have shown that those people who eat most fish are at the lowest risk of colon cancer [61]; this has been confirmed in several case-control studies [62,63]. People who ate 80 g or more fish per day had a 40% less chance of developing colorectal cancer than did those who ate less than 10 g per day [64]. The action of DHA in preventing colon cancer is at least partly due to the prevention of inflammation and neoplasia. Whatever the cause of the cancer, and high intakes of saturated fats increase the risk, the omega-6/omega-3 fatty acid ratio is an important parameter; a ratio of 1–2 seems to help to prevent this cancer [49]. The effective intake of EPA + DHA is estimated to be about 2.5 g per day, or 1.4–4.2 g of EPA and 1.2–3.6 g per day of DHA [65,66].

9.3. Other cancers

Australian studies have shown a negative correlation between the intake of polyunsaturated fatty acids and the skin cancer, melanoma. Omega-3 fatty acids may well be important for controlling other types of cancer [65], such as that of the uterus. Women whose diet includes two portions of fish per week have a 40% lower risk of contracting this cancer than those eating only 0.2 portions per week [67]. But these studies are too fragmentary and contradictory to be definitive.

10. Inflammatory diseases

Omega-3 fatty acids if adequately preserved from oxidation [68,69], are involved in atherosclerosis, chronic hepatitis, inflammatory bowel diseases, psoriasis, and rheumatoid arthritis [70], unfortunately, specific action has not been studied in women so far.

11. Psychiatric disorders

The influence of omega-3 fatty acids on psychiatric disorder was reviewed recently [71]. There is a negative correlation between the risk of depression and the DHA concentration in adipose tissue [72]. An epidemiological study covering 23 countries showed that the risk of postpartum depression was inversely proportional to fish consumption and the DHA in the mother’s milk [73], thus pregnant women are invariably likely to benefit from a prophylactic treatment based on DHA and EPA [74]. At least seven epidemiological studies have found a relationship between the depression and the consumption of fatty fish, a major dietary source of omega-3 fatty acids.

Eating fish could also reduce the risk of attempted suicide [75]. Comparisons of data from several countries show that consuming over 65 g of seafood per day reduces the frequency of bipolar disorder (manic-depressive patients), but seems to have no effect on schizophrenia [76]. Five studies have shown that eating fish reduces the risk of dementia, particularly Alzheimer’s disease. Increasing the daily intake of DHA from 30 mg to 100 mg (over one portion per week) lowers the risk by 60%; the ALA in fish is also involved, but not the EPA [77]. The risk is reduced by about 40% in France [78].

12. Cardiovascular disease

12.1. ALA

The Cretan diet showed the importance of ALA for protecting against cardiovascular disease. The “Lyon” study on patients of both sexes found only five non-mortal infarcts and three deaths in those patients taking ALA supplements, while there were 17 infarcts and 16 deaths in controls [79].

12.2. Fish consumption

Epidemiological studies in many countries have examined the influence of dietary fish on all sorts of populations, including women, although the proportions of men and women are frequently not given. The importance of including fish in the diet for cardiovascular protection has been well documented over many years and is beyond dispute. This is true for people of all ages and both sexes, but particularly for women [80]. The “Nurses health study” showed that eating fish five times a week reduced the risk of death from cardiovascular disease by 50%; even those eating fish only 1–3 times a month had a 20% better chance of survival [81]. The fish intake was more effective for diabetic women; the high consumption reduced the risk by 60% and the low consumption by 30%. The effect was also seen in young women, even in those who were overweight [82]. Those women taking part in this study who consumed most omega-3 fatty acids had the lowest concentrations of markers of inflammation and endothelial cell activation [83]. A prospective study [84] has shown that women are also protected after the menopause, including older women [85]. A meta-analysis showed that omega-3 fatty acids are the most effective plasma-lipid lowering agents at preventing death from cardiovascular disease [86]. A diet that includes as little as 30 g per day of fish can protect a man or woman against the development of cardiovascular disease [87]. Any increase of as little as 20 g fish per day will reduce the risk of a person who eats little fish dying from cardiovascular disease by 7% [88]. A study on patients of average age 45 years, 70% of whom were women, was used to define an “omega-3 index” as an indicator of cardiovascular risk as the EPA + DHA concentration in erythrocytes [89].

12.3. Fish oils

Hundreds of publications describing studies on animals and humans (mainly on men) have shown how effective omega-3 fatty acids from fish oil are at preventing ischemic cardiovascular disease and cerebral infarcts. One major effect is to reduce mortality by 20%, deaths due to cardiovascular accident by 30% and sudden deaths by 50% [90]. Omega-3 fatty
acids act mainly by reducing the concentration of plasma triglycerides. This is particularly important for women, especially those on oral contraceptives. A combination of proposals [91] can be summarized as follows: at least 450 mg per day EPA + DHA for prevention by those not suffering from cardiovascular disease and 1 g per day for those having detected cardiovascular disease, with higher doses for people who have had a cardiovascular accident.

12.4. Metabolism of omega-3 fatty acids in women: desaturases

The DHA in all organs, including the nervous system and the heart, comes directly from the diet or is produced by transformation of dietary ALA in the liver; through the actions of desaturases. There is some doubt about whether an optimum dietary intake of ALA can adequately cover the needs of the human body for DHA. This probably becomes critical if the ALA intake is insufficient, in combination with amounts of the competing LA. A study using stable isotopes showed that newborn babies can convert ALA to DHA, but only in small quantities [92]. And these capacities vary with age and physiological conditions; conversion is more active in young women than in men or older people and is changed in lactating women. As a result, it has also been proposed that DHA is an essential nutrient [93].

13. The reality of a lack of dietary omega-3 fatty acids

13.1. ALA

The diets of women, both pregnant and women of childbearing age, provide less than 50% of the RDA [94–96]. The findings for women in Canada [97] and for pregnant women in Hungary [98], in Sweden [99] and in the United States [77,100] are similar. A lack of dietary ALA probably leads to reduced DHA synthesis.

13.2. DHA

In Canada 90% of the women had less than the recommended intake [101]; the situation was similar in Australia, and in Hungary [98]. It has been estimated that French women obtain an average of twice the RDA from their diet [95]; but these intakes vary widely: the lowest intake found in the French cohort was 6.5 mg per day, while the highest was 1770 mg per day, which is about the same as that of Eskimos [102]. The present generation of Eskimos consumes less than their parents, who were the subject of surveys for disorders such as cardiovascular disease. In contrast, the subjects of the French Brittany study (people encouraged to eat no animal lipids) consumed about 100 times more than the present occurrence.

14. Conclusions

Omega-3 fatty acids may be beneficial in situations other than those described above. They are frequently said to help prevent menstrual syndromes, particularly dysmenorrhea. They are believed to do this by reducing the production of eicosanoid pro-inflammatory molecules derived from omega-6 fatty acids by competing with their common metabolic enzymes. This is also why other problems, such as menopausal hot flushes, are less frequent in Japanese women who eat large amounts of fish. Bone formation and mineralization also seems to benefit from a high omega-3/omega-6 fatty acid ratio, which could reduce the risk of osteoporosis. All these proposals are not as well as documented as the other topics covered here.

The dietary lack of ALA is readily overcome. The only rich foods are rapeseed (canola) and walnut oils (soybean oil has an imbalance of omega-3 and omega-6 fatty acids) and so-called “omega-3” eggs (Columbus® or Benefic®). Vegetables that contain over 50% rapeseed oil are most useful, as are some rare vegetable foods rich in ALA [103].

Only seafood provides adequate EPA and DHA. Even fish with the lowest DHA content has 20 times more than red meat, i.e. pork from pigs fed linseed. There is practically no toxicological risk from eating too much omega-3 fatty acid, as this would require an intake far above that provided by a normal diet, 50–100 times more than the present occidental intake. But there is always a risk of undesirable effects, such as bleeding due to impaired coagulation and platelet aggregation if they are combined with certain drugs. Women therefore have specific requirements for omega-3 fatty acids that should be recognized and fulfilled, either by the diet or with capsules.

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