Palestrica of the third millennium – Civilization and Sport
Vol. 14, no. 2, April-June 2013, 83–89

ORIGINAL STUDIES
ARTICOLE ORIGINALE

Vitamin A, E and C supplementations and the aerobic exercise capacity in rats (Note II)

Suplimentarea cu vitamine A, E şi C şi capacitatea aerobă de efort fizic la şobolani (Nota II)

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Abstract

Background. The prooxidant effect of intense exercise, the effect of some antioxidant vitamins (A, E and C), the relationship between exercise and these vitamins regarding the reduction of the effects of exercise on skeletal muscles and immunity led us to investigate experimentally the influence of vitamin supplementations on the exercise capacity and the phagocytic capacity of rats trained to exercise.

Aims. The influence of exercise and vitamin A, E and C supplementations on leukocytes and phagocytic capacity in rats was studied.

Methods. The investigations were carried out on groups of 10 male albino Wistar rats (weighing 170-190 g): group I - control group of animals trained to exercise by using the swimming test; group II - animals trained to exercise and vitamin A supplementation (150,000 IU/day); group III - animals trained to exercise and vitamin E supplementation (15 mg/day;) group IV - animals trained to exercise and vitamin C supplementation (50 mg/day). In all groups, blood was taken from the retro-orbital vein of the rats and collected on anticoagulant on day 1, day 14 and day 28. The leukocyte count and the phagocytic capacity: phagocytic index, phagocytic activity and peroxidase activity were determined.

Results. Vitamin A supplementation and training determined significant increases in peroxidase activity after 28 days and changes in the phagocytic capacity. Vitamin E supplementation and training induced significant decreases of the leukocyte count and significant decreases of peroxidase activity. Vitamin C supplementation and training led to significant increases in the leukocyte count and to increases in the phagocytic capacity significant for the phagocytic index, phagocytic activity and peroxidase activity after 28 days.

Conclusions. Vitamins A and E do not affect the phagocytic capacity (phagocytic index, phagocytic activity) during exercise; in contrast, the vitamin C dose administered induces an increase in phagocytic capacity (phagocytic index, phagocytic activity, peroxidase activity).

Key words: exercise, vitamins (A, E, C), phagocytic capacity.

Rezumat

Premize. Efectul prooxidant al efortului fizic intens, efectul antioxidant al unor vitamine (A, E şi C), relaţia dintre efortul fizic şi aceste vitamine privind reducerea efectelor efortului fizic asupra musculaturii şi imunităţii, ne-au determinat să investigăm experimental influenţa suplimentării cu vitamine asupra capacităţii de efort fizic şi asupra capacităţii fagocitare, la şobolani antrenaţi la efort fizic.

Obiective. S-au studiat: influenţa efortului fizic şi a suplimentării de vitamine A, E şi C asupra leucocitelor şi capacităţii fagocitare la şobolani.

Metode. Au fost investigate loturi alcătuite fiecare din 10 şobolani albi, rasa Wistar, sex masculin (cu greutatea medie de 170-190 g): lotul I - lotul martor cu animale antrenate la efort fizic prin proba de înot; lotul II - cu animale antrenate la efort fizic şi suplimentare de vitamină A (150.000 I.U./zi); lotul III - cu animale antrenate la efort fizic şi suplimentare de vitamină E (15 mg/zi); lotul IV - cu animale antrenate la efort fizic şi suplimentare de vitamină C (50 mg/zi). De la toate loturile a fost recoltat sânge pe anticoagulant, din vena retro-orbitară, în ziua 1, în ziua 14 şi în ziua 28. S-au determinat: numărul de leucocite, respectiv capacitatea fagocitară: indicele fagocitar, activitatea fagocitară şi activitatea peroxidazică.

Rezultate. Suplimentarea de vitamină A şi antrenamentul determină creşteri semnificative la 28 zile ale activităţii peroxidazice şi modificări ale capacităţii fagocitare. Suplimentarea de vitamină E şi antrenamentul determină scăderi semnificative ale numărului leucocitelor şi scăderi semnificative ale activităţii peroxidazice. Suplimentarea de vitamină C şi antrenamentul determină creşteri semnificative ale numărului leucocitelor, creşteri ale capacităţii fagocitare semnificative pentru indicele fagocitar, pentru activitatea fagocitară şi activitatea peroxidazică la 28 zile.

Concluzii. Vitaminele A şi E nu influenţează capacitatea fagocitară (indicele fagocitar, activitatea fagocitară) în efortul fizic, în schimb vitamina C, în doza administrată, produce creşterea capacităţii fagocitare (indicele fagocitar, activitatea fagocitară, activitatea peroxidazică).

Cuvinte cheie: efort fizic, vitamine (A, E, C), capacitate fagocitară.

Received: 2013, March 2; *Accepted for publication:* 2013, May 4;
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Introduction

Changes of phagocytosis during exercise can be determined by antioxidant vitamin factors, which influence the exercise capacity, leukocyte count and phagocytic capacity. Supplementation with antioxidant vitamins: b-carotene, C and E in endurance athletes for 7 days before competition increases plasma vitamin concentrations. After exercise, there is an increase of polymorphonuclear neutrophil (PMNN) respiratory bursts, suggesting that antioxidant supplementations may be beneficial for maintaining innate immunity (Robson et al., 2003). Chronic moderate exercise increases chemotaxis and phagocytosis (Syu et al., 2012). In athletes, professional rugby players, it was found that during the period of intense training and competitions, the monocyte count, oxidized conjugated dienes, uric acid increase and vitamin E concentrations decreased. In a short training period, a decrease of PMNN and vitamin E occurs (Watson et al., 2005). Vitamin C and E supplementation in athletes and exercise do not affect the plasma vitamin E level, instead there is an increase in vitamin E concentration in lymphocytes and PMNN (Cases et al., 2005). Some studies have shown that the short-term effect of vitamin E supplementation against muscle damage induced by exercise is not physiologically significant (Kyparos et al., 2011). The literature data present little evidence to support the beneficial effects of antioxidant vitamin C or E supplementation on exercise-induced muscle damage, although there is evidence that this can reduce some oxidative stress markers in muscles during exercise (McGinley et al., 2009; Ryan et al., 2010; Askari et al., 2012; Taghiyar et al., 2013). Other studies show that antioxidant supplementation interferes with the adaptation induced by exercise (Peternelj & Coombes, 2011). The administration of an antioxidant supplement consisting of α-lipoic acid, vitamin E and coenzyme Q_{10} increases performance and mitochondrial function in female mice that are not trained to exercise and does not attenuate treadmill training in male mice (Abadi et al., 2013). Vitamin E supplementation and α-lipoic acid suppress skeletal muscle mitochondrial biogenesis, regardless of the training degree (Strobel et al., 2011). Other authors also indicate that increased vitamin C doses prevent the increase of mitochondrial biogenesis and antioxidant enzymes in skeletal muscles after exercise, but other researches show that they do not affect these markers (Wadley et al., 2010).

Objectives

The influence of exercise and vitamin A, E, C supplementation on leukocytes and phagocytic capacity in rats was studied experimentally.

Hypothesis

The relationship between exercise and vitamins and the effect of vitamin supplementations on the phagocytic capacity during exercise led us to explore the influence of antioxidant vitamins (A, E, C) on the phagocytic capacity in rats trained to exercise. Thus, supplementation with some vitamins may lead to an increase of the phagocytic capacity of rats.

Material and methods

a) *Subjects*

The investigations were carried out in groups of 10 male albino Wistar rats (weighing 170-190 g):

Group I - control group of animals trained to exercise daily by using the swimming test for 28 days;

Group II - animals trained to exercise daily and supplemented with vitamin A (150,000 IU/day) (Sicovit® A; SICOMED S.A. Bucharest);

Group III - animals trained to exercise daily and supplemented with vitamin E (15 mg/day) (Vitamin E; SICOMED S.A. Bucharest);

Group IV - animals trained to exercise daily and supplemented with vitamin C (50 mg/day) (Sicovit® C; SICOMED S.A. Bucharest).

b) *Tests*

- *Hematologic samples.* In all groups, blood was taken from the retro-orbital vein of the rats and collected on anticoagulant (heparin) on day 1, day 14 and day 28, in the Laboratory of Experimental Research of the Department of Physiology, "Iuliu-Haţieganu" University of Medicine and Pharmacy Cluj-Napoca, with the approval of the Ethics Committee.

We determined: the leukocyte count (values being expressed in leukocyte count/µl) by using SYSMEX SF-3000 Analyzer from Medical Analysis Laboratory, Integrated outpatient facility, Clinical Hospital for Infectious Diseases, Cluj-Napoca, the phagocytic index, phagocytic activity (using the phagocytosis technique), and peroxidase activity using the Sato method, the smears stained with May-Grünwald Giemsa (the classical technique) being examined by immersion with the 90 x objective of the optical microscope, with Cedar oil.

c) *Statistical processing*

The materiality threshold for the tests used was considered $\alpha = 0.05$. Statistical calculations were performed by using SPSS 13.0 Statistical 7.0 and Microsoft Excel applications.

Table I

Comparative analysis of leukocytes between days 1-28 in groups I and II.

Group	Day A - Day B	Day A		Day B		p
		Mean	Standard deviation	Mean	Standard deviation	
Group I	Day 1 - Day 14	10476.6	2874.01	7947.4	865.35	0.02
	Day 1 - Day 28	10476.6	2874.01	9342.4	2324.63	0.15
	Day 14 - Day 28	7947.4	865.35	9342.4	2324.63	0.08
Group II	Day 1 - Day 14	9630	3887.49	9692	2923.49	0.97
	Day 1 - Day 28	9630	3887.49	11462	3977.1	0.34
	Day 14 - Day 28	9692	2923.49	11462	3977.1	0.14

Results

The influence of vitamin supplementations and exercise on the leukocyte count

a) *The influence of vitamin A supplementation and exercise on the leukocyte count*

Vitamin A does not have a significant effect on leukocytes during exercise (groups I and II) (Table I). In exercise trained group I, leukocytes significantly decreased on days 1 and 14, and then they increased insignificantly, while in group II trained to exercise and supplemented with vitamin A, the leukocyte count was not significantly different during the test. The leukocyte count in rats was compared for a period of 1-28 days. On the tested days, leukocytes were not significantly different between groups I and II (Table I).

b) *The influence of vitamin E supplementation and exercise on the leukocyte count*

Vitamin E does not have a significant effect on leukocytes during exercise (groups I and III) (Table II). In exercise trained group I, leukocytes decreased significantly on days 1 and 14 and then they increased, but insignificantly. In group III trained to exercise and supplemented with vitamin E, leukocytes decreased significantly on days 1 and 14 and then they increased, but insignificantly. On the tested days, leukocytes were not significantly different between groups I and III and they were not significantly different between the days when they were measured in both groups (Table II).

Vitamin E does not have a significant influence on leukocytes in the exercise trained groups (p=0.18).

c) *The influence of vitamin C supplementation and exercise on the leukocyte count*

Vitamin C has a significant effect on leukocytes during exercise (groups I and IV) (Table III). In exercise trained group I, leukocytes significantly decreased on days 1 and 14 and then they increased, but insignificantly, while in group IV trained to exercise and supplemented with vitamin C, leukocytes increased significantly on days 1 and 14 and then they decreased, but insignificantly. On the tested days, leukocytes were not significantly different between groups I and II, except for day 14 (Table III).

Vitamin C has a significant influence on leukocytes in the exercise trained groups (p=0.001).

The influence of vitamin supplementations and exercise on the phagocytic index

d) *The influence of vitamin A supplementation and exercise on the phagocytic index*

Vitamin A has a significant effect on the phagocytic index during exercise. In exercise trained group I, the phagocytic index decreased significantly on day 14 compared to day 1, then it increased significantly, while in group II trained to exercise and supplemented with vitamin A, the phagocytic index decreased significantly in the first period and decreased in the second period of testing, but not significantly (Table IV). On the tested days, the phagocytic index was not significantly different between groups I and II and was not significantly different between the days when it was measured in both groups (Table IV).

Table II

Comparative analysis of leukocytes between days 1-28 in groups I and III.

Group	Day A - Day B	Day A		Day B		p
		Mean	Standard deviation	Mean	Standard deviation	
Group I	Day 1 - Day 14	10476.6	2874.01	7947.4	865.35	0.02
	Day 1 - Day 28	10476.6	2874.01	9342.4	2324.63	0.15
	Day 14 - Day 28	7947.4	865.35	9342.4	2324.63	0.08
Group III	Day 1 - Day 14	12879	3474.4	8818	1603.29	0.003
	Day 1 - Day 28	12879	3474.4	9125	1129.52	0.01
	Day 14 - Day 28	8818	1603.29	9125	1129.52	0.62

Table III

Comparative analysis of leukocytes between days 1-28 in groups I and IV.

Group	Day A - Day B	Day A		Day B		p
		Mean	Standard deviation	Mean	Standard deviation	
Group I	Day 1 - Day 14	10476.6	2874.01	7947.4	865.35	0.02
	Day 1 - Day 28	10476.6	2874.01	9342.4	2324.63	0.15
	Day 14 - Day 28	7947.4	865.35	9342.4	2324.63	0.08
Group IV	Day 1 - Day 14	9279	3794.78	12381.1	4137.51	0.001
	Day 1 - Day 28	9279	3794.78	10377.4	2151.8	0.38
	Day 14 - Day 28	12381.1	4137.51	10377.4	2151.8	0.13

Table IV

Comparative analysis of the phagocytic index between days 1-28 in groups I and II.

Group	Day A - Day B	Day A		Day B		p
		Mean	Standard deviation	Mean	Standard deviation	
Group I	Day 1 - Day 14	1.81	0.54	1.24	0.16	0.02
	Day 1 - Day 28	1.81	0.54	1.65	0.41	0.27
	Day 14 - Day 28	1.24	0.16	1.65	0.41	0.01
Group II	Day 1 - Day 14	2.23	0.51	1.69	0.29	0.01
	Day 1 - Day 28	2.23	0.51	1.58	0.23	0.02
	Day 14 - Day 28	1.69	0.29	1.58	0.23	0.38

Vitamin A has a significant influence on the phagocytic index in the exercise trained groups (p=0.02).

e) *The influence of vitamin E supplementation and exercise on the phagocytic index*

Vitamin E has a significant effect on the phagocytic index during exercise. In exercise trained group I, the phagocytic index was decreased significantly on day 14 compared to day 1, then it increased significantly, while in group III trained to exercise and supplemented with vitamin E, the phagocytic index did not significantly differ between the two measurements (Table V). On the tested days, the phagocytic index differed significantly between groups I and III on day 14. The phagocytic index was significantly different between the days when it was measured in group I, but not in group III (Table V).

Vitamin E has a significant influence on the phagocytic index in the exercise trained groups (p=0.03).

f) *The influence of vitamin C supplementation and exercise on the phagocytic index*

Vitamin C has a significant effect on the phagocytic index during exercise. In exercise trained group I, the phagocytic index decreased significantly after 14 days compared to day 1, then it increased significantly, while in group IV trained to exercise and supplemented with vitamin C, the phagocytic index was not significantly different in the first period, but significantly increased during the second period (Table VI). On the tested days, the phagocytic index was not significantly different between groups I and IV and was significantly different between the days when it was measured in both groups (Table VI).

Vitamin C has a significant influence on the phagocytic index in the exercise trained groups (p=0.04).

The influence of vitamin supplementations and exercise on phagocytic activity

g) *The influence of vitamin A supplementation and exercise on phagocytic activity*

Vitamin A does not have a significant effect on phagocytic activity during exercise (groups I and II) (Table VII). On the tested days, phagocytic activity was significantly different between groups I and II and was not significantly different between the days when it was measured in both groups (Table VII).

Vitamin A does not have a significant influence on phagocytic activity in the exercise trained groups (p=0.05).

h) *The influence of vitamin E supplementation and exercise on phagocytic activity*

Vitamin E supplementation does not have a significant effect on phagocytic activity during exercise (groups I and III) (Table VIII). On the tested days, phagocytic activity differed significantly between groups I and III and was not significantly different between the days when it was measured in both groups (Table VIII).

Vitamin E does not have a significant influence on phagocytic activity in the exercise trained groups (p=0.22).

i) *The influence of vitamin C supplementation and exercise on phagocytic activity*

Vitamin C does not have a significant effect on

Table V

Comparative analysis of the phagocytic index between days 1-28 in groups I and III.

Group	Day A - Day B	Day A		Day B		p
		Mean	Standard deviation	Mean	Standard deviation	
Group I	Day 1 - Day 14	1.81	0.54	1.24	0.16	0.02
	Day 1 - Day 28	1.81	0.54	1.65	0.41	0.27
	Day 14 - Day 28	1.24	0.16	1.65	0.41	0.01
Group III	Day 1 - Day 14	1.56	0.48	1.74	0.56	0.39
	Day 1 - Day 28	1.56	0.48	1.6	0.44	0.81
	Day 14 - Day 28	1.74	0.56	1.6	0.44	0.42

Table VI

Comparative analysis of the phagocytic index between days 1-28 in groups I and IV.

Group	Day A - Day B	Day A		Day B		p
		Mean	Standard deviation	Mean	Standard deviation	
Group I	Day 1 - Day 14	1.81	0.54	1.24	0.16	0.02
	Day 1 – Day 28	1.81	0.54	1.65	0.41	0.27
	Day 14 – Day 28	1.24	0.16	1.65	0.41	0.01
Group IV	Day 1 - Day 14	1.53	0.32	1.4	0.43	0.34
	Day 1 – Day 28	1.53	0.32	1.86	0.42	0.01
	Day 14 – Day 28	1.4	0.43	1.86	0.42	0.004

Table VII

Comparative analysis of phagocytic activity between days 1-28 in groups I and II.

Group	Day A - Day B	Day A		Day B		p
		Mean	Standard deviation	Mean	Standard deviation	
Group I	Day 1 - Day 14	2.94	0.94	2.8	0.44	0.62
	Day 1 - Day 28	2.94	0.94	3.58	1.26	0.06
	Day 14 - Day 28	2.8	0.44	3.58	1.26	0.08
Group II	Day 1 - Day 14	2.59	0.24	2.32	0.22	0.02
	Day 1 - Day 28	2.59	0.24	2.33	0.39	0.13
	Day 14 - Day 28	2.32	0.22	2.33	0.39	0.92

phagocytic activity during exercise (groups I and IV) (Table IX). On the tested days, phagocytic activity was significantly different between groups I and IV and was significantly different between the days when it was measured only in group IV (Table IX).

Vitamin C does not have a significant influence on phagocytic activity in the exercise trained groups (p=0.17).

The influence of vitamin supplementations and exercise on peroxidase activity

j) *The influence of vitamin A supplementation and exercise on peroxidase activity*

Vitamin A does not have a significant effect on peroxidase activity during exercise. Peroxidase activity remained constant in exercise trained group I. In group II trained to exercise and supplemented with vitamin A, peroxidase activity decreased progressively from one test to another, this decrease being significant, but overall it was too small to justify our saying that vitamin A had a significant influence (in multi-way analysis) (Table X). On the tested days, peroxidase activity was not significantly different between groups I and II and was not significantly different between the days when it was measured in the exercise trained groups (Table X).

Vitamin A does not have a significant influence on peroxidase activity in the exercise trained groups (p=0.25).

k) *The influence of vitamin E supplementation and exercise on peroxidase activity*

Vitamin E does not have a significant effect on peroxidase activity during exercise. Peroxidase activity remained constant in exercise trained group I. In group III trained to exercise and supplemented with vitamin E, peroxidase activity decreased progressively from one test to another; this decrease was significant, but overall it was too small to justify our saying that vitamin E had a significant influence (in multi-way analysis) (Table XI). On the tested days, peroxidase activity was not significantly different between groups I and III and was not significantly different between the days when it was measured in both groups (Table XI).

Vitamin E does not have a significant influence on peroxidase activity in the exercise trained groups (p=0.10).

l) *The influence of vitamin C supplementation and exercise on peroxidase activity*

Vitamin C does not have a significant effect on peroxidase activity during exercise. On the tested days, peroxidase activity was not significantly different between groups I and IV (Table XII). Peroxidase activity was not significantly different between the days when it was measured in group I, but it was significantly different in group IV (Table XII).

Vitamin C does not have a significant influence on peroxidase activity in the exercise trained groups (p=0.07).

Discussion

Our results (Boboş et al., 2006; Boboş et al., 2009; Boboş & Tache, 2013) are in agreement with the literature data concerning the effects of vitamin supplementations

Table VIII

Comparative analysis of phagocytic activity between days 1-28 in groups I and III.

Group	Day A - Day B	Day A		Day B		p
		Mean	Standard deviation	Mean	Standard deviation	
Group I	Day 1 - Day 14	2.94	0.94	2.8	0.44	0.62
	Day 1 - Day 28	2.94	0.94	3.58	1.26	0.06
	Day 14 - Day 28	2.8	0.44	3.58	1.26	0.08
Group III	Day 1 - Day 14	1.73	0.71	1.77	0.35	0.86
	Day 1 - DayDay 28	1.73	0.71	1.8	0.19	0.76
	Day 14 - Day 28	1.77	0.35	1.8	0.19	0.76

Table IX

Comparative analysis of phagocytic activity between days 1-28 in groups I and IV.

Group	Day A - Day B	Day A		Day B		p
		Mean	Standard deviation	Mean	Standard deviation	
Group I	Day 1 - Day 14	2.94	0.94	2.8	0.44	0.62
	Day 1 – Day 28	2.94	0.94	3.58	1.26	0.06
	Day 14 – Day 28	2.8	0.44	3.58	1.26	0.08
Group IV	Day 1 - Day 14	1.76	0.21	2.24	0.42	0.01
	Day 1 – Day 28	1.76	0.21	2.32	0.25	0.002
	Day 14 – Day 28	2.24	0.42	2.32	0.25	0.66

Table X

Comparative analysis of peroxidase activity between days 1-28 in groups I and II.

Group	Day A - Day B	Day A		Day B		p
		Mean	Standard deviation	Mean	Standard deviation	
Group I	Day 1 - Day 14	79.4	10.64	78.3	6.33	0.78
	Day 1 – Day 28	79.4	10.64	79	7.99	0.9
	Day 14 – Day 28	78.3	6.33	79	7.99	0.84
Group II	Day 1 - Day 14	74	4.94	76.4	5.32	0.3
	Day 1 – Day 28	74	4.94	79.9	7.19	0.01
	Day 14 – Day 28	76.4	5.32	79.9	7.19	0.12

Table XI
Comparative analysis of peroxidase activity between days 1-28 in groups I and III.

Group	Day A-Day B	Day A		Day B		p
		Mean	Standard deviation	Mean	Standard deviation	
Group I	Day 1 - Day 14	79.4	10.64	78.3	6.33	0.78
	Day 1 - Day 28	79.4	10.64	79	7.99	0.9
	Day 14 - Day 28	78.3	6.33	79	7.99	0.84
Group III	Day 1 - Day 14	83.2	12.74	78.4	6.75	0.3
	Day 1 - Day 28	83.2	12.74	72.5	4.93	0.02
	Day 14 - Day 28	78.4	6.75	72.5	4.93	0.07

Table XII
Comparative analysis of peroxidase activity between days 1-28 in groups I and IV.

Group	Day A - Day B	Day A		Day B		p
		Mean	Standard deviation	Mean	Standard deviation	
Group I	Day 1 - Day 14	79.4	10.64	78.3	6.33	0.78
	Day 1 - Day 28	79.4	10.64	79	7.99	0.9
	Day 14 - Day 28	78.3	6.33	79	7.99	0.84
Group IV	Day 1 - Day 14	75.5	7.07	85.6	6.9	0.03
	Day 1 - Day 28	75.5	7.07	84.7	5.08	0.004
	Day 14 - Day 28	85.6	6.9	84.7	5.08	0.69

(administration of a vitamin or a complex of vitamins) (Gerster, 1991; Goldfarb, 1993; Kanter et al., 1993; Rokitzki et al., 1994; Balakrishnan & Anuradha, 1998; Schroder et al., 2001; Urso & Clarkson, 2003).

Swimming training determined significant decreases of the leukocyte count, significant decreases of the phagocytic index after 14 days, insignificant increases of phagocytic activity after 28 days, as other authors have shown (Peters-Futre, 1997; Giraldo et al., 2009; Ferreira et al., 2010).

The results obtained are in agreement with the literature data, especially those relating to vitamin E supplementation (Sumida et al., 1989; Drăgan et al., 1991; Gerster, 1991; Goldfarb, 1993; Rokitzki et al., 1994; Tiidus and Houston, 1995; Clarkson, 1995; Kanter, 1998; Takanami et al., 2000; Evans, 2000; Clarkson and Thompson, 2000; Schroder et al., 2001; Metin et al. 2002; Asha et al., 2003).

Our results show that vitamins A and E do not influence significantly the phagocytic capacity (phagocytic index, phagocytic activity) during exercise. Some researchers (Ciocoiu et al., 1998) show that vitamins E and C stimulate the phagocytic capacity, in accordance with the result of the present work.

Vitamin C supplementation and exercise induce significant increases in the leukocyte count, with increases in the phagocytic capacity that are significant after 28 days for the phagocytic index, phagocytic activity and peroxidase activity, as shown in other studies; at the doses used in this study, vitamin C acted as a prooxidant (Keith & Driskell, 1982; Alessio et al., 1977).

Conclusions

1. Vitamin A supplementation and exercise training determine significant increases in peroxidase activity and changes in the phagocytic capacity after 28 days.

2. Vitamin E supplementation and exercise training induce significant decreases in the leukocyte count, significant decreases in peroxidase activity, without a significant influence on the phagocytic index and phagocytic activity.

3. Vitamin C supplementation and exercise training lead to significant increases in the leukocyte count, with increases in the phagocytic capacity that are significant for the phagocytic index after 28 days, for phagocytic activity and for peroxidase after 14 days and after 28 days.

Conflict of interests
Nothing to declare.

Acknowledgements
This paper is based on the results of the first author's doctoral thesis. Many thanks to Mrs. Cosmina Ioana Bondor for consultancy on the statistical analysis of the results and to Mr. Remus Moldovan for his assistance in laboratory experiments.

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