Optimizing Wellness for Peak Physical Performance

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Exercise is not dead, by any means, in the United States. The usual headlines highlighting the disturbing infrequency of exercise by U.S. citizens, as well as the dismal percentages of Americans who are obese, tend to produce a negative view regarding exercise. However, consider the following statistics that demonstrate clearly the vigor with which Americans engage in physical activity:

- In the United States, approximately 30 million children and adolescents participate in some form of organized sport and approximately 30 million people in the United States enjoy running, with 10 million people running on a regular basis.[1]
- Americans place maintaining good physical health and keeping up their physical appearance among the top of their personal priorities, with 97 percent of Americans saying these are essential. An annual consumer report determined that the 33 million Americans who currently belong to health clubs visited gyms an average of 89 times per year, translating into nearly 3 billion visits last year.[2]
- The total number of health-club patrons, including both members and nonmembers, climbed 7 percent, from 54.5 million in 2000 to 58.3 million people in 2001.[2]

The positive benefits of exercise are well-studied at this time. Performing regular exercise on most days of the week reduces the risk of developing (or dying from) some of the conditions that are the leading causes of illness and death in the United States. (See box entitled Benefits of Activity.)

It is clear that keeping fit is an important part of life for many people. In addition to getting in shape, people are increasingly looking for ways to maintain a competitive edge in sports. The use of supplements as ergogenic supports is increasingly popular among all athletes. Using natural medicines can help athletes to maintain their health and can help to prevent exercise-related injuries. Many natural medicines that athletes use counteract the pro-oxidative effects of exercise, limit joint wear, decrease inflammation, and increase energy, thereby positioning athletes, whether they be professionals or amateurs, for optimal wellness.

Antioxidants

Despite the clear benefits of exercise, it does induce oxidative stress, which is potentially injurious to cellular macromolecules, such as lipids, proteins, and nucleic acids. Free radicals, such as superoxide, nitric oxide, and hydroxyl radicals, and other reactive oxygen species (e.g., hydrogen peroxide, peroxynitrite, and hypochlorous acid) are the main byproducts of aerobic metabolism. Reducing molecular oxygen to water creates aerobically generated cell energy. The cytochrome C oxidase-catalyzed reaction, as well as other energy-generating enzymatic processes, such as the flavin enzyme systems, produces partially reduced oxygen species. Approximately 1–2 percent of total oxygen consumption is converted to one such reactive oxygen species, the superoxide anion.

Formation of the superoxide anion radical leads to a cascade of other reactive oxygen species, namely hydroxyl and peroxyl radicals. The initial reaction spawns a second reactive oxygen, which, in turn, reacts with another macromolecule, propagating the chain reaction. Reactive oxygen species affect the structure and function of polyunsaturated fatty acids adversely because of lipid peroxidation. And, individual nucleotide bases of proteins are modified in such a way that unwanted single-strand breakage and crosslinking occur. The effects of oxidative stress have been associated with decreased physical performance, muscular fatigue, muscle damage, and overtraining syndrome.[3]

When examining the physiologic effects of exercise and the resultant increase in overall metabolism, an astute clinician can focus on decreasing potentially damaging metabolic "side-effects" of exercise (i.e., increased free-radical damage). Such free-radical damage from aerobic exercise can be quantified in the form of oxidative stress-related biomarkers. These include lipid peroxidation, protein oxidation (in the form of protein carbonyls), and total antioxidant levels in the blood following exhaustive aerobic exercise. Indirect measurements of free-radical activity include mitochondrial membrane damage, conjugated dienes, hydroperoxides, thiobarbituric-acid reactive substances, short-chain hydrocarbons, and oxidized nucleosides.

Several studies have implicated elevated volume of oxygen (VO_2) consumption caused by aerobic exercise as a contributor to the body's total oxidative stress.[4] There may be a number of other sources of this oxidative stress, including mitochondrial superoxide production, ischemia-reperfusion mechanisms, and auto-oxidation of catecholamines. The exact role of exercise in free-radical processes is not clear; however, a large body of evidence suggests that elevated oxygen consumption may lead to an increase in free-radical activity.[5] An athlete's training status and exercise type, duration, and intensity will affect the biomarkers of free-radical activity as well.

Because severe or prolonged exercise can overwhelm antioxidant defenses, it is hypothesized that the body's physiologic amount of antioxidants is not sufficient to prevent exercise-induced oxidative

Benefits of Activity

Regular physical activity improves health by

- Reducing the risk of dying prematurely
- Reducing the risk of dying from heart disease
- Reducing the risk of developing diabetes
- Reducing the risk of developing high blood pressure
- Helping to reduce blood pressure
- Reducing the risk of developing colon cancer
- Reducing feelings of depression and anxiety
- Helping to control weight
- Helping to build and maintain healthy bones, muscles, and joints
- Helping older adults to maintain and develop strength so that they are able to move about without falling
- Promoting psychologic well-being.

stress and that additional antioxidants are needed to reduce oxidative stress, muscular damage, and inflammation. By bolstering the athlete's store of antioxidant defenses, such long-term supplementation may ameliorate exercise-induced free-radical damage.[6]

Glucosamine's pain-relieving effects appear to be the result of its cartilage-rebuilding properties.

Some studies have reported that antioxidant vitamins such as C and E, as well as other antioxidants, or antioxidant mixtures can reduce the symptoms or indicators of oxidative stress resulting from exercise. Ingestion of antioxidant vitamins (592 mg of α-tocopherol equivalents, 1000 mg of ascorbic acid, and 30 mg of beta-carotene) resulted in significantly lower resting and postexercise levels of expired pentane and serum malondialdehyde, both of which are markers of lipid peroxidation.[7] In addition, older men, when exposed to exercise-induced oxidative stress, had significantly lower levels of lipid peroxides in urine compared to placebo controls after receiving vitamin E supplements for 48 days.[8]

Thus, antioxidants, such as arginine, citrulline, creatine, glutathione, taurine, selenium, zinc, vitamin E, vitamin C, vitamin A, and green tea (*Camellia sinensis*) polyphenols are likely to provide beneficial effects against exercise-induced oxidative damage.[9] Using any of the preceding antioxidants is indicated for competitive athletes who are routinely engaged in strenuous exercise. Supplementation of an athlete's diet with antioxidants may serve as a potent therapeutic tool. Efforts to determine athletes' individual needs, and to ensure consumption of a balanced diet that is rich in antioxidants, are highly recommended.

Prevention of Physical Wear and Tear

While many health care providers experience frustration in trying to motivate their patients to exercise, the problem is often amplified when such patients return with complaints of exercise-related aches and pains. Most exercise-related injuries occur from overuse stress on the muscles, tendons, bones, or joints. Sporting activities with major risk for creating pain are, not surprisingly, those that include repetitive, high-intensity, high-impact forces going through the affected joints, especially when there is a high association of the activities with risks of injury. Various nutritional supplements can mitigate the effects of exercise-induced wear-and-tear on the body. The mechanism of action for these supplements focuses on ligamentous and cartilaginous tissue repair and maintenance.

Glucosamine Sulfate

Glucosamine sulfate is comprised of glucose and glutamine, is the key precursor for the manufacture of joint glycosaminoglycans, and comprises 50 percent of hyaluronic acid, the core protein from cartilage and proteolglycans are formed. The three most common commercial forms are glucosamine sulfate (as the sodium or potassium salts), glucosamine hydrochloride, and *N*-acetylglucosamine, the acetylated derivative. The majority of clinical trials have used a chemically bonded glucosamine sulfate. In vitro studies have revealed that glucosamine increases sulfate uptake by cartilage and stimulates glycosaminoglycan synthesis by cartilage cells (chondrocytes).[10] Glucosamine has been shown to have both anti-inflammatory and antioxidant activities. Its anti-inflammatory activity is independent of an effect on cyclo-oxygenase (COX) or the inflammatory mediators bradykinin or histamine.[11]

In a 3-year study of glucosamine sulfate in subjects with osteoarthritis of the knee, radiography was used to determine structural changes in the knee joint while pain reduction was assessed in comparing a single daily dose of 1500 mg of glucosamine to placebo. Radiography studies of the knee indicated that joint damage had progressed in the placebo group but not in the glucosamine sulfate group. Pain worsened slightly among members of the placebo group while improvements of 20–25 percent occurred in the treatment group.[12] Another study compared 1.2 g of ibuprofen per day to 1.5 g of glucosamine sulfate per day for reducing pain. The results of this study showed that glucosamine sulfate's efficacy is similar to that of ibuprofen.[13] Earlier studies had yielded positive clinical effects and the absence of significant adverse effects. However, the improvement in pain occurred more slowly than with nonsteroidal anti-inflammatory drugs (NSAIDS) but appeared to be longer lasting.[14]

Glucosamine's pain-relieving effects appear to be the result of its cartilage-rebuilding properties; conventional analgesic therapy does not produce the disease-modifying effects of glucosamine supplementation. For the active athlete, glucosamine can be used as an alternative to anti-inflammatory drugs and analgesics or as a useful adjunct to standard analgesic therapy while supporting cartilage repair and regeneration.

Methylsulfonymethane

Methylsulfonymethane (MSM) is a sulfur-containing substance that is currently utilized primarily for pain control and for its antiarthritic and anti-inflammatory properties. It is a metabolite of dimethylsulfoxide. MSM is found in certain plants, algae, fruits, vegetables, and grains. MSM is a precursor source of sulfur for the amino acids cysteine and methionine, which are building blocks for cartilage. Preliminary research suggests MSM might inhibit the degenerative changes of osteoarthritis.[15]

The clinician who cares for athletes must emphasize the importance of preventive and protective measures for the joints. Protecting against joint destruction and providing the essential materials that are necessary for cartilage maintenance and repair can prevent both short-term aches and long-term disability. In addition, the athlete must be attentive to correct posture and positioning while participating in both high- and low-impact activities. Limiting high-impact contact with excessively hard surfaces such as gym floors and concrete is also important. Finally, athletes must be made aware of their physical limitations and be taught to recognize the early symptoms of overuse injuries associated with their athletic endeavors.

Table 1. Supplements for Building Peak Physical Performance

Antioxidants	Dosages
Vitamin A	5000 IU per day, with food
Vitamin C	2000–6000 mg, in divided doses, per day
Vitamin E	400–800 IU per day, with food
Selenium	50–60 μg per day
Zinc	50 mg per day
Cartilage supports	**Dosages**
Glucosamine sulfate	500 mg, 3 times per day (4 times per day for patients more than 200 lbs.)
Methylsulfonlymethane	1000–3000 mg per day, with meals

IU = international units.

Table 2. Anti-Inflammatory Treatment for Athletes

Supplements	Dosages
Bromelain[a]	1800–2400 GDU or MCU or 350–750 mg, 3 times per day, between meals
Curcumin[a]	1500–3000 mg, 3 times per day, between meals
Mixed blend of flavonoids (quercitin, hesperidin, and rutin)	1000 mg 3 times per day
Essential fatty acids	500–1000 mg, 3 times per day

GDU = gelatin-dissolving unit; MCU = milk-clotting unit.

[a]Do not use in patients who have gastrointestinal ulcers or esophagitis; monitor patients who are on blood-thinners carefully.

Aches and Pains

Even when they observe appropriate preventive measures, athletes are susceptible to aches and pains resulting from physical activity. Alleviation of these symptoms is important for two reasons: (1) a prompt reduction in pain is necessary for the athlete to continue performing at his or her desired level; and (2) the pain-inciting inflammatory process must be halted before a chronic inflammatory condition develops.

Tendonitis, bursitis, arthritis, sprains, strains, and other inflammatory conditions that result from athletic activity have been treated conventionally with over-the-counter or prescription non-steroidal anti-inflammatory drugs (NSAIDS). However, these medications do not provide the most desirable results for patients with inflammatory injuries because NSAIDS are associated with increased cartilage degeneration via inhibitory effects on cartilage proteoglycan metabolism. In addition, NSAIDS exert inhibitory effects on the production of gastrointestinal mucosal prostaglandins, resulting in deleterious modulation of prostaglandin-related cellular mechanisms that are important for mucosal defenses.[16]

Various plant-derived anti-inflammatories can be used to achieve immediate prevention of inflammatory cascade byproducts in the injured athlete.

Bromelain

A proteolytic enzyme derived from the pineapple (*Ananas comosus*) causes the release of kinins, which, in turn, stimulate the production of prostaglandin E1–like compounds, eliciting an anti-inflammatory effect.[17] Recent investigations have revealed that bromelain exerts a significant effect on T-cell response by inhibiting T-cell signal transduction and can ameliorate the inflammatory process by reducing the number of CD4+ cells and by diminishing interferon-γ mRNA levels.[18] In vitro bromelain treatment has selectively removed certain cell-surface molecules that affect lymphocyte migration and activation on a broad range of cell-surface molecules and on lymphocytes, monocytes, and granulocytes. These cell-surface molecules, which are altered by bromelain, are involved in leukocyte homing, cellular adhesion, and activation.[19] These effects on the inflammatory pathways suggest a decrease in the creation of proinflammatory byproducts of exercise, pain, swelling, and edema, making bromelain an optimal choice for treating sports injuries.

However, bromelain does have side-effects. Because this pineapple-stem–derived medicine acts proteolytically, caution should be used when treating athletes who are prone to gastric mucosal irritation or ulceration, or patients who are on anticlotting regimens, because bromelain can amplify the effects of blood-thinning pharmaceuticals.

Curcumin

Curcumin (*Curcuma longa*) is the yellow pigment of the spice turmeric. Curcumin has various properties that are beneficial for the athlete. Curcumin behaves as an inhibitor of the transcription factor NF-κB, which allows it to act as a stimulator of muscle regeneration after traumatic injury. One recent study showed that in-vivo muscle regeneration is greatly enhanced after the systemic administration of curcumin. Biochemical and histologic analyses indicated this effect in subjects after 4 days of curcumin administration compared to controls who required more than 2 weeks to attain fully restored muscle-tissue architecture.[20] Because of curcumin's role in regulating myogenesis, it is an appropriate treatment for sports-related muscle injuries.

Table 3. Adaptogenic Herbal Supports

Latin binomials	Common names	Parts used and dosages
Glycyrrhiza glabra	Licorice	*Dried root:* 1000–2000 mg per day[a] *Fluid extract:* 2–4 mL per day[a]
Withania somnifera	Ashwaganda	*Fluid extract*: 1–2 mL per day *Dried herb:* 3000–4000 mg per day
Panax ginseng	Korean ginseng	*Fluid extract:* 1–2 mL per day *Standardized dried root:* 200 mg per day
Eleutherococcus senticosus	Siberian ginseng	*Fluid extract:* 1–2 mL per day *Dried root:* 400 mg 2–4 times per day

NOTE: Caution must be taken to cycle herbs to avoid side-effects caused by long-term supplementation that are not yet well-defined in studies. These effects may include habituation, development of allergic sensitivity, or disturbance of innate physiologic pathways.

[a]Monitor blood pressure

In addition, curcumin has long been known as a selective COX-2 inhibitor and as a potent anti-inflammatory agent, working to inhibit leukotriene synthesis, platelet aggregation, and neutrophil reactivity. Curcumin is also a stabilizer of the cell membrane, where many proinflammatory molecules are synthesized and released.[21] Like bromelain, curcumin produces similar side-effects, such as the potential to cause gastric irritation and antiplatelet activity and, therefore, has the same contraindications as bromelain.

Flavonoids

Flavonoids comprise a group of plant pigments numbering in the thousands with remarkable antioxidant and anti-inflammatory activities. Hesperidin, rutin, and quercitin are among the plant flavonoids that attenuate inflammation via inhibiting important regulatory enzymes. Certain flavonoids are potent inhibitors of the production of proinflammatory prostaglandins. Studies have shown that this effect is the result of flavonoids inhibiting key enzymes involved in prostaglandin biosynthesis, such as lipoxygenase, phospholipase, and COX.

Flavonoids also inhibit phosphodiesterase, which is involved in inflammatory-type cell activity, namely, manufacturing protein cytokines that mediate adhesion of circulating leukocytes to sites of injury.[22]

Protein kinases are another class of regulatory enzymes affected by flavonoids, primarily by way of binding flavonoids competitively with adenosine triphosphate at catalytic sites on the enzymes. These various modes of inhibitory action provide the mechanisms by which flavonoids inhibit the inflammation response.

Two specific types of bioflavonoids, proanthocyanidin and quercetin, are potentially useful for treating musculoskeletal conditions. Evidence suggests that these flavonoids may be beneficial for connective tissue because of their ability to limit inflammation and associated tissue degradation, improve local circulation, and promote the manufacture of a strong collagen matrix.[23] In addition, other anti-inflammatory effects of quercitin are attributable to its inhibition of leukotriene and prostaglandin production and activity and inhibition of basophil and mast-cell release histamine.[24]

Another flavonoid, hesperidin, appears to exert anti-inflammatory effects via inhibiting cell-activating enzyme systems, such as phosphodiesterase A2 and protein kinase C. In addition, hesperidin inhibits inflammatory cellular processes by preventing the production of prostaglandin-synthesizing enzymes, such as phospholipase, cyclo-oxygenase, and lipoxygenase. Hesperidin also seems to exert its anti-inflammatory effect by sequestering phosphodiesterase, thereby increasing intracellular cyclic adenosine monophosphate levels, which causes decreased production of inflammatory prostaglandins E2 and F2 and thromboxane B2.[25]

Essential Fatty Acids

Omega-3 fatty acids produce anti-inflammatory and antithrombotic effects because of their ability to compete with arachidonic acid (AA) for binding sites on cyclo-oxygenase and lipoxygenase enzyme systems. Consequently, essential fatty acids (EFAs) inhibit the synthesis of inflammatory prostaglandins from the precursor AA.

Prostaglandins are derived from dietary EFAs via short biochemical pathways. Synthesis of inflammatory prostaglandins can be manipulated by modifying EFA intake. Prostaglandins of the 1 and 3 series have desirable (i.e., anti-inflammatory) or neutral actions while those of the 2 series are mixed, with some being desirable and others being highly undesirable (i.e., proinflammatory).

By supplementing the diet with omega-3 fatty acids, several aspects of neutrophil, monocyte, and lymphocyte functions, including the production of inflammatory mediators, can be reduced. The majority of studies indicating reduced inflammatory functions used a minimum of 1.2 g per day of eicosapentaenoic acid and docosahexaenoic acid for 6 weeks.[26]

The anti-inflammatory effects produced by EFAs influence inflammatory cell-activation processes, such as signal transduction and protein expression at the genomic level, decreasing cytokine-induced adhesion molecule expression (thereby reducing inflammatory leukocyte-endothelium interactions), and influencing leucocyte migration.[27]

Using fish oils and other EFA oils for preventive management of inflammatory processes is well-supported and can modulate unwanted and excessive inflammatory responses to athletic activities.

Adaptogenic Botanicals

The term "adaptogen" is used to characterize the medicinal plants that can improve the nonspecific response to stress and promote recovery from stress. Because the body interprets exercise as an essentially stressful event, responding, for example, with increased pulse, respiration, blood pressure, et cetera, athletes can benefit from incorporating adaptogenic herbs into supplement regimens.

Licorice (*Glycyrrhiza glabra*) retains modest glucocorticoid activity via its cortisol-sparing effect. Glycyrrhizin, a component of licorice, inhibits the activity of 11-hydroxy-steroid dehydrogenase, which leads to an increase in cortisol half-life.[28] Glycyrrhizin can bind to glucocorticoid and mineralocorticoid receptors, exerting a weak mimetic effect.[29] In addition, licorice inhibits phospholipase A2, which then lowers inflammatory prostaglandin and leukotriene production.

Ashwaganda (*Withania somnifera*) has active components, withanolides, that have a sterol structure and are thought to be the main inducers of the herb's glucocorticoid-like effects. Given to animals exposed to experimental physical stress, ashwaganda produces antistress and anabolic activity similar to that of Asian ginseng (*Panax ginseng*).[30] When administered to animals, another form of ginseng, Siberian ginseng (*Eleutherococcus senticosus*) inhibited many of the biologic changes accompanying extreme stress, such as adrenal weight, cortisol levels, and blood-sugar levels.[31]

A large body of research has demonstrated an enhanced response to physical or chemical stress in animals that have been given Asian ginseng or its active components.[32] In a double-blinded study, an Asian ginseng root extract that was added to the base of a multivitamin improved subjective parameters in a population exposed to the stress of high physical and mental activity, suggesting an adaptogenic or antistress ability of this combination in humans.[33]

A review of the body of literature regarding the clinical trials of Siberian ginseng's antistress effects on more than 2100 healthy human subjects, ranging in age from 19 to 72, suggested that the subjects who took this botanical had an increased ability to accommodate to adverse physical conditions, had improved mental performance, and enhanced quality of work under stressful conditions.[32] Another study demonstrated increased exercise time to exhaustion in swimming rats that had been given this herb, as well as attenuated changes of the hypothalamic-pituitary-adrenal axis under extreme conditions in the animals.[34]

Summary

Given that there are only a few standard conventional medicines for preventing exercise-induced injury and wear, natural medicines provide an extensive armamentarium from which practitioners can offer athletes for attenuating the effects of excessive exercise and increasing their performance to optimal levels. □

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