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**Athletics and Herbal Supplements**

**Do current products enhance athletes' health and performance?**

Athletes' use of herbal supplements has skyrocketed in the past two decades. At the top of the list of popular herbs are echinacea and ginseng, whereas garlic, St. John's wort, soybean, ephedra and others are also surging in popularity or have been historically prevalent. According to a publication by the American Botanical Council, herbal supplement sales grossed $5.3 billion in the United States during 2011, a 4.5 percent increase from the preceding year. Despite their increasing popularity, recent events have illuminated possible concerns regarding efficacy and safety of herbal supplements. Remarkable sports performances at the end of the 20th century raised suspicions about supplement use by athletes, prompting the formation of the World Anti-Doping Agency, or WADA. Shortly thereafter, the deaths of two professional athletes raised concerns that an herbal supplement, ephedra, may have contributed to their deaths. These events and others have prompted clinicians and scientists to reevaluate the role of herbal supplements in athletics. The meaning of the term herbal supplement is itself nebulous. Some use it to refer to products derived directly from plants, whereas others use it to mean any product containing molecules of botanical origin, such as caffeine pills. Herbal supplements are variously called botanicals, phytomedicines, dietary supplements, nutritional supplements or nutraceuticals. In this article, the term herbal supplement refers to plant-derived products containing multiple bioactive chemicals, with some exceptions for products of fungal or bacterial origin (which are technically not "herbal" but are often treated the same).

Although industry has kept pace with athletes' interests and simultaneously spurred them, research has lagged behind and many questions linger. Why do athletes consume these herbs? Do they use the product as directed on the label or by a doctor? What claims are made about these supplements, and does clinical research support them? How can scientists and sports medicine personnel best design experiments to answer these questions, and what obstacles do they encounter?

[**A Multidisciplinary Framework**](http://web.b.ebscohost.com.library.capella.edu/ehost/delivery?sid=7b543dd8-d3fe-46bd-a1ae-283851737208%40sessionmgr106&vid=1&ReturnUrl=http%3a%2f%2fweb.b.ebscohost.com%2fehost%2fdetail%2fdetail%3fvid%3d0%26sid%3d7b543dd8-d3fe-46bd-a1ae-283851737208%2540sessionmgr106%26bdata%3dJnNpdGU9ZWhvc3QtbGl2ZSZzY29wZT1zaXRl#toc)

Herbal supplement sales, the number of available herbs and the number of preparation types have all grown in recent years, and many of these are popular among American athletes (see Figure 2). Despite this burgeoning industry, research on supplements' effects on human biology remains inconclusive overall, and athletes are often left to trust manufacturers' claims or teammates' advice when it comes to making choices about what supplements to take and whether to take them.

Early studies of any herbal supplement are almost exclusively of the clinical variety. They strive to address questions of efficacy by testing supplements available for over-the-counter purchase. Studies often include detailed information on subjects' characteristics, dosing regimens, methods for assessing efficacy and, in athletic studies, aerobic endurance exercise or anaerobic strength training regimens. But such studies frequently lack information about the chemical contents, botanical origin or agricultural provenance of the supplements. In addition, medical pilot studies are often characterized by small sample sizes, and a paltry number of studies typically exist for a given herb. This complex interplay of factors makes results hard to replicate or interpret and makes it difficult to identify confounding variables among studies.

Even when every study for an herb is stalwartly reviewed, one is typically forced to conclude that the data are equivocal--for every study that supports efficacy, another refutes it, even after controlling for demographics, dosing and so forth. The predictable outcome is confusion and miscommunication within the sports science community.

Dovetailing botany, chemistry and medical disciplines from cell biology to physiology is absolutely critical to the advancement of research on herbal supplements in athletic contexts. In addition to many others' work on this subject, collaborators from Drake and Iowa State Universities Nisarg Shah, Danielle Doty, Cole Sanderson, Justus Hallam and I have developed novel experimental data on previously neglected preclinical factors. The species of plant chosen, the location from which the plant was gathered, the specific organ extracted or the extraction method may in large part explain the heterogeneous clinical outcomes.

One of the biggest challenges such a multidisciplinary approach presents is conceptualizing the myriad pre-clinical and clinical factors that can potentially influence a trial. In a 2009 article in Exercise Immunology Review, we proposed a conceptual model for this multidisciplinary approach. We originally categorized factors in our model by botanical, chemical and clinical disciplines. Our revised seed-to-stomach model incorporates these as well as commercial factors to better reflect the societal context of herbal supplement research (see Figure 3). The model discourages the mistaken conclusion that equivocal is synonymous with ineffectual, moving the field from simplistic questions of "Does a given supplement 'work'?" to "Under what conditions does a given supplement produce a given outcome?"

[**Why Athletes Use Herbs**](http://web.b.ebscohost.com.library.capella.edu/ehost/delivery?sid=7b543dd8-d3fe-46bd-a1ae-283851737208%40sessionmgr106&vid=1&ReturnUrl=http%3a%2f%2fweb.b.ebscohost.com%2fehost%2fdetail%2fdetail%3fvid%3d0%26sid%3d7b543dd8-d3fe-46bd-a1ae-283851737208%2540sessionmgr106%26bdata%3dJnNpdGU9ZWhvc3QtbGl2ZSZzY29wZT1zaXRl#toc)

Exercise is a physical stress. If the athlete's body can manage the stress, it adapts by increasing muscle mass, optimizing metabolism or improving motor performance. If the athlete's body cannot manage the stress, then muscle soreness, malnutrition or declines in performance may manifest. Thus exercise can serve as either a positive or negative stressor.

For example, the J-curve model proposed by David Nieman of Appalachian State University shows that individuals who exercise regularly at moderate intensities have lower incidence of upper respiratory infection events than their sedentary or rigorously training counterparts (see Figure 4). Individuals who train moderately--for example, people who run three times a week for 30 minutes--demonstrate decreased incidence of such infections compared to sedentary counterparts. On the other hand, elite athletes often demonstrate increased incidence of such infections due to the stress of their demanding training schedules. The category "very high" in Figure 4 includes individuals such as professional or Olympic athletes, but from a medical standpoint it could encompass any athletes who train at levels beyond what their bodies can accommodate. These athletes may include college and high school athletes and even so-called (often erroneously) amateur recreational athletes.

Herbal supplements appeal to the sports community because of their potential for improving performance capacity either through conferring ergogenic benefits or through offsetting the deleterious effects of rigorous training regimens. Most herbal supplements, such as ginseng and echinacea, are available over the counter, making them both legal and readily available; others, such as ephedra or ma huang, are now illegal. Whether a given supplement is illegal varies by country and sports regulatory agency; within the context of sports, illegality is often declared if a supplement engenders an unfair ergogenic benefit ("doping") or constitutes a health threat. Ephedra, for example, is banned because it has no confirmed ergogenic benefits yet contains toxic alkaloids.

Importantly but not surprisingly, athletes' rationales for choosing and using any given supplement are often discordant with contemporary indications, as evidenced by surveys of U.K. athletes performed by Andrea Petroczki at Kingston University, in collaboration with colleagues at the University of Birmingham and Swansea University. Their work has shown that professional athletes may use supplements for reasons other than their purported purpose; ignore advice from medical professionals despite the fact that athletes consult those professionals for advice more frequently than coaches or trainers; misunderstand side effects or assume a supplement is safe because it is "natural"; and sacrifice health benefits for perceived performance benefits. Circumstances may be different for nonprofessional, noncollegiate athletes. Many people assume that the Food and Drug Administration regulates herbal supplements, but in the United States the Dietary Supplement Health and Education Act of 1994 allows most herbal supplements to be sold without FDA approval. Vendors position herbal supplements on store shelves alongside regulated items such as vitamins, which may perpetuate this perception.

[**Popular Herbs**](http://web.b.ebscohost.com.library.capella.edu/ehost/delivery?sid=7b543dd8-d3fe-46bd-a1ae-283851737208%40sessionmgr106&vid=1&ReturnUrl=http%3a%2f%2fweb.b.ebscohost.com%2fehost%2fdetail%2fdetail%3fvid%3d0%26sid%3d7b543dd8-d3fe-46bd-a1ae-283851737208%2540sessionmgr106%26bdata%3dJnNpdGU9ZWhvc3QtbGl2ZSZzY29wZT1zaXRl#toc)

The extent of athletes' herbal supplement use is unclear. Part of the problem is that few studies address this topic. Surveys of athletes' supplement use exist, but herbal supplements are often relegated to a category called "other." And when supplements are identified as a separate category, the specific supplements used are often unreported. In the United States alone, 17 to 61 percent of athletes reported using herbal supplements, although the categorization of herbal supplement varied across surveys, and this likely explains the huge discrepancy. Although these numbers should be interpreted cautiously, it appears safe to conclude that athletes' use of herbal supplements is higher than in the general public.

Purportedly performance-enhancing herbs include those that benefit both endurance and strength athletes, such as ginseng (Panax species or Eleutherococcussenticosus), ephedra (Ephedra sinica) and arctic root (Rhodiolarosea). They also include herbs such as caltrop (Tribulusterrestris) that may primarily benefit strength athletes (see Figure 5). Ephedra and ginseng are also considered central nervous system stimulants along with guarana (Paulliniacuptma). Herbs taken primarily to boost immune function include echinacea (Echinacea species), elderberry (Sambucusnigra) and milk vetch (Astragalus species). Other herbs, such as caltrop, soy (Glycine max) and sarsaparilla (Smilax species), are believed to contain plant-produced compounds capable of modulating anabolic steroidal pathways. And some supplements are promoted as having more specialized functions, such as the supposed metabolism-enhancing fungus, Cordycepssinensis. Still others are treated as multipurpose food ingredients, for example, the cyanobacterium Spirulina (Spirulina species).

The organisms mentioned above demonstrate that these supplements are taxonomically diverse and include flowering, seedless vascular and nonvascular plants, fungi and algae with distinct evolutionary histories. The bioactive molecules attributed to each taxon are equally diverse, although most are classified as secondary metabolites, chemical compounds produced by living organisms but not required for their primary functions. Many herbs used in sports supplements or energy drinks contain alkaloids--small, nitrogen-based compounds that encompass many notorious naturally derived molecules, from morphine to cocaine--that act as stimulants. Examples include caffeine from the kola plant (Cola species), ephedrine and pseudoephedrine from ephedra, guaranine from guarana, and theobromine and theophylline from the chocolate plant (Theobroma cacao).

Current research on the dozens of botanical dietary supplements used by athletes all suffer from the problems outlined above. Two of the most well known of these supplements, echinacea and ginseng, will serve as representative examples.

[**Echinacea**](http://web.b.ebscohost.com.library.capella.edu/ehost/delivery?sid=7b543dd8-d3fe-46bd-a1ae-283851737208%40sessionmgr106&vid=1&ReturnUrl=http%3a%2f%2fweb.b.ebscohost.com%2fehost%2fdetail%2fdetail%3fvid%3d0%26sid%3d7b543dd8-d3fe-46bd-a1ae-283851737208%2540sessionmgr106%26bdata%3dJnNpdGU9ZWhvc3QtbGl2ZSZzY29wZT1zaXRl#toc)

Echinacea is purported to boost defense against upper respiratory infections, so athletes use it primarily to offset the deleterious effects of intense training on immunity. Although the general public uses the genus name as the common name, genus Echinacea is comprised of nine species (some divided into subspecies). The three species most often used commercially are Echinacea angustifolia, E. pallida and E. purpurea.

Bioactive molecules produced by these species include alkamides, organic molecules made of fatty acids often found in plants, and phenols, another class of organic molecules also dubbed carbolic acids that are known for their acidity. Phenols encompass caffeic acid derivatives, echinacoside and ketones; distributions and quantities of these molecules vary by species. It is important to differentiate these molecules because the body processes them differently and they have different effects. Alkamides move from gut to bloodstream apparently unmodified within an hour. Complex carbohydrates have largely been discounted by multiple studies due to their inability to move from gut to bloodstream without modification. Roots contain the highest levels of these compounds, but oftentimes manufacturers will instead harvest aboveground parts, such as leaves and stems, to allow the plants to regrow and thus provide multiple harvests per planting. In North America, echinacea is most widely consumed as capsules or tablets.

Only five studies have been published concerning in vivo dosing of athletes with echinacea supplements (Figure 6). Studies by Aloys Berg of Albert Ludwigs University and collaborators and Heather Hall of Elmhurst College and collaborators reported reduced incidence or duration of upper respiratory infection events after intense exercise (such as competitive sprint triathlons or laboratory sprint cycling) in athletes dosed with E. purpurea supplements for four weeks either before or after a scheduled bout of exercise. The reduced incidence of infections was corroborated by molecular immunological data from blood, saliva and urine samples, demonstrating increases in circulating concentrations of certain antibodies and changes in circulating concentrations of several signaling molecules important in regulating inflammation (see Figure 6). White blood cells are the cells associated with the immune system, but no changes in white blood cell subsets or counts were identified. Taken together, the findings suggest that echinacea may reduce incidence and severity of upper respiratory infections by changing the quantities of immune molecules produced by white blood cells, rather than changing other aspects of white blood cells, such as their rate of multiplication or specific functions. In further support of the link between echinacea, exercise and upper respiratory infections, Roland Schoop and colleagues at Bioforce AG in Switzerland reported reduced incidence and duration of self-reported upper-respiratory-infection symptoms in athletes dosed in a similar manner to those in the previous two studies, when compared to a control group generalized from control data in previous studies.

Looking at physiological parameters important in athletic performance, Malcolm Whitehead, now at Stephen F. Austin State University in Texas, published two reports with colleagues from Troy University, College of Charleston and the University of Southern Mississippi on a recreational group of athletes, dosed with E. purpurea for four weeks and compared to placebo-treated controls. They found that common measures of aerobic performance--maximal oxygen consumption (Vo2max), running economy (oxygen use efficiency) and erythropoietin (a hormone that controls red blood cell genesis)--were higher among the echinacea-treated group than among controls. However, the authors reported no differences in total red blood cell count, hemoglobin (the molecule within red blood cells that carries oxygen) or hematocrit (packed red blood cell volume) between the two groups. The fact that there were no changes in red blood cell-associated parameters but there were changes in performance parameters is difficult to interpret but may suggest that echinacea supplementation influences performance by modulating oxygen dynamics or metabolism at body sites distinct from the red blood cells themselves. Other scientific teams report relatively good tolerability and low side effects from echinacea supplements, although interactions with certain prescription medications have been documented.

In contrast to studies in athletes, studies of echinacea supplementation in the general population have yielded conflicting findings, likely due to the confounding factors discussed previously. Our team has endeavored to reduce the problem of preclinical factor variation by translating the concepts from our seed-to-stomach model into an experimental design adapted for athletic applications (Figure 7). We opted for an ex vivo approach, where white blood cells were taken from study participants before and after an acute exercise bout and then treated with echinacea extracts in the laboratory. This method, although less representative of the organismal context, allows us to more tightly control some variables.

We initially worked with white blood cells from resting donors to establish the effects of key preclinical factors. Several interesting findings accrued; for example, our lab and others have repeatedly demonstrated that different echinacea species vary in the way they modulate the immune system, probably because of differences in plant chemistry. We showed how deliberate choices in species, plant organ, solvent and extraction method influenced cell growth rates and production rates of immune system signaling molecules.

After the work in resting subjects we incorporated an acute exercise component, still controlling for the preclinical factors as we had in our previous studies. Early work conducted on teams of wrestlers and soccer players showed that the different species of echinacea plant, given in tincture form to the players' white blood cells cultured under laboratory conditions, resulted in different effects on signaling molecules important during infection (Figure 8). We also showed that acute exercise changed how echinacea supplements interacted with the white blood cells. However, we have since switched to testing athletes individually on treadmills and stationary bicycles so we can better ensure that the amount of exercise is more consistent across subjects.

Collectively, data from studies of echinacea in athletes suggest that different species of echinacea have different effects on the human body, that exercise changes these effects and that effects are cell- and body site-specific. The work also suggests that preclinical factors have not been adequately accounted for across studies; further, preclinical factors are expected to vary greatly between manufacturers and even between batches from the same manufacturer. Given that awareness, and the understanding that so few studies have been conducted and often with small sample sizes, one cannot conclusively argue for or against the use of echinacea by athletes.

[**Ginseng**](http://web.b.ebscohost.com.library.capella.edu/ehost/delivery?sid=7b543dd8-d3fe-46bd-a1ae-283851737208%40sessionmgr106&vid=1&ReturnUrl=http%3a%2f%2fweb.b.ebscohost.com%2fehost%2fdetail%2fdetail%3fvid%3d0%26sid%3d7b543dd8-d3fe-46bd-a1ae-283851737208%2540sessionmgr106%26bdata%3dJnNpdGU9ZWhvc3QtbGl2ZSZzY29wZT1zaXRl#toc)

Like echinacea, ginseng is taken to augment immunity, but its primary indication is to improve performance. The name ginseng refers to any of approximately a dozen species within the genus Panax, three of which are used most often commercially (P. ginseng is used most frequently, but also P. pseudoginseng and P. quinquefolius). Ginsensosides, from the plant steroids' saponin subgroup (plant-derived chemicals that in solution produce soaplike foaming when shaken), are the classically recognized bioactive molecules in ginseng. Roots are used most often, typically in dried or powdered form. So-called Siberian ginseng, Eleutherococcussenticosus, is sometimes confused with ginseng and is also frequently used by athletes, although it has different bioactive molecules and may be less effective in the context of performance enhancement.

Unlike echinacea, studies of ginseng or Siberian ginseng in athletic contexts have yielded conflicting results owing to differences in experimental design or outcomes measured. Systematic reviews by JohannahShergis and colleagues at Royal Melbourne Institute of Technology University, and Michael Bahrke of Human Kinetics along with collaborators at University of Wisconsin-Madison, have concluded that human studies have not convincingly demonstrated any ergogenic benefits of ginseng supplementation in athletes, although supplementation may transiently alter cardiological or pulmonary function. Side effects and prescription drug interactions appear to be more severe and extensive than those associated with echinacea and may include insomnia, gastrointestinal upset and heart palpitations.

Less contentious but more complicated are findings regarding the effects of ginseng supplements on immune function in athletes (Figure 9). From eight different studies that used no fewer than four different ginseng preparations along with a spectrum of exercise modalities, no clear overall patterns emerge. This lack of clarity is probably due to interexperimental variability. Indicators of immune system activity including white blood cell counts, subsets and activities, as well as interactions with signaling molecules associated with the immune system, were variously upregulated, downregulated or unaffected. Conservatively, these facts together indicate ginseng is likely a modulator of immune system activity, but the specific effects that different preclinical factors have on clinical outcomes are poorly understood. Thus, although ginseng is a much more popular herbal supplement than echinacea in the United States and globally, experimental data supporting its use in athletic contexts are currently weak.

Contrasting echinacea studies with ginseng studies reveals that immunological findings from the echinacea studies were more consistent, whereas those from the ginseng studies were more variable (see Figures 6 and 9). There are fewer studies of echinacea's effects on athletes than ginseng's effects on athletes, so variation in the effects of ginseng may be better documented than the variation in echinacea's effects. Echinacea studies mostly focus on aerobic performance, whereas ginseng studies mostly focus on anaerobic, strength athletes' performance. Although the names echinacea and ginseng encompass multiple species each, studies of them in the context of athletic performance focus on one species each (E. purpurea and P. ginseng, respectively). Why a clearer pattern emerges from the literature on echinacea's effects on athletes is not known, but the difference in variability may be because the echinacea studies used herbal preparations that were more consistent in species, plant part used and other preclinical factors. Both the echinacea and the ginseng studies drew their participants from diverse populations in terms of age, gender and physical activity levels. Future studies of ginseng and Siberian ginseng preparations may elicit stronger and more consistent findings if both preclinical and clinical factors are controlled better.

[**Full Speed Ahead**](http://web.b.ebscohost.com.library.capella.edu/ehost/delivery?sid=7b543dd8-d3fe-46bd-a1ae-283851737208%40sessionmgr106&vid=1&ReturnUrl=http%3a%2f%2fweb.b.ebscohost.com%2fehost%2fdetail%2fdetail%3fvid%3d0%26sid%3d7b543dd8-d3fe-46bd-a1ae-283851737208%2540sessionmgr106%26bdata%3dJnNpdGU9ZWhvc3QtbGl2ZSZzY29wZT1zaXRl#toc)

Promising strides have been made in our understanding of herbal supplements in exercise and sport contexts. However, several irksome and perhaps insoluble problems remain. It would be quixotic to expect a single investigative team or lone experiment to address each individual factor--and some factors may not be possible to accurately measure or may be beyond manufacturers' control. Preparations containing several herbs and other ingredients, such as those used in traditional Chinese medicine, may compound the difficulty of identifying preclinical factors. And analytical chemists have shown repeatedly that the contents of retail herbal supplements are often inconsistent with their own product labels in terms of ingredients or quantities, even when manufacturers make claims of standardization. Given these realities, even the most diligent clinical or bench scientists cannot accurately report their findings and may unwittingly report false data.

Directions for future research are innumerable. Hundreds of herbal supplements are currently used by athletes and nonathletes alike, and most of those substances have not been clinically tested. Those herbs need to be explored further. For instance, elderberry is an herbal supplement that is increasingly popular in sports contexts, and it appears to have immune-modulating attributes similar to those of echinacea and may provide similar benefits. Compounds associated with antioxidant activities, called lectins and anthocyanins, are found in elderberry and may interfere with influenza binding to human cells. One report by Sepp Porta from the University of Graz and colleagues suggested elderberry extracts may lower exercise-induced lactate levels.

Many herbal supplements have the potential to improve both human health and athletic performance, but as the examples show, the potential benefits are greatly influenced by preclinical factors, necessitating an interdisciplinary approach to studies of herbal supplements. Scientists and sports medicine professionals are taking steps toward such an approach, which we hope will improve our understanding of how supplements work, or don't work, to aid human performance.

PHOTO (COLOR): Figure 1. Teammates may be the primary and most frequent source of information about herbal supplements for "recreational" athletes, such as these city league baseball players, who do not have access to support systems like professional athletes do. (Photographs courtesy of the author, unless otherwise noted.)

GRAPH: Figure 2. Sales of selected supplements popular among athletes, including soy (#2 in overall sales), garlic (#4), echinacea (#7), St. John's wort (#9), ginseng (#10), elderberry (#18) and Siberian ginseng (#36), are compared to cranberry (#1). (Data from M. Blumenthal et al., HerbalGram 95:60.)

PHOTO (COLOR): Figure 3. The seed-to-stomach model identifies preclinical factors that may impact clinical trial outcomes. Each factor in an herbal supplement's production introduces mounting variation. Generally, these preclinical factors are not accounted for. Planning factors (1) occur prior to planting (selection of species and seed supplier). Field factors (2) are introduced as the crop grows, such as ecological factors (hydration, soil, sunlight exposure, pathogen infections and time grown). Production factors (3) include harvest factors (a), or how the plants were removed and transported to the processing site, and manufacturing facility factors (b), or how the herb was processed and packaged, such as the plant organs, solvents, procedures or bottling used. Postproduction factors (4) cover warehouse factors (a), market factors (b) and household factors (c), because storage conditions such as temperature, oxidation and expiration often vary across these sites. Consumer factors (5) include demographics, supplement dosing, preexisting health status and psychological or societal contexts of those individuals enrolled in the study.

GRAPH: Figure 4. Individuals who exercise regularly at moderate intensities have lower incidence of upper respiratory infections than sedentary or rigorously training counterparts. (Figure adapted from D. C. Nieman, Journal of Athletic Training, 32:344.)

PHOTO (COLOR): Figure 5. Herbs popular with athletes include supplements from the above plants, clockwise from top left, arctic root (Rhodiolarosea), echinacea (Echinacea purpurea), caltrop (Tribulusterrestris), ginseng (Panax ginseng) and elderberry (Sambucusnigra). (Photographs courtesy of Wikimedia Commons.4 Top right photograph by Forest & Kim Starr [<http://www.hear.org/starr/>].)

PHOTO (COLOR): Figure 6. Immunological and physiological effects of Echinacea purpurea supplementation in aerobic athletes, summarized from five studies, and based on illness rates and blood, saliva and urine analyses. Athletes supplemented with echinacea reported reduced incidence or duration of upper respiratory infections, perhaps because of changes in circulating concentrations of immune system signaling molecules (cytokines) and antibodies. However, more studies are needed to understand the full gamut of possible outcomes. Pictured: Erin Poss, Drake University cross-country.

PHOTO (COLOR): Figure 7. Putting the seed-to-stomach model into action reduces variation introduced by preclinical factors. (1) Plants are grown in common gardens, where field conditions are controlled. (2) Extracts are produced and stored under controlled conditions and analyzed for bioactive chemicals. These first two steps account for many preclinical factors that are ignored in many studies. (3) A pre-exercise blood sample is obtained. (4) The athlete performs an acute exercise bout. Using metabolic monitoring, intensity is standardized. (5) A postexercise blood sample is obtained. (6) White blood cells are isolated and treated in vitro with the plant extracts from steps 1 and 2. Measurements such as cell proliferation rates or signaling molecule production are used as markers of immune function.

GRAPH: Figure 8. Different species of echinacea may result in different immune system effects. White blood cells isolated from the blood of male soccer athletes, both before (rest) and after (post) a two-hour aerobic exercise bout, were cultured in vitro with Echinacea pallida tincture, E. simulata tincture or a solvent vehicle control. After 72 hours, cell cultures were assayed for a cytokine important during infection, called interleukin-10 (IL-10). E. simulata extract, but not E. pallida extract, improved IL-10 production. (Figure adapted from D. S. Senchina et al., Exercise Immunology Review 15:66.). Inset, Drake University soccer player Logan North.

PHOTO (COLOR): Figure 9. Summarized from eight different studies on the effects of ginseng on immune function in strength athletes, research remains inconclusive and contradictory. Preclinical factors could account for some of the wide variation in results. For example, four different ginseng preparations were used across these eight studies. Pictured: Travis Merritt, Drake University football.

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