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# DIETARY OMEGA-3 FATTY ACIDS AND PSYCHIATRY: MOOD, BEHAVIOUR, STRESS, DEPRESSION, DEMENTIA AND AGING

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**Abstract:** In view of the high omega-3 polyunsaturated fatty acid content of the brain, it is evident that these fats are involved in brain biochemistry, physiology and functionning; and thus in some neuropsychiatric diseases and in the cognitive decline of ageing. Though omega-3 fatty acids (from fatty fish in the human diet) appear effective in the prevention of stress, their role as regulator of mood and of libido is a matter for discussion pending experimental proof in animal and human models. Dietary omega-3 fatty acids play a role in the prevention of some disorders including depression, as well as in dementia, particularly Alzheimer's disease. Their direct role in major depression, bipolar disorder (manic-depressive disease) and schizophrenia is not yet established. Their deficiency can prevent the renewal of membranes, and thus accelerate cerebral ageing; nonetheless, the respective roles of the vascular component on one hand (where the omega-3's are active) and the cerebral parenchyma itself on the other, have not yet been clearly resolved. The role of omega-3 in certain diseases such as dyslexia and autism is suggested. In fact, omega-3 fatty acids participated in the first coherent experimental demonstration of the effect of dietary substances (nutrients) on the structure and function of the brain. Experiments were first of all carried out on ex-vivo cultured brain cells (1), then on in vivo brain cells (2), finally on physiochemical, biochemical, physiological, neurosensory, and behavioural parameters (3). These findings indicated that the nature of polyunsaturated fatty acids (in particular omega-3) present in formula milks for infants (both premature and term) determines the visual, cerebral, and intellectual abilities, as described in a recent review (4). Indeed, the insufficient dietary supply of omega-3 fatty acids in today's French and occidental diet raises the problem of how to correct dietary habits so that the consumer will select foods that are genuinely rich in omega-3/the omega-3 family ; mainly rapeseed, (canola) and walnut oils on one hand and fatty fish on the other.

**Key words:** Fatty acids, omega-3, brain, psychiatry, depression, dementia, stress, mood.

**Abbreviations used.** ALA: alpha-linolenic acid. EPA: eicosapentaenoïc acid. DHA: docosahexaenoïc acid. FA:

## Introduction

The main component of omega-3 fatty acids is alpha linolenic acid (ALA, 18:3 omega-3) and it is mainly produced by plants and is essential for mammals, including human. The other members of this family are derived from ALA, they have longer chain that are more unsaturated and are mainly produced by animals. The most abundant are eicosapentaenoïc acid (EPA, 20:5 omega-3) and docasohexanoïc acid (DHA, 22:6 omega-3). There is considerable interest in these compounds, not only in medicine and dietetics, but also for applications such as advertising. A range of non-prescription capsules are available in health stores; their most recent selling point has been their effect on brain function in adult human.

The main relevance of the omega-3 fatty acids to health is in the prevention and treatment of cardiovascular disease. Fish oil preparations, which are rich in EPA and DHA, are recognized as true drug by the French health system. They are mostly used to reduce blood triglycerides, since they have been found to reduce the risk of cardiovascular disease in Eskimos. Hundreds of studies on their cardiovascular actions have been published. In general, the omega-3 fatty acids help to prevent vascular disease; ALA seems to act by preventing platelet aggregation and inflammation, among others, directly by itself or through its transformation into EPA; while the long chain FAs (EPA and DHA) modulate at least plasma triglyceride concentrations, among others. Their overall actions include improving the physiology of vascular wall cells (endothelial cells as well as smooth muscle cells), reducing blood pressure, preventing cardiac arythmia, and reducing inflammation.

The omega-3 FAs acids are also valuable because they are indispensable for the construction, maintenance and function of the brain. Nearly all lipids in this organ, particularly the phospholipids, are constituents of biological membranes – they are never used as sources of metabolic energy in the brain. The phospholipids are made up of fatty acids. About 1/3 of the fatty acids in the brain are polyunsaturated. Of these about 1/3 are omega-3 FA (the proportion varies from one brain area to another). Thus the omega-3 FA are major brain components, important for higher functions, as reviewed recently (4, 6). Experimental studies in several disciplines have all shown that ALA is the first dietary constituent to be important for the structure and function of the brain. It was first demonstrated that the differentiation and function of brain cells in culture required not only ALA, but also the very long carbon chain omega-3 FA (1). Subsequent work showed that a lack of dietary ALA altered the course of brain development, disturbing the composition of the membranes of brain cells, neurons, oligodendrocytes, astrocytes and organelles like myelin and nerve terminals (2). This lack of ALA resulted in physicochemical changes that caused biochemical and physiological disturbances resulting in abnormal neurosensory and behavioral patterns. There was also a dose-response effect linking the amounts of omega-3 FA in the mother's diet during gestation and breastfeeding to the accumulation of these compounds in the child's brain. This relationship held up to the optimum omega-3 FA concentration. Higher dietary concentrations had no further effect on brain lipids (3). Thus the nature of the polyunsaturated FA (particularly the omega-3 FA) in baby formulas for newborns (both premature and full-term) influences their visual and cerebral capacities, including both cognitive and intellectual functions. This is why all baby formulas that have been marketed in recent years have been supplemented with omega-3 FA, to bring the ALA content up to at least that of human milk, which naturally contains this FA; DHA has been recently added.

Several experiments have studied the brains of a range of animals; they have examined the effects of omega-3 FA on brain biochemistry, membrane physical chemistry, enzyme activities and carrier function, neuromediators, electrophysiological parameters and behavior. Many studies have also looked at how these FA, plus others, are implicated in the nervous systems of animals and humans during life – particularly during development and aging. They have been covered in recent reviews (4, 7); there have even been popular books written about them (5, 8), including a recent one on omega-3 FA (9)

It is hardly surprising, then, that psychiatrists are interested in omega-3 FA for several reasons. The high content of these FA in the brain is one. Another is the direct consequence of studies on experimental animals showing that a lack of dietary ALA results in behavioral and cognitive defects, particularly problems of learning (3, 10-13), memory and habits (14, 15) and reactions to morphine (16). A lack of ALA results in the abnormal metabolism of neuromediators, as reviewed recently (17-19). Several of these problems can be overcome by feeding an appropriate diet (20-24). DHA is certainly important for the development of the human brain (25).

Nevertheless, their influence on vascular components and the cerebral parenchyma are not yet completely clear. There appears to be a relationship between dementia and cardiovascular risk, as there is a lack of omega-3 FA in both cases, together with an increase in homocysteine concentration (26). Elevated plasma homocysteine is also a risk factor for psychiatric disorders during aging (27).

## Mental health and mood

There have been few studies on the relationship between fatty acids (particularly omega-3 FA) and mood, but there have been much speculation. A New Zealand study of 4644 subjects aged over 15 years found that the personal perception of good mental and physical health varied with the consumption of fish, thus of omega-3 fatty acids, so that they were considered to stabilize mood (28). But an English study found that the consumption of fish did not improve mood in people who were not depressed (29). An Australian study reported that regular normal meals (including omega-3 FA) plus breakfast consistently improved mood and cognitive performance (30). Thus these fatty acids are essential components of normal general health and well being, mainly because of their biochemical properties. The rare attempts to use them to treat chronic fatigue have given contradictory results (31). It is thus too early to say that omega-3 FAs modulate mood.

## Stress

The optimum dietary ratio between omega-3 and omega-6 fatty acids, given as capsules prepared from vegetable oils, to counteract stress, is 4 for linoleic acid and ALA. This will protect particularly against changes in the hippocampus in response to excess cortisol and corticosteroids (32). The aggressive nature was found to vary inversely with the consumption of fish, with an Odds ratio of 0.82 (33). Also daily doses of 1.5-1.8 g DHA (found in fish oil) helped to reduce stress (34, 35), and decreased the aggressive tendencies of young adults, perhaps by modulating stress: DHA intake could prevent extraggression from increasing at times of mental stress, this might help to understand how fish oils prevent disease like coronary heart disease (35). Similar doses given to subjects aged 50-60 years for 2 months reduced their aggressiveness by 30%, but doses of 150 mg per day were insufficient (36). Thus, the French recommended daily dose (DHA: 150 mg per day in adult man) is not enough to have any effect. EPA has been used to treat women with personality disorders (37). Omega-3 FAs could be also directly implicated in reducing the neuronal and glial processes that generate inflammatory pain (38).

## Hyperactive and dyslexic children

Polyunsaturated fatty acids, including omega-3 FA, could be implicated in disorders of cerebral development, attention deficit, hyperactivity, dyslexia and even autism (39). The severity of dyslexic signs was found to vary with the lack of polyunsaturated fatty acids in boys, but not in girls (40). Dyslexia was studied in a group of 135 adults (74 men) and found to be accompanied by indications of a lack of polyunsaturated fatty acids (41). Fatty acids seem to be important for attention deficit associated with hyperactivity

(42); the oxidative breakdown of omega-3 fatty acids was 50% above normal, while that of protein was unaltered (43). A pilot study carried out on 50 children showed that supplementing their diet with essential fatty acids (daily doses of 480 mg DHA, 80 mg EPA, 40 mg arachidonic acid, 96 mg gamma-linolenic acid and 24 mg tocopherol acetate) improved their symptoms (44). However, another study showed that dietary supplements improved the blood parameters of hyperactive children suffering from attention deficit, but not their clinical symptoms (45).

## Depression

The increased prevalence of depression over the past half century seems to parallel fundamental changes in dietary habits, with a reduced intake of foods containing omega-3 fatty acids (46). The frequency of depression in British Columbia increased as the traditional dietary habit of fish eating was lost, and then fell as these dietary elements were re-introduced (47). There is a relationship between the drop in omega-3 fatty acid consumption (in fish) and the risk of depression, particularly as the incidence of the disorder varies from 1 to 50 per 1000 population, depending on the country, in parallel with fish consumption (48, 49). This was not confirmed by another recent study (50). Yet another study showed that, in Crete, there is an inverse relationship between the DHA concentration in adipose tissue and the risk of depression (51). A mega study of data from 41 published studies covering 23 countries showed that a fish-poor diet led to a low DHA concentration in mothers' milk (which is undesirable for newborns) and an increased risk that the mothers would suffer from postnatal depression (52). But there was no such relationship between dietary EPA or arachidonic acid.

An increase in the blood plasma arachidonic acid/EPA ratio is an indicator of increased risk of depression (53). Similar abnormalities have been found for plasma cholesterol esters and phospholipids (54), as in major depressions (55). Thus the severity of depression varies with the degree by which omega-3 fatty acids in erythrocyte membranes are decreased, regardless of the caloric intake (56), which might well indicate a link with oxidative damage (57). The link between decreased plasma DHA and the severity of postnatal depression, together with a slower return to normal of the plasma DHA concentration, indicates the value of supplementing the maternal diet with EPA and DHA during pregnancy and the period immediately after childbirth (58-59).

There is still, however, little hard evidence showing a relationship between changes in fatty acids and the risk of depression with aging, although plasma fatty acids composition and depression are associated during aging (60). A reduction in omega-3 fatty acid consumption increases the risk of depression and suicide, perhaps by increasing the serotoninergic activity in the brain and reducing impulsive and aggressive behaviour (61).

Two clinical studies have used doses of 2g per day of EPA ethyl ester to successfully treat cases of depression that responded only partially to classical psychiatric treatment (62, 63). A single patient was given EPA together with conventional treatment; this not only improved the clinical signs (suicidal tendencies, social phobias), it also resulted in morphological changes (reduced volume of the lateral ventricles) (64). DHA is also a successful treatment for minor depression (65). One study of a single patient showed that omega-3 fatty acids successfully treated pregnancy and postnatal depression (66), while another study using fish oil at 2.69g per day (EPA/DHA = 1.4) starting at the 34-36 week of pregnancy and continuing until 12 weeks after birth obtained negative results (67). Yet another study found that a dietary supplement of 200 mg DHA per day for four months after childbirth prevented the drop in plasma DHA but did not alter the patients' self-evaluated state of depression (68). This could be because they measured mood changes rather than real depression and/or because the doses of DHA were too low. Treatment with 9.6g omega-3 fatty acid per day for 8 weeks gave positive results with cases of major depression (69), but DHA alone (2g per day for 6 weeks) did not seem to be effective (70). In fact, EPA seems to increase the action of antidepressant drugs (71).

A study of bipolar disorder patients (manic depressives) in 14 countries showed a correlation between the prevalence of the disorder and a low fish consumption, with the threshold of vulnerability being 65g per day (72) ; treatment with omega-3 fatty acids could be useful under certain specific conditions (73).

Classical treatment with any of the antidepressants does not seem to be accompanied by normalization of omega-3 fatty acids (74). Omega-3 fatty acids are probably not involved (at least not directly) in neurological depression disorders that are somatic, such as Parkinson's disease, tumors, temporal epilepsy or cranial/cerebral trauma, or in endocrine ones such as hypo- and hyperthyroid. The same holds for those associated with a lack of vitamin B12 (and less importantly folate and vitamin B9) whose psychiatric signs precede any drop in circulating concentration. Thus there is little doubt that omega-3 fatty acids may be important for treating seasonal affective disorder syndrome (SADS) as it modifies certain activities of the hypophysis in animals, particularly melatonin secretion (75).

## Drug addiction

Omega-3 fatty acids, and perhaps omega-6 fatty acids, may also be involved in drug addiction. Ex-cocaine addicts more rapidly return to addiction if they lack polyunsaturated fatty acids (76, 77). It is possible that a diet-related change in the membranes of certain cerebral neurons makes some people more unstable, so that they are perhaps more predisposed to drug addiction in response to other impulses. Whatever the cause, drug addicts often have very poor diets, but how this can aggravate their condition, interfere with curing their addiction or make readdiction more likely remains a major question. However, animal experiments have shown that a lack of ALA alters the response to morphine (78).

## Dementias

Several epidemiological studies have shown that omega-3 fatty acids play a role in the prevention of dementia. For example, the Rotterdam study found that the risk of dementia with vascular features was positively correlated with the consumption of saturated fatty acids, but negatively correlated with the consumption of omega-3 fatty acid-rich fish (79). But this was not confirmed by the results of another study (80). A diet rich in unsaturated fatty acids and unhydrogenated fat was found to protect against Alzheimer's disease, in contrast to a diet rich in saturated fatty acids and trans fatty acids (81). The consumption of wild fish also seems to protect against dementia, including Alzheimer's disease. In France, the consumption of meat, because of its saturated fatty acid content, is only poorly correlated with an increased risk of dementia, while the consumption of fish has a protective effect. This conclusion was arrived at following examination of participants in the PAQUID study of 1,416 subjects aged over 67 living in the south west of France. The study, which lasted 7 years, showed the development of 170 cases of dementia, 135 of which were Alzheimer's. Those subjects who ate fish at least once a week were 34% less likely to develop any form of dementia, and 31% less likely to suffer from Alzheimer's disease. The effect was still present when socio-economic factors were taken into account, as these factors are linked to both the reduced risk of Alzheimer's disease and the fish consumption (82). A study carried out in the USA found that Alzheimer's disease was 60% less common in people that consumed about 60mg DHA per day (at least one fish meal a week) than in people that ate very little (83). The overall findings in Japan are the same (84).

A low plasma concentration of omega-3 fatty acids (including DHA) is an indication of risk of cognitive deficiencies and other types of dementia, including Alzheimer's disease (85). Nevertheless, one study has reported that plasma omega-3 fatty acid concentrations were unaltered (86).

Vascular dementias and Alzheimer's disease have nutritional factors in common: an excess of omega-6 fatty acids and a lack of omega-3 fatty acids; this leads to changes in the microvasculature, chronic inflammation, platelet aggregation and endothelial dysfunction (87). This provides at least a partial explanation of why the cognitive disorders in very elderly people are positively correlated with the consumption of linoleic acid, and negatively correlated with the consumption of fish [80]. But there has been no published report on the use of omega-3 fatty acids in the preventive treatment of dementia. The cardiovascular risk increases the risk of dementia, particularly vascular dementia (88). Inflammatory processes may well be implicated in all these disorders (89).

A 1/4 mixture of ALA and linoleic acid, given as a capsule, was shown to improve the quality of life for those suffering from Alzheimer's disease, as measured by tests of spatial orientation, cooperation, mood, appetite, short and long term memory, sleep and halucinations (90).

There have been no studies to date on the implication of omega-3 fatty acids in alcoholism and alcoholic dementia, although studies on experimental animals have shown that dietary ALA modulates the effects of alcohol on such things as the nerve terminals (91).

## Schizophrenia

Changes in phospholipid metabolism are believed to be implicated in the cause of schizophrenia, as the price of human development because of the amounts of omega-3 fatty acid-rich phospholipids in the brain (92). Schizophrenics whose diet includes plenty of fish have less severe clinical signs (93). The erythrocyte membranes of schizophrenia patients contain subnormal concentrations of DHA and EPA, but a link was found between the change in fatty acid profile and the severity of the clinical disease. The differences did not depend on sex, hormonal status of cannabis use (94). Another study did not find these results, as tobacco smoking seemed to be a discriminating factor (95). However, there could well be subgroups of patients for whom the omega-3 fatty acids are particularly important, which would explain how the same group of clinicians found divergent results in which the DHA content was either elevated, depressed, or normal, depending on the publication. The turnover of phospholipids has also been found to be abnormal in schizophrenics (96).

A course of 10g per day fish lasting 6 weeks seems to improve these symptoms (97) , as does a combination of 120mg EPA, 150mg DHA, 500mg vitamin C and 400IU vitamin E given twice a day for 4 months, but the improvement is relatively modest (98). A single patient given EPA alone showed improved symptoms; the turnover of brain phospholipids (as measured by 31p NMR) returned to normal and brain atrophy had receded after treatment for 6 months (99). This clearly needs to be confirmed. Patients who had been treated and stabilized and then given EPA for 3 months (100); it was also use to supplement a 6-month course of anti-psychotic drugs, but that left residual symptoms (101). One author reported that treatment with 3g EPA per day produced no results (102), perhaps because of a dose effect or because the patients concerned were non-responders (103). There have been several proposals as to how omega-3 fatty acids are involved in schizophrenia (104), including the modulation of neurotransmission, particularly dopaminergic transmission, but there is as yet no hard evidence (100).

## Autism

A French study has shown that the DHA in the plasma phospholipids of autistic children is decreased by 23%, with the total omega-3 fatty acid concentration being decreased by 20% and the omega-6 fatty acids being unchanged (105). Another study found that the phospholipids in erythrocytes were 70% below normal (106). An autistic boy aged 11 years was successfully treated with fish oil (540mg EPA per day) for 4 weeks (107). The transmission of signals involving phospholipids is nevertheless normal in these subjects (108).

## Neurological handicaps and disorders

Neurologically handicapped children do not absorb sufficient omega-3 fatty acids, as indicated by the presence of marker such as 20:3 omega-9 and 22:5 omega-6 fatty acids in their blood plasma, and this does not facilitate the satisfactory renewal of damaged brain structures (109). The changes seen in some patients, such as infantile neuronal ceroid lipofuscinosis associated with dementia, are side effects (110). The successful treatment of Zellweger peroxysomal disease with DHA simply compensates for the metabolic defect (111).

It has long been held that fatty acids are important for preventing and treating multiple sclerosis; but perhaps they simply supply the polyunsaturated fatty acids needed for reconstruction of the myelin sheath (112). The dietary supplement helps to reduce the severity of the disease and prevent recurrence, at least for 2 years (113), while the linoleic acid in the plasma erythrocytes is decreased (114). Giving patients 0.9g omega-3 fatty acid per day (as fish oil) for a total of 2 years may decrease the occurrence and severity of disease incidents, perhaps by modulating cytokines (115).

## Cognitive aging

The changes that occur with advancing age are complex, in both animals and humans. Omega-3 fatty acids may be involved either directly or indirectly, depending on the part of the body, the structure, cells and organelles or lipids concerned (4). Docosanoids have been detected in the nervous system (116, 117), while omega-3 fatty acids, particularly DHA, regulate ATPases. This is important as these enzymes provide 60% of the energy used by the brain (118) and because various isoforms of them are modulated by specific omega-3 fatty acids, ALA (119), or DHA and EPA from fish oil (120). Peroxysome metabolism is also implicated in controlling brai FA during aging, especially for polyunsaturated fatty acids (121). A recent French study showed that age-related cognitive deficit is linked to a reduction in the omega-3:omega-6 fatty acid ratio in erythrocytes (122) ; an excess of nutritional linoleic acid was also coupled to a decline in cognitive performance, while the reverse is true for fish oils (79, 123).

An increased oxidative stress during aging, due to reduced protection against free radicals, can result in a lower omega-3 fatty acid concentration in the nervous system. Hence a diet rich in EPA could have antioxidant properties that would help counteract the effects of aging (124). A lower concentration of polyunsaturated fatty acids in brain structures could result in poorer movement of solutes across the blood-brain barrier, because of lower incorporation into membranes, or reduced activities of the enzymes delta-6 and delta-9 desaturase, together with increased production of free radicals due to oxidative stress. All these factors reduce membrane fluidity (125). Phosphatidyl choline improves the memory, learning, concentration, vocabulary recall and mood of elderly people suffering from cognitive loss (126). Phosphatidyl choline, together with vitamin B12, improves learning in aging mice (127). There appears to be no question but that an adequate intake of omega-3 fatty acids could ensure the turnover of membranes so helping to protect against brain aging. However, a dietary supplement of high concentrations of omega-3 fatty acids produces behavioural changes that vary with the age of the individual, improving learning in young animals, but reducing learning and motor activity in older ones (128). This should be borne in mind when considering dietary supplements.

Several studies have been carried out on humans and experimental animals to identify the abnormalities of lipid metabolism, particularly phospholipids, that are associated with aging, together with a range of neurological and psychological disorders. The tissues examined have included the brain and the skin, where lipid messengers are involved. As these have no direct link with diet they are not included here, but can be found in (4).

## Conclusions

Roles of unsaturated fatty acids (especially omega-3 fatty acids) in the brain at various ages and during ageing have been recently reviewed in this journal (4). In fact, omega-3 fatty acids, have two broad categories of action, one long term and the other short term. Their long-term actions are on membrane composition and function. This is supported by studies on brain development and probably the role of dietary omega-3 fatty acids in the prevention of dementia, including Alzheimer's disease. Their short-term actions could involve phospholipid metabolism, and hence the modulation of signal transduction. The evidence for this could include the effect of EPA on depression, schizophrenia and autism. But the two types of action can occur simultaneously, as in inflammation during Alzheimer's disease. But it is too soon to state that omega-3 fatty acids prevent depression by treating inflammation, even though there are good indications of inflammation occurring during depression. While there is clear evidence that omega-3 fatty acids do, to some extent, prevent and reduce these symptoms, these relationships are not necessarily causal.

There are therefore two fundamental concepts of how fatty acids influence brain physiology. One is the effects of dietary fatty acids, especially omega-3 fatty acids, on the production and maintenance of brain structures, and hence on their function. The other involves the physiological mechanisms in which fatty acids take part. Most experimental data has focused on the prevention of psychological problems (like depression, dementias and other disorders) by consuming oily fish. The main feature of these oily fish is indeed their high omega-3 fatty acid content, but other components, such as iodine, which has a considerable effect on the brain, and selenium, may also have positive effects. Rigorous clinical trials have yet to provide incontrovertible proof that capsules containing omega-3 fatty acids as fish oil extracts are effective. The same applies to purified omega-3 fatty acids, generally supplied as their ethyl esters, as not nearly enough experiments or psychiatric clinical trials have been done to provide conclusive, convincing evidence. Omega-3 fatty acids are not isolated pure compounds in their natural state, but are parts of large natural molecules, triglycerides and phospholipids, that are used by the human body. These compounds must be destroyed and the omega-3 fatty acids extracted. This results in a product that is no longer natural, but a chemical, and there is no proof that this is a medication; moreover its bioavailability is not clearly documented, but lower that triglycerides. The safest approach is therefore to look for these essential omega-3 fatty acids in foods that naturally contain them.

We now need to know which foods are rich in omega-3 fatty acids, as these need to be a priority according to the recommendations of French AFSSA (129) and the ANC (French recommended dietary intake) (130). These foods should provide some tens of grams of ALA per day. In fact, the average daily consumption is less than 1g, while the recommended intake is 2g for men and 1.6g for women. The major source of these fatty acids in the normal French diet is rapeseed oil, (canola oil) walnut oil (which is less readily available), soybean oil (but this also contains a large amount of the omega-6 fatty acid, linoleic acid). Walnuts are a good source. The main sources of very long chain omega-3 fatty acids are oily fish (both wild and farmed; the farmed fish must be correctly fed, as discussed in a recent issue (7), "benefic" eggs, "columbus" eggs and "omega-3 eggs". The French recommended daily intake of DHA is 120 mg for men and 100mg for women. An equivalence factor for calculating the amount of ALA provided by the dietary intakes of DHA and EPA is generally assumed to be 10, but this differs for men and women and with age and physiological condition (131-134).

While an increased dietary intake of omega-3 fatty acids is fundamental, it is not enough. The presence of omega-6 fatty acids must also be taken into account, to ensure that the omega-6/omega-3 ratio is not above 5. And this ratio is far too high in the diet of most western people. It can only be effectively reduced by increase the intake of omega-3 fatty acids, and most certainly not be decreasing the intake of omega-6 fatty acids. The intake of the latter is only slightly above the recommended value.

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Dietary omega-3 fatty acids play a role in the prevention of some disorders including depression, as well as in dementia, particularly Alzheimerâ€™s disease. Their direct role in major depression, bipolar disorder (manic-depressive disease) and schizophrenia is not yet established.Â  Mood, behaviour, stress, depression, dementia and aging. or make readdiction more likely remains a major question. However, animal experiments have shown that a lack of ALA alters the response to morphine (78). Dementias. Several epidemiological studies have shown that omega-3 fatty acids play a role in the prevention of dementia. emotional behavior, including depression, associated with the low. levels of n-3 PUFAs that are frequently observed in western diets. Methods Methods and any associated references are available in the online Âversion of the paper at http://www.nature.com/natureneuroscience/.Â  1. Bourre, J.M. Dietary omega-3 Fatty acids and psychiatry: mood, behaviour, stress, depression, dementia and aging. J. Nutr. Health Aging 9, 31â€“38 (2005). 2. Rapoport, S.I., Rao, J.S. & Igarashi, M. Brain metabolism of nutritionally essential polyunsaturated fatty acids depends on both the diet and the liver. Prostaglandins Leukot. Essent. Fatty Acids 77, 251â€“261 (2007). Dietary omega-3 fatty acids play a role in the prevention of some disorders including depression, as well as in dementia, particularly Alzheimer's disease. Their direct role in major depression, bipolar disorder (manic-depressive disease) and schizophrenia is not yet established. Their deficiency can prevent the renewal of membranes, and thus accelerate cerebral ageing; none the less, the respective roles of the vascular component on one hand (where the omega-3's are active) and the cerebral parenchyma itself on the other, have not yet been clearly resolved. The role of omega-3 in ce