How Does Research Determine If Antioxidants Benefit Performance?

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"Combat muscle fatigue"

"Neutralize free radicals"

"Reduce DNA damage"

"Naturally detoxify"

"Add youth, health, and strength"

Truth in advertising? Well, sort of.

Advertisements for antioxidant supplements make some tantalizing promises about how their products can benefit athletes. Those sales pitches often rely upon some compelling scientific truths as the basis for what often turn out to be misleading claims. For example, vigorous exercise results in the production of radical oxygen species (ROS), radicals such as hydrogen peroxide, superoxide anion, and the hydroxyl radical. ROS cause oxidative damage to muscle cells, contribute to muscle fatigue, and have been linked to processes associated with aging and disease. Fortunately, dietary antioxidants such as vitamins A, C, E, and a litany of phytonutrients such as lycopene, quercetin, and lutein all play roles in combating oxidative stress. Common sense would dictate that if oxidative stress is one cause of muscle fatigue and antioxidants combat oxidative stress, then consuming antioxidants should improve performance by reducing muscle fatigue. Hence the compelling nature of the sales pitches.

So why isn't the scientific literature overflowing with studies that demonstrate the performance-related benefits of antioxidant supplementation?

Redox balance is key

The answer to this question is that the relationship between antioxidants and oxidative stress is far from simple. Emerging research shows that curbing the normal changes in *cellular redox balance* (the balance between oxidative and reductive reactions) that accompany exercise may also curb some of the benefits associated with exercise. For

example, changes in insulin sensitivity and other adaptations that occur with regular exercise rely on signals resulting from oxidative stress. Blocking the production of ROS with antioxidants blocks the downstream benefits that are provoked by ROS. In other words, some oxidative stress is beneficial. But how much oxidative stress is too much?

Theoretically, there is an ideal combination of endogenous and exogenous antioxidants that form a cooperative network to maximize the benefits of ROS production and minimize the harm. Understanding more about the combinations and doses of antioxidants that provoke the most positive effects for muscle performance will require a lot of in-depth research before significant scientific agreement can be reached. That topic was the focus of a 2010 paper co-authored by Dr. Scott Powers, an exercise scientist and antioxidant expert from the University of Florida (Powers SK et al. Experimental guidelines for studies designed to investigate the impact of antioxidant supplementation on exercise performance. *Int J Sports Nutr Exerc Metab* 20:2-14, 2010.)

Antioxidant research principles

Dr. Powers and his colleagues outlined some principles that researchers can use to guide the design of experiments intended to evaluate how antioxidant supplementation might affect performance. Dr. Powers points out that there are no clear criteria for evaluating the antioxidant capacity of tissues and no single biomarker of oxidative stress can be used to assess whether damage has been reduced. Also complicating the picture are the following considerations:

- Single antioxidants are unlikely to affect performance because a network of different antioxidants, both endogenous and exogenous, is required for protection against ROS-mediated damage;
- Antioxidant bioavailability varies widely;
- The biological half-lives of antioxidants vary widely;
- The time required for dietary antioxidants to be functionally incorporated into tissues varies widely;
- Dietary antioxidant intake varies widely among subjects, making dietary control an important aspect of antioxidant research.

Biomarkers matter

To assess the effectiveness of antioxidant supplementation, it is essential to be able to measure changes in biomarkers of oxidative damage. If supplementation reduces the presence of a biomarker during or after exercise, that is evidence that the antioxidant is reducing damage. To be scientifically useful, such biomarkers have to be detectable in tissue assays, known to increase or decrease with exercise, have half-lives that allow for measurement, and not be affected by diet.

There is no single biomarker of oxidative stress, so researchers have to rely upon an assortment of measures. For example, biomarkers for lipid peroxidation (F_2-isoprostanes), protein oxidation (protein carbonyls), and DNA damage (products of DNA damage in muscle

cells and urine) can be used to assess changes in oxidative stress. It is also important to determine if antioxidant supplementation improves the antioxidant capacity of blood and muscles. Although there is no one assay that accomplishes that task, Dr. Powers believes the ORAC assay (oxygen-radical absorbance capacity) is an acceptable measure of total antioxidant capacity in the blood.

Redox redux

The question of whether or not athletes should use antioxidant supplements remains an important and highly debated issue in sports nutrition. Additional research will be required to firmly establish whether antioxidant supplementation is beneficial or harmful to athletes. At present, there is limited scientific evidence to recommend antioxidant supplements to athletes or other physically active individuals. In fact, the current evidence suggests that athletes should use caution when considering supplementation with high doses of antioxidants that may disrupt the redox balance of muscle cells.