Antioxidants

Technical Document
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Introduction

Antioxidants are vitamins, minerals or enzymes that can be produced by the body or introduced into the body through dietary means. The main dietary sources, the best sources for obtaining antioxidants, are plant-based foods including dark coloured vegetables e.g. broccoli, fruits, berries, legumes, nuts, grains, seeds and oils (AIS Sports Nutrition). Other sources include both black and green tea which are rich sources of flavonoids. Some alternative preparations that purport to have antioxidant benefits include Coenzyme Q10, Quercetin, Rhodiola rosea L., Cucumis melo Lc., and Lemon verbena extract to name a few. Antioxidants protect cells from the inevitable production of free radicals, which occurs during normal metabolism and leads to the formation of reactive oxygen species (ROS) or reactive nitrogen species.

Physical exercise induces a significant increase in oxygen uptake. Mitochondria, the organelles that provide energy (ATP) to cells, are the main source of ROS production (Powers et al. 2008, Williams et al. 2006, Aguiló et al. 2004). The temporary increase in ROS production during exercise can lead to oxidative stress, which occurs when tissues antioxidant defence systems are overwhelmed by high levels of ROS production (Sen 2001). Muscle damage during physical exercise may further increase ROS formation by activating phagocytic cells (Nikolaidis et al. 2008). Oxidative stress has been linked to cardiovascular disease, neurodegenerative diseases and some cancers (Williams et al. 2006, Basarici et al. 2008, Chan et al. 2008). There is some evidence that suggests an association between exercise-induced oxidative stress and disease in people who partake in large amounts of physical activity (Paffenbarger et al. 1986, Quinn et al. 1990, Shaper et al. 1991, Lee et al. 1995). Many athletes consume antioxidant supplements, predominantly in the forms of vitamins C and E, in the belief that they will reduce oxidative stress. While excessive ROS can exert harmful effects within skeletal muscle during exercise, lower levels are crucial for adaptation of metabolic and signalling pathways in response to exercise (Newsholme et al. 2011).

There are a number of scientific reviews on the use of antioxidants as a means of decreasing oxidative stress and the possibility of preventing muscle damage (Peternelj and Coombes, 2011; McGinley et al. 2009), Stear et al. 2009. Paternelj and Coombes (2011) concluded that high doses of antioxidants lead to a reduction of the positive effects of exercise training and interferes with important ROS-mediated physiological processes, such as vasodilation and insulin signalling. More research is needed to produce evidence-based guidelines regarding the use of antioxidant supplementation during physical exercise. An adequate intake of vitamins and minerals through a varied and balanced diet remains the best approach to maintain the optimal antioxidant status.

Nieman et al. (2012) conducted a review of the use of Quercetin, Resveratrol and Rhodiola rosea and concluded that more research is necessary to determine if these compounds benefit athletic performance. Previously, Stear et al. (2009) conducted a brief review and concluded that there is limited scientific evidence to recommend antioxidant supplementation. Conflicting scientific evidence as to the possible benefits and detriments athletes may experience from antioxidant supplementation does not enable health professionals to make specific supplementation recommendations.

ROS are produced when the muscle eccentrically contracts, so it has been proposed that antioxidant supplementation may assist with preventing muscle damage. A review by McGinley et al. (2009) assessed the premise that antioxidant supplementation decreases muscle damage. Overall, the conclusion is that there is insufficient evidence to suggest that antioxidants, though they assist with reducing oxidative stress, are effective for protecting against muscle damage (McGinley et al. 2009).
Williams et al. (2006) reviewed the impact of antioxidant supplementation on oxidative stress in endurance athletes and summarised research investigating the effect of antioxidants on oxidative stress. This review concluded that there is not enough scientific evidence to recommend antioxidant supplementation for endurance athletes (Williams et al. 2006).

These reviews, albeit a small selection of the many available, provide a solid information base in regards to the underlying mechanisms of antioxidants, their use within sport, purported benefits and conclusions in regards to their use. Overall there is no consistent evidence that suggests antioxidant use in athletes enhances performance or prevents muscle damage, and the consumption of excessive amounts of antioxidants may lead to long term health side effects (Peternelj and Coombes 2011; Stear et al. 2009; McGinley et al. 2009; Williams et al. 2006; Sen, 2001).

**The athletic benefits of consuming antioxidant supplements**

The two main proposed benefits from consuming antioxidants include decreasing muscle damage (McGinley et al. 2009) and combating free radical damage during exercise, therefore possibly preventing muscle fatigue (Powers et al. 2008). Many athletes therefore consume antioxidant supplements in a bid to prevent oxidative stress and possibly maintain muscular power output.

Many other studies have assessed possible antioxidant benefits from a range of different preparations in athletes. Some of these include:

- Moderate antioxidant supplementation with lemon verbena extract (containing 10% verbascoside) did not block the cellular adaptive response to exercise, reduced oxidative damage of neutrophils and reduced signs of muscular damage in chronic running exercise (Funes et al. 2011)
- When consumed prior to altitude training, antioxidant supplementation (combination of beta-carotene, alpha-tocopherol acetate, ascorbic acid, selenium, and zinc) can improve ventilatory threshold after acute (but not chronic) altitude exposure (Subudhi et al. 2006)
- Supplementation with superoxide dismutase (SOD) rich *Cucumis melo* LC. (SOD is a key component of the intracellular antioxidant system) promoted antioxidant status and protected against increased inflammation in the serum in professional rowers but had no effect on oxidative damage induced by exhaustive exercise (Skarpanska-Stejnborn et al. 2011)
- Similarly, supplementation with *Rhodiola rosea* L. (a perennial herb which claims antioxidant properties in traditional medicine) increased antioxidant levels in the plasma of professional rowers but had no effect on oxidative damage induced by exhaustive exercise (Skarpanska-Stejnborn et al. 2009)
- Supplementation with Vitamin C (500mg) and Vitamin E (400 IU) in trained and previously untrained individuals did not increase insulin sensitivity or expression of transcriptional and anti-oxidant proteins abolishing the health promoting of exercise observed in the control group (Ristow et al. 2009)
- Oral quercetin supplementation, (a flavanol with purported antioxidant properties) did not alter blood plasma lipid or aqueous-phase antioxidant capacity or oxidative damage during an ultramarathon challenge (Quindry et al. 2008)

Though there is limited evidence that antioxidant supplementation will enhance performance through decreasing muscle fatigue, the one circumstance that may justify the use of antioxidant supplements is in athletes who have a less than adequate diet and may be deficient in particular vitamins and minerals (Stear et al. 2009). Similarly when considering supplementing antioxidants, only a blood test can identify actual deficiencies.
**Concerns with antioxidant supplementation**

There is evidence that excessive antioxidant consumption can prevent skeletal muscle adaptations as ROS are involved in the expression of many skeletal muscle proteins. As reported by Stear et al. (2009) recent studies have demonstrated that high consumption of Vitamins C and E can preclude the training and health promoting adaptations of exercise (Ristow et al. 2009, Gomez-Cabrera et al. 2008). Ristow et al. (2009) proposed that ROS production from exercise is essential for promoting insulin sensitivity in humans. This finding may be particularly important for individuals who have diseases such as diabetes. There is also a meta-analysis (Bjelakovic et al. 2007) that reports excessive antioxidant supplementation does not improve health outcomes and may increase mortality.

**Summary**

Taking into consideration all currently available literature, particularly from review articles, there is not sufficient evidence for the general recommendation of antioxidant supplementation in athletes. There appears to be a greater slant towards advising athletes against antioxidant supplementation, if after nutritional assessment their reported food intake is rich in antioxidant foods. Supplementation should therefore be recommended only if a blood test identifies a specific nutrient deficiency, and foods rich in antioxidants recommended instead. A balanced diet including a variety of fruits and vegetables remains the best nutritional approach to maintain optimal antioxidant status.

**Notes**

Pubmed (Medline), SPORTDiscus and Cochrane library were searched for all human studies published in peer reviewed journals. The terms searched were “antioxidant supplements AND exercise” and “antioxidant supplements AND sport” and “antioxidant supplements AND athletes”. Studies included in this review adhered to the following criteria:

**Inclusion criteria**

- Human studies published in English
- Healthy subjects
- Original investigations assessing the use of antioxidant supplements and/or exercise
- Incorporated the use of an indistinguishable placebo

**Exclusion Criteria**

- Qualitative studies assessing the prevalence of supplement use in both the general and athletic population
- Methods for assessing oxidative damage

After title and abstract review, six original articles that assessed the use of antioxidants in exercise settings that compared antioxidants to a placebo were retrieved for review.
References


Basarici I, Altekin RE, Demir I, Yilmaz H. Urinary 8-isoprostane levels can indicate the presence, severity and extent of angiographic coronary artery disease. Acta Cardiol. 2008;63:415-422.


