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The effect of a combined omega-3 fatty acid and a-tocopherol supplementation on physical work capacity and blood antioxidant status in male subjects

by

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The main objective of the work was to determine the influence of a 3 week combined supplementation with polyunsaturated fatty acids (PUFA) omega-3 and a-tocopherol on physical performance, blood antioxidant status, CK activity, concentration of MDA as well as lipid and lipoprotein profile. The research project included 24 students of physical education, which were randomly divided into supplemented (S) and control groups (C), of 12 subjects each. The S group received PUFA omega-3 over a 3 weeks period in a daily dose of 1,3 g, which included EPA- 30% and DHA- 20% with a total of 4 mg·g^{-1} of a-tocopherol. The students were subjected to an identical, 1-hour ergocycle effort with a workload of 60% Wmax. The pedaling rate was steady over the first 45 min (60 rev·min^{-1}) and maximal over the last 15 min.

After 3 weeks of supplementation with omega-3 fatty acids a tendency for increased total external work occurred yet this difference was statistically not significant. During this period of time the S group showed a significant rise in SOD activity and GSH concentration in the blood. The supplementation protocol did not affect the activities of GPx, GR and CAT, the concentration of a-tocopherol, g-tocopherol, KM and MDA as well as plasma CK activity. No effect was observed in relation to the concentration of TAG, total cholesterol and HDL, LDL cholesterol. The lipoprotein fraction „b", „pre-b" and „a" were unaffected by the omega-3 fatty acid supplementation. A tendency for a decrease of the TAG concentration in the supplemented group occurred.

***Keywords**: omega-3 fatty acids, physical performance, antioxidants, and plasma lipid profile*

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Introduction

Muscular work is regulated at several levels, from cells to tissues, organs and whole systems. The ability to perform prolonged physical work depends to a large degree on energy production in the mitochondria, which on the other hand is dependent on substrate and oxygen delivery. The effectiveness of these processes is related to the regulation of carbohydrate, fat and protein metabolism, which is dependent on proper functioning of the pulmonary, cardiovascular and nervous systems. The hormone status of the organism also effects energy production by integrating all these functions (Kozlowski and Nazar 1995).

Recently scientists have turned their attention to non-energetic factors regulating physical work capacity. One of them includes free radicals generated during physical exercise and antioxidants, which protect the organism from reactive forms of oxygen.

For many years attempts to supplement the diet with compounds increasing the effectiveness of cellular metabolism have been made. One of these compounds includes polyunsaturated fatty acids (PUFA) from the omega -3 family, which are derived from a linolenic acid. This family of fatty acids also includes octadecatetraenoic, eicosatetraenoic, eicosapentaenoic (EPA), docosapentaenoic and docosahexaenoic acids (DHA) (Michajlik and Bartnikowska 1999). PUFA are indispensable components of all biological membranes and significantly effect their elasticity and permeability (Devon 1992). Additionally their presence in the phospholipid layer of membranes of circulating white and red blood cells influences their smoothness, which is deformed while passing through the placenta of capillaries. This improves microcirculation and increases oxygen delivery to working muscles (Lands 1992, Osmandsen and Clouet 2000). The presence of PFUA in the sarcolema assures proper functioning of insulin receptors (Liu et al 1994), which indirectly activates glucose transporters GLUT-4 and improves membrane transport of electrolytes to and from cells through the modification of phospholipids. They also act as a stimulator or inhibitor of enzyme protein synthesis responsible for glucose metabolism, including Krebs cycle enzymes (Osmundsen and Clouet 1997) as well as lipogenesiss and oxidation of fatty acids in the liver and muscles (Clarke 2001, Jump and Clarke 1999, Wtambi and Bene 2001). Omega-3 fatty acids are a part of nervous cell membranes and are indispensable for the development and proper functioning of the central nervous system (Sanders

1993). Cardio protective properties of PUFA relate to the inhibition of plate late aggregation restriction of inflammation.

Additionally omega -3 fatty acids decrease the synthesis of cytokines and plate late growth factor through the influence on specific gene expression which result in changes of leukocytes and red blood cell endothelium properties (Jump and Clarke 1999). PUFA decrease blood post exercise lactate concentration while increasing glycogen and aAMP concentration in skeletal muscles (Skalski et al 2001). They also act as anti-inflammatory agents and relive the symptoms of chronic fatigue (Tamizi and Tamizi 2002). The effects of omega-3 fatty acids on plasma lipid profile vary. For example the supplementation with EPA decreases the level of triglycerols (TAG) and very low-density lipoproteins (VLDL), while increasing the concentration of low-density lipoproteins (LDL). On the other hand supplementation with DHA does not effect the concentration of cholesterol, TAG, VLDL, LDL as well as high-density lipoproteins (HDL) (Pownall et al 1999, Rambjor et al 1996).

Imbedded in the cellular membrane PUFA make them more prone to peroxidation with the use of free oxygen radicals (Brown and Whale 1990), which attack double bonds in molecules, causing irreversible changes in their structure (Halliwell et al 1992). The products of peroxidation of fatty acids include aldehydes, for example malondialdehyde (MDA) which are excreted. Other byproducts include gasses such as penthane or ethane, which are expired (Huertas et al 1994). The increase in lipid oxidation is a signal for adaptive changes in activity of nonenzymatic antioxidants such as vitamin E as well as enzymatic ones like: superoxide dismutase (SOD), gluthatione peroxidase (GPx) and catalase (CAT) (Chen et al 2000, Nalboneet al 1985, Sen et al 1997).

Earlier research has indicated that supplementation with omega-3 fatty acids does not increase physical work capacity and does not influence the level of antioxidants as well as oxidation of LDL (Ostenbrug et al 1997, Raastad et al 1997). Most authors show no ergogenic effect of omega03 fatty acid supplementation (Williams 1999) yet some (Brill and Landerholm 1990) showed improved aerobic capacity after omega-3 fatty acid supplementation. Recent data indicates a positive effect of supplementation with these fatty acids on the muscular work, mainly through indirect influence of cell metabolism.

The main objective of this research project was to determine the influence of a 3-week supplementation with polyunsaturated fatty acids from the omega-3 family on total external work performed during the last 15 min. of a 1-hour continuous effort as well as the antioxidant status of blood and plasma lipid profile.

Material and methods

The research was conducted on 24 untrained physical education students (non-smoking, caffeine and alcohol). They were randomized into two groups – supplemented (S, n=12) and control (C, n=12). During the experiment subjects participated only in minimum program of physical education (3 hours per day). All subjects were informed about the aim and procedures of protocol and gave written consent about participation in experiment. Research program was accepted by Ethics Committee in Silesian Medical Academy in Katowice.

Subjects from S group were supplemented during 3 weeks with "Rybasol" (Pronova Biocare A.S., Norway) everyday in morning hours. Supplement included 1,3 g of omega-3 fatty acids - 30% of eicosapentaenoic acid [EPA, C20:5 (n-3)], 20% of docosahexaenoic acid, [DHA, C22:6 (n-3)] and 4 mg/g α-tokopherol which prevented their autooxidation. The energetic value of diet and vitamin E, C, and A (retinal) was determined with the use of dietary interview from two workdays and one weekend day (computer program Dietus, BUI InFit 1995, Poland). During the experiment subjects from both group employed diet, which included similar amount of polyunsaturated fatty acids (PUFA). The amount of PUFA was determined on the basis of meals compounds (Szczyglowa et al. 1991) and the tables of chosen food products and standard meals caloric values (Kunachowicz et al. 2003).

Six days before experiment all subjects were maximal power (Wmax) was evaluated with the use of progressive intensity test protocol (Jeukendrup et al. 1996). According to individual values of Wmax the load equal to 60% of W max was determined and used during the further procedures.

All subjects performed 1-hour cycloergometric test (Monark 814 E cycloergometer) according to Jeukendrup at al. (1996) protocol. Testing schedule included 45 min. of pedaling with constant velocity (60 rev./min.) and load equal 60% of individual Wmax. During last 15 min. of test subjects were obliged to perform maximal amount of work pedaling with the maximal possible frequency. The amount of work was calculated with the use of computer program MCE 2,3 (JBA-Poland). All subject were tested twice i.e. before and after 21 days of supplementation, at same time and similar circumstances of environment (temp. 21-22^{o}C, relative humidity 52-55%). Each subject was weighted before and after test with 0,1 kg precision. In order to evaluate the gasometric aspect of effort part of subjects performed identical test with oxygen uptake registration. The measurements were conducted with Alpha Oxycon Jaeger (Germany).

The blood samples were taken from ulnear vein in the morning to heparinized test-tubes – before and after supplementation. The hemoglobin concentration was determined with Drabkin cyanmethemmoglobin method (Randox diagnostic test HG 980, Great Britain). Glutation peroxidase (GPx, EC 1.11.1.9) with Flohe and Gunzler method (1984) and reducted glutathione (GSH) with Beutler et al. (1963) method were evaluated in full blood. The blood was then centrifugalizated in 4°C and in free from hemolysis plasma creatine kinase (CK, EC 2.7.3.2) activity with the Analco kit was was determined. Malonedialdehyde (MDA) concentration was evaluated according to Buege and Aust method (1978). α-and γ-tokopherol concentration in blood plasma was determined with high precision liquid chromatography HPLC (Beckman System Gold; Analoque Interface module 406 and Programmable Solvent module 126) in Sobczak at al. (1999) modification. The uric acid concentration was evaluated with Analco diagnostic test (Poland). The concentration of triacylglicerol (TAG), total cholesterol, LDL and HDL cholesterol were determined with enzymatic and precipitation methods with the use of BioMerieux diagnostic tests. Lipoprotein profile of serum (β, pre-β and α fractions) were determined on agar plates (Beckman Paragon Electrophoresis System LIPO P/N 655910 (USA) dividing lipoproteins with Beckman kit (Paragon Power Supply-240V. Mod.6558, Beckman Instr. INC, USA) using 100 V voltage and Emco DT-93 (Poland) densytometer. Before and after test the lactate concentration (LA) was determined with BioMerieux kit. The activity of superoxide dismutase (SOD, EC 1.15.1.1) was determined with Ransod kit from Randox (Great Britain), catalase (CAT, EC 1.11.1.6) with Aebi method (1974) and glutathione reductase (GR, E.C. 1.6.4.2) according to Glatzlea et al. (1970) method.

The statistical analysis was performed with the use of STATISTICA 5,0 (StatSoft Inc., 1995). The t-Student test for dependent and independent variables, non-parametric U Mana-Whitneya for independent variables and paired Wilcoxon test for dependent samples were used. The significance was set at $p \leq 0,05$.

Results

The energetic value in supplemented group (S) was constantly lower than in control C group ($p=0,30$), however even after relativization to body mass tab. 2, $p=0,23$) still remained insignificant. Similarly the PUFA content in S group was lower ($p=0,20$), but after calculation in relation to body mass this difference became statistically significant ($p=0,076$). The vitamin A (retinal) concentration

was similar in both groups, while vitamin C and E insignificantly lower in group S. After supplementation period the vitamin E concentration was higher in comparison to C group (tab. 2). BMI index was similar in both groups and equal approx. 23 (tab. 1).

Table 1 Physical characteristics of tested subjects

Variables	Group S (n=12)		Group C (n=12)	
	$\bar{x}$	SD	$\bar{x}$	SD
Age (years)	21,0	0,9	20,7	1,1
Body mass (kg)	73,5	6,1	70,8	5,7
Body height (cm)	176,8	5,2	175,9	7,5
BMI ($kg \cdot m^{2\,-1}$)	23,5	1,3	22,9	1,6
W max (W)	260,2	26,4	234,5	36,9

Table 2 Mean daily energy intake and the amount of antioxidant vitamins (A, E, C) and polyunsaturated fatty acids (PUFA) in the diet, in supplemented (S) and control (C) groups

Groups		Energy intake. (kcal)	PUFA (g)	Vitamin A[1] (mg)	Vitamin C (mg)	Vitamin E (mg)
S	$\bar{x}$	3076,2	17,1	750,1	66,9	6,2 (+4)[2]
	SD	966,9	4,3	265,1	47,4	3,4
C	$\bar{x}$	3523,8	19,7	710,9	86,5	8,5
	SD	783,6	3,9	280,7	54,9	4,8

It was registered that during 1-hour test body mass of tested subjects decreased on average 0,67 kg before and 0,62 kg after supplementation. It may be treated that such a small dehydration (les than 1% of body mass) did not influenced significantly the subject energetic capacities.

Evaluation of test character in relation to energetic metabolism domination it may be stated that it was endurance effort with variable intensity with the aerobic metabolism share during first 45 min. and anaerobic during last 15 min. of test. The oxygen uptake registered during test was diversified. In rest oxygen uptake equal 387,0±41,3 $ml \cdot min^{-1}$ was registered, increased to average level of 2414,3±198,7 $ml \cdot min^{-1}$ during first 10 min. and remained on similar level up to 45th min. of test. In last 15 min. of test oxygen uptake increased successively to mean value of 3521,0±50,2 $ml \cdot min^{-1}$ (fig. 1). The LA concentration registered in S group after test equaled 8,8 $mmol \cdot l^{-1}$ before and 8,5 $mmol \cdot l^{-1}$ after supplementation, while in C group respectively 7,9 and 8,4 $mmol \cdot l^{-1}$.

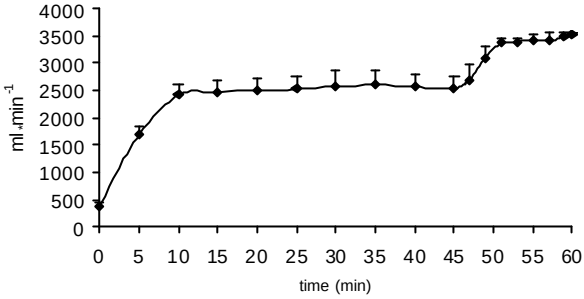

Fig. 1 Oxygen uptake (VO_2) during the 1-hour endurance cycling exercise (45 min at power output of 180 W and then last 15 min at 199 W)

The comparison relative work during last 15 min. of test did not indicated any statistically significant differences. Only in S group the increase tendency (by 5%) was observed (tab. 3)

Table 3 Relative work output during the last 15 min of the endurance cycling test in subjects from supplemented (S) and control (C) groups

Period	Group S (J·kg body weight^{-1})		Group C (J·kg body weight^{-1})	
	$\bar{x}$	SD	$\bar{x}$	SD
Initial values	2024,3	339,1	2001,6	269,6
After 3 weeks of research	2131,2	320,6	2052,0	261,1

Table 4 Changes in activities of the antioxidant enzymes: superoxide dismutase (SOD), glutatione peroxidase (GPx), catalase (CAT) and glutathionee reductase (GR) in supplemented (S) and control (C) groups

Variables	Group S				Group C			
	Initial values		After 3 weeks		Initial values		After 3 weeks	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
SOD (U·gHb^{-1})	803,9	118,0	891,4[A]	84,2	862,1	71,6	914,1	51,8
GPx (U·gHb^{-1})	14,6	2,5	14,7	2,6	15,1	2,6	14,9	2,7
CAT (k·gHb^{-1})	176,1	21,3	184,9	32,7	173,2	23,8	179,9	17,8
GR (U·gHb^{-1})	25,5	4,6	25,6	3,0	24,8	4,8	25,2	4,2

[A] Significantly different ($p<0,01$) from the corresponding value before research

The activity of antioxidative enzymes (SOD, GPx, CAT and GR) before experiment was similar in both groups (tab. 4). After 3 weeks of experiment in

group C activity of these enzymes remained unchanged, while in S group statistically significant increase was observed only in SOD activity in comparison to initial value (tab. 4). There were no changes in activity of GPx, CAT and GR in this group.

Table 5 Changes in α-tocopherol, γ-tocopherol, malondialdehyde (MDA) uric acid (KM), reduced glutathionee (GSH) concentration and creatine kinase activity (CK) before and after 3 weeks in supplemented (S) and control (C) groups

Variables	Group S				Group C			
	Initial values		After 3 weeks		Initial values		After 3 weeks	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
α-tocopherol ($\mu g \cdot ml^{-1}$)	14,6	2,0	15,5	3,2	13,6	4,6	12,2	2,4
γ-tocopherol ($\mu g \cdot ml^{-1}$)	0,76	0,31	0,82	0,21	0,82	0,34	0,87	0,27
KM Mg/dl	4,2	0,5	4,4	0,5	4,6	0,8	4,7	0,6
GSH ($\mu mol \cdot g\ Hb^{-1}$)	2,7	0,2	3,0[A]	0,3[A]	2,7	0,5	2,8	0,4
CK ($U \cdot l^{-1}$)	95,5	26,4	104,6	21,2	99,6	26,7	89,3	24,6
MDA ($\mu mol \cdot l^{-1}$)	4,4	0,8	4,1	0,6	4,3	0,7	4,5	0,8

[A] Significantly different ($p<0,05$) from the corresponding value before research

After supplementation there were no significant changes in α- and γ-tokopherol in both groups. Only slight increase in group S and decrease tendency in group C was observed (tab. 5). Before the supplementation the GSH concentration in blood was similar in both groups, while after experiment only in S group significant increase of this metabolite was registered ($p<0,01$) (tab. 5). Supplementation had no significant influence on uric acid in plasma, as well as, creatine kinase (CK) activity after 3 weeks of experiment. slight increase in group S and decrease tendency in group C was observed (tab. 5).

MDA concentration after 3 weeks was slightly decreased (by 7%) in group S, while in control group inversed tendency was observed (increase by 5%), however these differences were statistically insignificant (tab. 5).

TAG concentrations in both experimental groups did not differed significantly, however after 3 weeks of supplementation the decrease tendency (by 6%) were registered (tab. 6). Similar lack of changes was obtained in HDL,

LDL and total cholesterol (tab. 6). Lipoprotein profile in plasma did not changed statistically significant and the highest stability was presented by „α" fraction (includes HDL cholesterol) (tab. 7).

Table 6 Changes in triacyloglycorol (TAG), HDL cholesterol, LDL cholesterol and total cholesterol (TCH) concentration before and after 3 weeks, in supplemented (S) and control (C) groups

Variables	Group	Before research		After 3 weeks	
		$\bar{x}$	SD	$\bar{x}$	SD
TAG (mg·dl^{-1})	S	108,8	13,9	101,9	13,9
	C	102,3	20,8	105,0	27,7
HDL (mg·dl^{-1})	S	43,6	7,2	42,6	8,6
	C	39,4	7,2	40,1	7,1
LDL (mg·dl^{-1})	S	71,1	16,7	70,5	14,5
	C	68,6	14,3	67,5	18,2
TCH (mg·dl^{-1})	S	153,1	18,1	148,7	19,5
	C	149,4	32,7	155,7	22,1

Table 7 Changes in serum lipoprotein profile „β", „pre-β" and „α" in supplemented (S) and control (C) groups, befere (A) and after 3 weeks (B)

Group	Period	β (%)		Pre-β (%)		α (%)	
		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
S	Initial values	37,3	4,6	30,5	5,3	32,2	4,6
	After 3 weeks	39,2	4,9	28,4	7,5	32,4	5,2
C	Initial values	42,9	5,7	24,6	7,2	32,5	3,9
	After 3 weeks	43,5	5,1	22,8	7,1	33,7	4,8

Discussion

The caloric value of daily meals did not differ between the tested groups. Similar differences occurred in relation to PUFA intake, which varied less than 5% between groups. The supplemented group registered a slightly lower intake of vitamin E, which was increased after the 3 weeks of the experiment yet those differences were not statistically significant. The low level of vitamin C intake was most likely caused by the annual time of research (fall-winter) when the intake of fresh fruits and vegetables is reduced. Vitamin A (retinal intake was similar in both groups. It can be stated the diets tested subjects did not differ significantly in relation to caloric and antioxidant vitamin intake. The

supplementation with omega-3 thus created a significant stimulus for eventual metabolic changes. In this experiment the supplemented group received a daily dose of 1,3 g of omega-3 fatty acids recommended for therapeutic purposes (Bartnikowska and Obiedzinski 1997).

The amount of total external work evaluated in all subjects was done according to the exercise protocol proposed by Jeukendrup et al. (1996). He registered oxygen uptake and lactate concentration allowed to determine the metabolic conditions under which the exercise was performed. During the first 45 min. of the test aerobic metabolism dominated while the last 15 min. of the exercise protocol was conducted under mixed conditions. The last phase of the exercise protocol (finish) was performed under anaerobic conditions.

The supplementation with omega-3 fatty acids (group S) did not influence the amount of total external work performed during the last 15 min. of the test. A tendency to increase this variable was observed (5,3%) yet this values were not statistically significant.

It is worthy to notice that an increase in total external work performed was observed in 75% of the tested subjects. The results seem positive and further research with higher doses of omega-3 fatty acids supplementation are fully justified. The diet of tested subjects has to be considered since unpublished data suggest greater influence omega-3 fatty acids supplementation on physical work capacity in vegetarians.

Literature data of omega-3 supplementation in relation to work capacity differs. The following authors observed no ergogenic effects of omega-3 supplementation on physical work capacity: Bellisola et al. (1992) - 4,6 g/day, Oostenbrug et al. (1997) - 6 g/day, Raastad et al. (1997) - 1,6 g/day of EPA and Williams (1999) 1,04 g/day of DHA. Positive results of supplementation with omega-3 on aerobic work capacity were obtained by Brill and Landerholm (1990) after 100 weeks of 4 g per day.

PUFA are supplemented along with vitamin E, which protects the fatty acids incorporated in cell membranes from selfperoxidation. Insufficient intake of this vitamin increases the oxidant stress and stimulates peroxisomal ß-oxidation during which peroxide hydrogen as by product is developed (Sen et al. 1997). An increase in peroxidation of lipids is accompanied by an increase in the concentration of reactive forms of oxygen after diet rich in PUFA adaptive changes occur in the activity of antioxidant enzymes (SOD, GPx, CAT and GR) in the blood and tissue (Chen et al. 2000, Kedziora 1998). For example Bellisola et al. (1992) supplemented adults with 20 ml/day of fish oil and registered a significant increase in GPx activity in erythrocytes. In similar research Atalay et al. (2000) observed an increase in CAT and GPx activity of liver and slow-twitch

muscle fibers of rats. After adding vitamin E to fish oil the activity of antioxidant enzymes in those tissues was similar to that of the control group receiving soya oil and vitamin E.

Oostenbruk et al. (1997) did not confirm a significant effect of fish oil supplementation on antioxidant activity, while Goldfarb (1993) believes that intake of DHA causes a rise in the antioxidant index in the plasma and fast-twitch muscles fibers, as well as, a reduced activity of GPx in blood plasma. Additionally it was determined that supplementation with fish oil in small doses (2,4 g/day) did not significantly increase lipid peroxidation (Turley et al. 1998). The supplement used in this research contained vitamin E and after 3 weeks of intake a significant rise in SOD activity was observed, responsible for superoxide anion-radical dismutase. The activity of GPx, CAT and GR did not change during this period of time.

The supplementation with "Rybasol" did not significantly affect plasma concentration of a- and ß-tocopherol. Demoz et al. (1994) showed that omega-3 supplementation over a period of 3 month in rats caused a significant decrease in the concentration of plasma a-tocopherol as an effect of an increased demand for this vitamin, indispensable in the protection of membranes from lipid peroxidation. Bellisola et al. (1992) also indicated that an intake of 4,6 g/day of omega-3 over 10 weeks had a negative influence on antioxidants properties of erythrocytes, causing a decrease in blood concentration of FSH. The reduced glutathionee is the main low-molecular antioxidant in red blood cells, protecting them from homolysis and oxidation of SH cell proteins (Dafaux et al. 1997; Sen 1999). The conducted research in which students were supplemented with "Rybasol" over 3 weeks caused a statistically significant increase of blood GSH concentration what may indicate to a small dose of omega-3 fatty acids for the reduction of the antioxidant potential of red blood cell.

The research indicates that omega-3 supplementation did not significantly effect the concentration of malonedialdehyde (MDA), an indicator of lipid peroxidation yet the supplemented group registered a decreased concentration (by 7%). Venkatraman et al. (1998) also indicated that supplementation with low doses of omega-3 does not increase lipid peroxidation while Higdon et al. (2000) observed an increase in MDA concentration after fish oil supplementation containing 2g/day of EPA and 1,4 g/day of DHA. No changes in plasma uric acid were registered.

Creatine kinase (CK) activity, a specific indicator of muscle disruption (Lu et al. 1992, Walliman et al. 1998) did not change after omega-3 supplementation. On this basis the author concluded that the structure of muscle cell membranes did not change.

Omega-3 supplementation over the 3-week period did not change the lipid profile significantly, which included total cholesterol (low risk level < 200 mg/dl^{-1}), HDL cholesterol (low risk value <35 mg/dl^{-1}), TAG (low risk value 60-150 mg/dl^{-1}) and LDL (low risk value <130 mg/dl^{-1}). It is worthy to notice that the concentration of TAG decreased by 6% in the supplemented group. This is confirmed by Rambjor et al. (1996) who supplemented subjects with 3 g/day of omega-3 containing different doses of EPA and DHA over 3 weeks. They concluded that only EPA was a significant factor causing a decrease of TAG, total cholesterol, VLDL and increased LDL concentration. The other component DHA did not show such an effect. The dose of omega-3 used in this research did not influence significantly the serum lipoprotein profile. The registered fractions of "ß", "pre- ß" (VLDL) as well as "a" (HDL were similar in both groups. The "a" fraction of lipoprotein containing HDL cholesterol was not stable.

Conclusions

1. A 3-week supplementation with omega-3 fatty acids with a dose of 1,3/day along with vitamin E did not show any ergogenic effect.
2. Omega-3 supplementation did not increase blood lipid peroxidation and did not decrease antioxidant properties of erythrocytes and other plasma components.
3. Supplementation also did not influence the plasma lipoprotein profile. Only a tendency of reduced TAG concentration was observed following supplementation.

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