Palestrica of the third millennium – Civilization and Sport
Vol. 15, no. 2, April-June 2014, 131–133

REVIEWS
ARTICOLE DE SINTEZĂ

The importance of omega-3 fatty acids in diet
Importanţa acizilor graşi omega 3 în alimentaţie

Mihnea C. Manea[1], Codruţa Florina Bulduş[2], Simona Tache[3]
[1] "Carol Davila" University of Medicine and Pharmacy, Bucharest
[2]Faculty of Physical Education and Sport, "Babeş-Bolyai" University, Cluj-Napoca
[3] "Iuliu Haţieganu" University of Medicine and Pharmacy, Cluj-Napoca

Abstract
Essential fatty acids are lipids that cannot be synthesized by the organism, but must be provided by diet. The two most important fatty acid classes are omega-3 and omega-6 polyunsaturated fatty acids. The importance of the beneficial effects of omega-3 fatty acids has been demonstrated by many studies that support their role as nutrients, as well as their beneficial protective and prophylactic role. Omega-3 fatty acids contain substances – eicosanoids, with multiple effects on the body functions. They are used for therapeutic purposes in mental diseases; cardiovascular diseases; inflammatory diseases; autoimmune diseases; herpes; multiple sclerosis; psoriasis, dermatitis, diabetes, cancer, arthritis, gout, allergies; weight loss. Studies on omega-3 PUFA and physical activity in animals or human subjects have shown contradictory effects: favorable and unfavorable. Different studies have evidenced contradictory data regarding the influence of dietary supplementation with omega-3 PUFA on the O/AO balance during physical exercise.
Key words: omega-3 fatty acids, diet, health.

Rezumat
Acizii graşi esenţiali sunt lipide care nu pot fi sintetizate de organism, dar trebuie asigurate prin dietă. Două clase de acizi graşi sunt mai importate – acizii graşi polinesaturaţi omega 3 şi omega 6. Importanţa efectelor benefice ale acizilor graşi omega 3 a fost demonstrată de numeroase studii care pledează pentru necesitatea lor ca nutrienţi şi rolul lor benefic protector şi profilactic. Acizii graşi omega 3 conţin substanţe – eicosanoizi, cu efecte multiple asupra funcţiilor organismului. Sunt utilizaţi în scop terapeutic în boli psihice; boli cardiovasculare; boli inflamatorii; boli autoimune; herpes; scleroză multiplă; psoriazis, dermatite, diabet, cancer, artrite, gută, alergii; scădere în greutate. Studiile privind AGPN omega 3 şi activitatea fizică, pe animale sau subiecţi umani, au arătat efecte contradictorii: favorabile şi nefavorabile. Diferite studii au evidenţiat date contradictorii privind influenţa suplimentării dietei cu AGPN omega 3 asupra balanţei O/AO în efortul fizic.
Cuvinte cheie: acizi graşi omega 3, alimentaţie, sănătate.

General considerations

Essential fatty acids (EFAs) are lipids that cannot be synthesized by the organism, but must be provided by diet. They have a hydrocarbon chain of variable length with double bonds. The position of the first double bond (omega) differentiates omega-3 from omega-6 polyunsaturated fatty acids (Dobreanu 2010). Of these, two classes are more important – omega polyunsaturated fatty acids (PUFA):

- Class n=3 ($C_{18:3}$): α-linolenic acid (ALA), eicosapentaenoic acid (EPA), docohexaenoic acid (DHA)
- Class n=6 ($C_{18:2}$): linoleic acid (LA), cis-linoleic acid (cis LA), γ-linoleic acid (GLA)

Omega-3 PUFA sources are present in phospholipids in marine animals, lower animals, cold water fish, trout, sardine, salmon, tuna, herring, anchovy, black cod, shrimp and fish oil, as well as in green leaf plants, linen seeds, canola seeds, walnuts, peanuts, soybeans, purslane, nuts, almonds.

Omega-6 PUFA sources are of plant origin: corn, soybean, saffron, sunflower, safflower, canola oil.

Current diet provides a low omega-3 EFA intake. The ratio between omega-6 EFAs/omega-3 EFAs has changed from 2/1 to about 30/1 over the past 100-150 years (Lieberman & Bruning, 2005; Simopoulos, 2002; Goldman et al., 2009; Wylde, 2013).

The importance of the beneficial effects of omega-3 fatty acids and of their deficiency in diet has been demonstrated by many studies that support their role as nutrients, as well as their fundamental although short-term role, through consumption in the form of fish oil in particular, for the replacement of excessive omega-6 fatty acid amounts, which are extremely harmful (Wylde, 2013).

Action mechanisms

A number of studies in rodent models have monitored the action mechanisms of the administration of omega-3

Received: 2014, May 27; *Accepted for publication:* 2014, June 10;
Address for correspondence: "Carol Davila" University of Medicine and Pharmacy Bucharest, No.8 Eroilor Sanitari Street
E-mail: mihnea.manea@live.com

Copyright © 2010 by "Iuliu Haţieganu" University of Medicine and Pharmacy Publishing

polyunsaturated fatty acids (n-3 PUFA) regarding their protective effect by:

- influencing of the oxidant/antioxidant balance indicators in the brain, the striated bodies, the hippocampus, the prefrontal cortex, the hypothalamus (Sarsilmaz et al., 2003; Songur et al., 2004; Ozyurt et al., 2007; Yu et al., 2013);
- impairment of the Na^+K^+ATP-ase pump in the sarcolemma (Turner et al., 2003);
- influencing of serotoninergic, cannabinoid and GABAergic receptors in the hippocampus and the hypothalamus (Yu et al., 2013), of prefrontal serotoninergic receptors (du Bois et al., 2006);
- influencing of cerebral neurotrophic factors in the prefrontal cortex, hippocampus and striated bodies (Gama et al., 2012);
- protection against neurodegeneration, modulation of synaptic plasticity (Kawashima et al., 2010);
- antagonizing / activation of inositol triphosphate/ protein kinase signal transduction pathways (Mc Namara & Strawn, 2013);
- alteration of neurotransmission systems and of neural membrane phospholipid composition (Du Bois et al., 2005);
- influencing of astrocytes, oligodendroglia and neurons (Katz et al., 2007).

Other studies have monitored the effects of dietary omega-3 polyunsaturated fatty acid deficiency as a risk factor through the influence on dopamine, at the level of striated bodies (Bondi et al., 2014), and the impairment of synapses, neuritogenesis, mitochondrial functions, exocytosis, endocytosis, the role of clathrin (English et al., 2013).

The results obtained evidenced the beneficial protective and prophylactic role of omega-3 PUFA (Bondi et al., 2014; Gama et al., 2012; Kim et al., 2012; Ozyurt et al., 2007; Mc Namara, 2006; Horrobin et al., 2002) in schizophrenia.

Effects of omega-3 PUFA

Omega-3 fatty acids contain substances – eicosanoids, with multiple effects on the body functions (systematization according to du Bois et al., 205; Garcia-Alonso et al., 2012; Goldman et al., 2009; Horrobin et al., 2002; Lieberman & Bruning, 2005; Wylde, 2013).

a) Cell functions

- structure of cell membranes: affinity for phospholipids; they can replace linoleic and arachidonic acid in some phospholipids (phosphatidylcholine);
- redistribution of n-6 PUFA from the phospholipid fraction in cholesterol esters and triglycerides;
- activation of intracellular metabolic processes;
- activation of antioxidant enzymes (antioxidant role);
- intracellular communication (chemical messengers);
- release of arachidonic acid, biosynthesis of prostaglandins and thromboxanes;
- platelet antiaggregants;
- inhibition of the increase in intracellular Ca^{2+} concentration;
- inhibition of neutrophil chemotaxis;
- antimitogen for epithelial and macrophage cells

b) Blood effects: anticoagulant; antifibrinolytic; decrease of triglycerides; increase of HDL-cholesterol.

c) Systemic effects: hypotension; regulation of heart rate; restoration of the elasticity of arteries in the elderly; antiinflammatory, antimicrobial, antiviral effects; antiallergic effects; antitumoral effects; consolidation of the immune system.

Therapeutic uses of omega-3 fatty acids

(systematization according to Goldman et al., 2009; Lieberman & Bruning, 2005; Zamaria, 2004; Wylde, 2013)

a) mental diseases: depression, schizophrenia, manic-depressive disorders, dyslexia, hyperactivity disorders, aggressiveness in children, behavioral disorders (Bondi et al., 2014; DeMar et al., 2006; Gama et al., 2012; McNamara & Strawn et al., 2013; Song et al., 2009);

b) cardiovascular diseases: atherosclerosis, reduction of CVA and heart attack risk;

c) inflammatory diseases;

d) autoimmune diseases: herpes, multiple sclerosis;

e) psoriasis, dermatitis, diabetes, breast cancer, colon cancer, lung cancer, arthritis, gout, allergies;

f) weight loss.

Omega-3 fatty acids and physical exercise

Studies on omega-3 PUFA, administered to animals or human subjects, have shown contradictory effects: favorable and unfavorable (Ayre & Hulbert, 1997; Huffman et al., 2004).

Different studies have evidenced contradictory data regarding the influence of dietary supplementation with omega-3 PUFA on the O/AO balance during physical exercise in rats, some of which showing the AO effect, others the PO effect. The effect might depend on the PUFA dose, the omega-6/omega-3 ratio, and the vitamin E amount in relation to the ingested PUFA amount (García-Alonso et al., 2012; Belviranlı et al., 2012).

Recent studies regarding dietary supplementation with omega-3 PUFA have demonstrated effects on the aerobic exercise capacity, serum and tissue redox homeostasis, blood lipid metabolism changes and histopathological changes in the myocardium and encephalon occurring during physical exercise (Bulduş et al., 2012). The results have shown the energogenic and antioxidant effect under exercise conditions, the increase of aerobic exercise capacity and antioxidant defense, for the improvement of performance (Bulduş et al., 2012).

Conclusions

1) The increased intake of omega 3 fatty acids through proper nutrition has a beneficial role, protective and preventive, for the physical and mental health.

2) The dietary supplementation with omega-3 fatty acids may help increase the exercise aerobic capacity and the performances.

Conflicts of interests

There are no conflicts of interest.

Acknowledgments

This paper is part of the research for the first author's doctoral thesis.

References

Ayre KJ, Hulbert AJ. Dietary fatty acid profile affects endurance in rats. Lipids. 1997;32 (12):1265-1270.

Belviranlı M, Gökbel H, Okudan N, Başaralı K. Effects of grape seed extract supplementation on exercise-induced oxidative stress in rats. Br J Nutr. 2012;108(2):249-256.

Bondi CO, Taha AY, Tock JL, Totah NK, Cheon Y, Torres GE, Rapoport SI, Moghaddam B. Adolescent behavior and dopamine availability are uniquely sensitive to dietary omega-3 fatty acid deficiency. Biol Psychiatry. 2014;75(1):38-46.

Bulduş C, Bolfă P, Borza G, Moldovan R, Tache S. Histopathological changes in the brain and myocardium of trained animals supplemented with hemp oil, Palestrica of the Third Millennium Civilization and Sport, 2012;13(2):86-90.

DeMar JC Jr1, Ma K, Bell JM, Igarashi M, Greenstein D, Rapoport SI. One generation of n-3 polyunsaturated fatty acid deprivation increases depression and aggression test scores in rats. J Lipid Res. 2006;47(1):172-180.

Dobreanu M. Biochimie clinică. Implicaţii practice, Ed. a II-a, Ed. Medicală, Bucureşti 2010;122-123.

du Bois TM, Deng C, Bell W, Huang XF. Fatty acids differentially affect serotonin receptor and transporter binding in the rat brain. Neuroscience. 2006;139(4):1397-1403.

du Bois TM, Deng C, Huang XF. Membrane phospholipid composition, alterations in neurotransmitter systems and schizophrenia. Prog Neuropsychopharmacol Biol Psychiatry. 2005;29(6):878-888.

English JA, Harauma A, Föcking M, Wynne K, Scaife C, Cagney G, Moriguchi T, Cotter DR. Omega-3 fatty acid deficiency disrupts endocytosis, neuritogenesis, and mitochondrial protein pathways in the mouse hippocampus. Front Genet. 2013;4:208.

Gama CS, Canever L, Panizzutti B, Gubert C, Stertz L, Massuda R, Pedrini M, de Lucena DF, Luca RD, Fraga DB, Heylmann AS, Deroza PF, Zugno AI. Effects of omega-3 dietary supplement in prevention of positive, negative and cognitive symptoms: a study in adolescent rats with ketamine-induced model of schizophrenia. Schizophr Res. 2012;141(2-3):162-167.

García-Alonso FJ, Jorge-Vidal V, Ros G, Periago MJ. Effect of consumption of tomato juice enriched with n-3 polyunsaturated fatty acids on the lipid profile, antioxidant biomarker status, and cardiovascular disease risk in healthy women. Eur J Nutr. 2012;51(4):415-424.

Goldman R, Klatz R, Berger L. Exerciţii pentru creier. Ed. Curtea Veche, Bucureşti, 2009,49.

Horrobin DF, Jenkins K, Bennett CN, Christie WW. Eicosapentaenoic acid and arachidonic acid: collaboration and not antagonism is the key to biological understanding. Prostaglandins Leukot Essent Fatty Acids. 2002;66(1):83-90.

Huffman DM, Altena TS, Mawhinney TP, Thomas TR. Effect of n-3 fatty acids on free tryptophan and exercise fatigue. Eur J Appl Physiol. 2004;92(4-5):584-589.

Katz R, Hamilton JA, Pownall HJ, Deckelbaum RJ, Hillard CJ, Leboeuf RC, Watkins PA. Brain uptake and utilization of fatty acids, lipids & lipoproteins: recommendations for future research. J Mol Neurosci. 2007;33(1):146-150.

Kawashima A1, Harada T, Kami H, Yano T, Imada K, Mizuguchi K. Effects of eicosapentaenoic acid on synaptic plasticity, fatty acid profile and phosphoinositide 3-kinase signaling in rat hippocampus and differentiated PC12 cells. J Nutr Biochem. 2010;21(4):268-277.

Kim HW, Cheon Y, Modi HR, Rapoport SI, Rao JS. Effects of chronic clozapine administration on markers of arachidonic acid cascade and synaptic integrity in rat brain. Psychopharmacology (Berl). 2012;222(4):663-674.

Lieberman S, Bruning N. Biblia vitaminelor şi a mineralelor esenţiale. Ed. Paralela 45, Bucureşti, 2005, 260-269.

McNamara RK, Strawn JR. Role of Long-Chain Omega-3 Fatty Acids in Psychiatric Practice. Pharma Nutrition. 2013;1(2):41-49.a

McNamara RK. The emerging role of omega-3 fatty acids in psychiatry. Prostaglandins Leukot Essent Fatty Acids. 2006;75(4-5):223-225

Ozyurt B, Sarsilmaz M, Akpolat N, Ozyurt H, Akyol O, Herken H, Kus I. The protective effects of omega-3 fatty acids against MK-801-induced neurotoxicity in prefrontal cortex of rat. Neurochem Int. 2007;50(1):196-202.

Sarsilmaz M, Songur A, Ozyurt H, Kuş I, Ozen OA, Ozyurt B, Söğüt S, Akyol O. Potential role of dietary omega-3 essential fatty acids on some oxidant/antioxidant parameters in rats' corpus striatum. Prostaglandins Leukot Essent Fatty Acids. 2003;69(4):253-259.

Simopoulos AP. The importance of the ratio of omega-6/omega-3 essential fatty acids. Biomed Pharmacother. 2002;56(8):365-379.

Song C, Zhang XY, Manku M. Increased Phospholipase A2 Activity and Inflammatory Response But Decreased Nerve Growth Factor Expression in the Olfactory Bulbectomized Rat Model of Depression: Effects of Chronic Ethyl-Eicosapentaenoate Treatment, J. Neurosci, 2009;29(1):14-22.

Songur A, Sarsilmaz M, Sogut S, Ozyurt B, Ozyurt H, Zararsiz I, Turkoglu AO. Hypothalamic superoxide dismutase, xanthine oxidase, nitric oxide, and malondialdehyde in rats fed with fish omega-3 fatty acids. Prog Neuropsychopharmacol Biol Psychiatry. 2004;28(4):693-638.

Turner N, Else PL, Hulbert AJ. Docosahexaenoic acid (DHA) content of membranes determines molecular activity of the sodium pump: implications for disease states and metabolism. Naturwissenschaften. 2003;90(11):521-523.

Wylde B. Antioxidanţii, reţetă pentru viaţă. Ed. Curtea Veche, Bucureşti, 2013.

Yu Y, Wu Y, Patch C, Wu Z, Szabo A, Li D, Huang XF. DHA prevents altered 5-HT1A, 5-HT2A, CB1 and GABAA receptor binding densities in the brain of male rats fed a high-saturated-fat diet. J Nutr Biochem. 2013;24(7):1349-1358.

Zamaria N. Alteration of polyunsaturated fatty acid status and metabolism in health and disease. Reprod Nutr Dev. 2004;44(3):273-282.