

COMMENTARY

Open Access

# Controversies of antioxidant vitamins supplementation in exercise: ergogenic or ergolytic effects in humans?

Cainara Lins Draeger, Andréia Naves, Natália Marques, Ana Beatriz Baptistella, Renata Alves Carnauba, Valéria Paschoal and Humberto Nicastro\*

## Abstract

The aim of this commentary was to discuss the last studies regarding the effect of antioxidant vitamins supplementation on oxidative stress in exercise in humans. The inclusion criteria encompassed published studies done in adult males and females between 2006 and 2013. The keywords used in the search engine were: endurance athlete, diet, oxidative stress, physical activity, diet, nutrition, antioxidant, antioxidant status, vitamin C, vitamin A, vitamin E,  $\beta$ -carotene and combinations. Twelve studies were identified and organized according to the methodology and results of supplementation: ergogenic, ergolytic, partial or no difference between groups. The results of these studies showed no effect on physiological parameters and activity of antioxidant enzymes ( $n = 07$ ), better response of the placebo treatment (ergolytic effect;  $n = 02$ ), partial results ( $n = 01$ ) and ergogenic results of antioxidant supplementation ( $n = 02$ ). It is concluded that supplementation with antioxidant vitamins has controversial effects to oxidative damage induced by endurance exercise. The discordances among the studies are presented and discussed.

**Keywords:** Endurance, Oxidative stress, Antioxidant, Athlete, Diet, Physical activity, Vitamin A, Vitamin C, Vitamin E and  $\beta$ -caroten

## Background

Oxidative stress occurs when there is an imbalance in the human body homeostasis, i.e. the production of pro-oxidants becomes excessive and the cellular antioxidant mechanisms cannot neutralize these radicals. Excessive production of free radicals can be triggered by several endogenous and exogenous factors and, among these, exposure to radiation, excessive heat, inflammation, infection, trauma and exhaustive physical exercise can be considered strong exogenous triggers [1].

The regular practice of exercise induces several adaptations in cardiovascular, skeletal muscle and respiratory systems providing positive results for the prevention and treatment of metabolic diseases [2]. However, despite the undeniable health benefits, exercise may increase mitochondrial formation of reactive oxygen species which may cause cellular damage [3]. When produced in

excess, free radicals may promote cellular oxidation, damage in the DNA structure, aging and a variety of diseases [4], impair skeletal muscle function and pain and, thereby affecting exercise performance [5]. In an attempt to minimize the effects of oxidative stress during physical activity, many athletes and sports professionals are performing supplementation with antioxidant vitamins.

However, recent studies raise the assumption that exercise alone could increase the oxidative capacity of skeletal muscle and potentiate the action of endogenous antioxidants, which is sufficient to counteract the negative effects of oxidative stress induced by the mechanical stimuli [3,6-8]. In view of this background, the aim of this commentary was to systematize the results of the last studies published regarding the effects of antioxidant vitamins intake on oxidative stress in exercise in humans.

\* Correspondence: nicastroh@yahoo.com.br

VP Research Institute, Rua Pedro Morganti, 103 – Vila Mariana, PO Box 04020-070, São Paulo, SP, Brazil

**Table 1 Results of the studies with endurance trained volunteers supplemented with vitamins A, C, and E**

Study	Experimental design	Sample	Duration	Supplementation protocol			Result	
				Vitamin A	Vitamin C	Vitamin E	Ergogenic	Ergolytic
Tauler et al. [6]	Randomized, double-blind	15 athletes	90 d*	30 mg (β-caroten)	1000 mg	500 mg	↔	↔
Gauche et al. [9]	Randomized, double-blind	22 athletes	21 d (pre-exercise) + 2 dias (post-exercise)	6 mg (β-caroten)	200 mg	32 mg	↑	N/R
Nielsen et al. [10]	Randomized, double-blind, cross-over	15 athletes	28 d	-	400 mg	180 mg	↔	↔
Patil et al. [11]	Randomized, double-blind	37 athletes	21 d	-	-	200 mg	↔	↔
Louis et al. [12]	Randomized, double-blind	16 athletes	21 d	17.1 mg (β-caroten)	319.2 mg	48 mg	↑	N/R

\* Vitamin C supplementation occurred only in the last 15 days of the study; ↑ Improved exercise performance; ↔ No results on exercise performance; N/R – not reported.

## Results and discussion

We included 12 studies published in the last years that addressed the supplementation of antioxidant vitamins in trained volunteers (n = 05; Table 1) and in volunteers submitted to endurance exercise (n = 07; Table 2).

In general, it was observed that there are controversial results about antioxidant supplementation during high-intensity exercise. According to two studies evaluated [3,7], the placebo group presented significant better physical performance, fatigue resistance and antioxidant protection when compared to the supplemented groups. In contrast, Gauche et al. [9] and Louis et al. [12] evaluated the effects of vitamin and mineral supplementation on muscle activity of athletes and observed that dietary supplementation provided a slight advantage over the

placebo group in maximum voluntary muscle contraction after high-intensity exercise. This small advantage in the supplemented group compared to the placebo group was sufficient for the authors to consider the antioxidant supplementation as an ergogenic aid. Regarding the other studies, no differences were found between the groups.

## Sample characteristics

The subjects included in the studies presented different metabolic and body composition patterns. It is known that untrained subjects are more responsive to an exercise bout and, consequently, much more susceptible to suffer cellular damage from oxidative stress than trained individuals. For example, muscle damage caused by

**Table 2 Results of the studies with untrained volunteers submitted to endurance exercise and supplemented with vitamins C e E**

Study	Experimental design	Sample	Duration	Supplementation protocol		Result	
				Vitamin C	Vitamin E	Ergogenic	Ergolytic
Bloomer et al. [13]	Randomized, double-blind	15 trained and e 15 untrained subjects	14 d (pre-exercise) + 2 d (post-exercise)	2000 mg	835 mg	↔	↔
Gomez-Cabrera et al. [7]	Randomized, double-blind	14 untrained subjects e 36 rats	8 weeks	1 g (humans) and 0.24 mg·cm <sup>-2</sup> (rodents)	-	N/R	↓
Ristow et al. [3]	Randomized, double-blind	20 trained and e 20 untrained subjects	4 weeks	1000 mg	440 mg	N/R	↓
Yfanti et al. [14]	Randomized, double-blind	21 untrained subjects	16 weeks	500 mg	400 IU	↔	↔
Yfanti et al. [5]	Randomized, double-blind	21 untrained subjects	16 weeks	500 mg	400 IU	↔	↔
Nalbant et al. [8]	Randomized	57 elderly	6 months	-	900 IU	↔	↔
Nakhostin et al. [15]	Randomized	16 untrained subjects	N/R	1000 mg	-	↑↓	N/R

↑ Improved exercise performance; ↓ Impaired exercise performance; ↑↓ Partial result; ↔ No results on exercise performance; IU – International Units; N/R – not reported.

oxidative stress, in general, is more pronounced in untrained individuals [16].

Another point to be considered is the sample size of the studies. It was observed that the number of individuals that comprise the groups used in the studies listed in Table 1 is smaller than those in Table 2. This can be partially justified by the difficulty of recruiting athletes to be volunteers. Consequently, the statistical power and the effect size of such data can be compromised and should be carefully interpreted.

### Dietary control

Parallel to vitamin supplementation, it was observed that several studies did not perform dietary control of the subjects [3] or performed an inadequate control [9-12] to assess the possible interference of diet on the outcome. The dietary control is quite important since some vitamins and minerals may compete in terms of absorption in the gastrointestinal tract. Thus, the absence or inadequate dietary control can be considered a bias of the published studies.

Tauler et al. [6] and Yfanti et al. [5,14] performed dietary control through food records before and after the intervention. Gomez-Cabrera et al. [7] instructed the subjects to repeat the diet in the day before the exercise test in the pre- and post-supplementation periods. Only in the study of Bloomer et al. [13] dietary control was performed through food records. The variables analyzed were: total caloric value of the meals, amount of proteins, carbohydrates and lipids and of vitamins A, C and E. Even using a better dietary control than the other studies, the authors did not identify differences in the diet that could justify the results obtained.

### Controversies

The differences between the results in the studies described can also be mainly attributed to the different methodologies, conveyed vitamin dosage, study length, sample size, differences in gender, age, and subjects characteristics (athletes and non-athletes). These differences make it difficult to draw conclusion about the advantages and disadvantages of antioxidant vitamins supplementation.

So far, the results of the studies presented confirm that exercise is capable of increasing the oxidative capacity of skeletal muscle and potentiate the action of endogenous antioxidants [6]. Exercise increases the expression of reduced glutathione (GSH) and antioxidant enzymes (superoxide dismutase [SOD], and glutathione peroxidase [GSH-Px]), which appear to be sufficient to counteract the negative effects of exercise-induced oxidative stress [3,7,8]. In this context, the real need to use antioxidant vitamins supplements as ergogenic aids is questionable. The safest and effective alternative in attenuating

exercise-induced oxidative stress could be a balanced diet based on foods with the recommended amounts of antioxidants in order to improve exercise performance.

### Conclusions

The results obtained in the considered studies with antioxidant vitamins supplementation are contradictory. Some studies show that supplementation does not improve exercise performance but can impair it. Others show that supplementation provides a slight advantage over the placebo. Thus, although many athletes use antioxidant supplementation to improve their physical performance, there is no consistent evidence suggesting that supplementation reduces oxidative stress and ensures better results in exercise.

### Abbreviations

DNA: Deoxyribonucleic acid; GSH: Reduced glutathione; GSH-Px: Glutathione peroxidase; SOD: Superoxide dismutase.

### Competing interests

The authors declare that they have no competing interests.

### Authors' contributions

CLD participate in the manuscript design and wrote the first draft of the manuscript. AN, NM, ANB, RAC, and VP participated in the interpretation and preparation of the manuscript. HN participated in the manuscript design, interpretation and preparation of the manuscript. All the authors read and approved the final manuscript.

Received: 9 October 2013 Accepted: 12 February 2014

Published: 19 February 2014

### References

1. Halliwell B: The wanderings of a free radical. *Free Radic Biol Med* 2009, **46**:531-542.
2. Chaput JP, Klingenberg L, Rosenkilde M, Gilbert JA, Tremblay A, Sjodin A: Physical activity plays an important role in body weight regulation. *J Obes* 2011, **2011**:11.
3. Ristow M, Zarse K, Oberbach A, Kloting N, Birringer M, Kiehntopf M, Stumvoll M, Kahn CR, Bluher M: Antioxidants prevent health-promoting effects of physical exercise in humans. *Proc Natl Acad Sci USA* 2009, **106**:8665-8670.
4. Sahlin K, Shabalina IG, Mattsson CM, Bakkman L, Fernstrom M, Rozhdestvenskaya Z, Enqvist JK, Nedergaard J, Ekblom B, Tonkonogi M: Ultraendurance exercise increases the production of reactive oxygen species in isolated mitochondria from human skeletal muscle. *J Appl Physiol* (1985) 2010, **108**:780-787.
5. Yfanti C, Fischer CP, Nielsen S, Akerstrom T, Nielsen AR, Veskokouk AS, Kouretas D, Lykkesfeldt J, Pilegaard H, Pedersen BK: Role of vitamin C and E supplementation on IL-6 in response to training. *J Appl Physiol* (1985) 2012, **112**:990-1000.
6. Tauler P, Aguilo A, Gimeno I, Fuentespina E, Tur JA, Pons A: Response of blood cell antioxidant enzyme defences to antioxidant diet supplementation and to intense exercise. *Eur J Nutr* 2006, **45**:187-195.
7. Gomez-Cabrera MC, Domenech E, Romagnoli M, Arduini A, Borrás C, Pallardo FV, Sastre J, Vina J: Oral administration of vitamin C decreases muscle mitochondrial biogenesis and hampers training-induced adaptations in endurance performance. *Am J Clin Nutr* 2008, **87**:142-149.
8. Nalbant O, Toktas N, Toraman NF, Ogun C, Aydin H, Kacar C, Ozkaya YG: Vitamin E and aerobic exercise: effects on physical performance in older adults. *Aging Clin Exp Res* 2009, **21**:111-121.
9. Gauche E, Lepers R, Rabita G, Leveque JM, Bishop D, Brisswalter J, Hausswirth C: Vitamin and mineral supplementation and neuromuscular recovery after a running race. *Med Sci Sports Exerc* 2006, **38**:2110-2117.

10. Nielsen HG, Skjonsberg OH, Lyberg T: **Effect of antioxidant supplementation on leucocyte expression of reactive oxygen species in athletes.** *Scand J Clin Lab Invest* 2008, **68**:526–533.
11. Patil SM, Chaudhuri D, Dhanakshirur GB: **Role of alpha-tocopherol in cardiopulmonary fitness in endurance athletes, cyclists.** *Indian J Physiol Pharmacol* 2009, **53**:375–379.
12. Louis J, Hausswirth C, Bieuzen F, Brisswalter J: **Vitamin and mineral supplementation effect on muscular activity and cycling efficiency in master athletes.** *Appl Physiol Nutr Metab* 2010, **35**:251–260.
13. Bloomer RJ, Falvo MJ, Schilling BK, Smith WA: **Prior exercise and antioxidant supplementation: effect on oxidative stress and muscle injury.** *J Int Soc Sports Nutr* 2007, **4**:9.
14. Yfanti C, Akerstrom T, Nielsen S, Nielsen AR, Mounier R, Mortensen OH, Lykkesfeldt J, Rose AJ, Fischer CP, Pedersen BK: **Antioxidant supplementation does not alter endurance training adaptation.** *Med Sci Sports Exerc* 2010, **42**:1388–1395.
15. Nakhostin-Roohi B, Babaei P, Rahmani-Nia F, Bohlooli S: **Effect of vitamin C supplementation on lipid peroxidation, muscle damage and inflammation after 30-min exercise at 75% VO<sub>2</sub>max.** *J Sports Med Phys Fitness* 2008, **48**:217–224.
16. Lamprecht M, Greilberger J, Oettl K: **Analytical aspects of oxidatively modified substances in sports and exercises.** *Nutrition* 2004, **20**:728–730.

doi:10.1186/1550-2783-11-4

**Cite this article as:** Draeger et al.: Controversies of antioxidant vitamins supplementation in exercise: ergogenic or ergolytic effects in humans? *Journal of the International Society of Sports Nutrition* 2014 **11**:4.

**Submit your next manuscript to BioMed Central and take full advantage of:**

- Convenient online submission
- Thorough peer review
- No space constraints or color figure charges
- Immediate publication on acceptance
- Inclusion in PubMed, CAS, Scopus and Google Scholar
- Research which is freely available for redistribution

Submit your manuscript at  
www.biomedcentral.com/submit

