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Neurofeedback for Attention Deficit/Hyperactivity Disorder

By Susan T. Marcolina, MD

ATTENTION DEFICIT/HYPERACTIVITY DISORDER (ADHD) IS A COMMON neurobehavioral disorder of childhood with an incidence of between 3% and 9%.[1] Its primary characteristics are age-inappropriate levels of inattention, hyperactivity, and impulsivity, noted prior to age 7. Children also may experience comorbid learning disabilities and conduct disorders.[2] These features often persist into adulthood with resultant negative social, academic, and vocational repercussions.[3]

Recognition in the medical literature dates back to 1902, when such children were labeled as "morally defective."[4] Drug treatment, primarily with stimulant medications, began in 1937, has been the mainstay of therapy, and often is the only treatment for many patients.[5] Although treatment with stimulant medications can result in short-term improvements in cognitive focus, the residual behavioral, social, and parenting difficulties persist and do not respond to pharmacotherapy.[6] If patients discontinue their stimulant medications, the ADHD behaviors return.[7]

Nonpharmacologic methods, though highly effective, are underused. Neurofeedback or electroencephalogram (EEG) biofeedback is such a modality, and has been studied over the past 25 years for ADHD. Mental health practitioners have successfully included neurofeedback in their therapeutic armamentarium for ADHD patients, and clinicians should consider it for their patients with ADHD.

The Diagnosis of ADHD

It is essential that every patient have a complete history and diagnostic evaluation to ascertain the appropriate diagnosis. Neurotherapy will not be successful in patients with mental retardation, severe depression, psychotic disorders, bipolar illness, or severe-conduct/oppositional defiant disorder.[8]

Broad diagnostic criteria outlined in the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) have resulted in a heterogeneous population of children diagnosed with this disorder. Diagnosis is made on the basis of history from parents and teachers, behavior

Volume 4 • Number 9 • September 2001 • Pages 97-108

INSIDE

rating scales such as the Connor's Behavioral Rating Scale (teacher's and parent's version), and the results of a continuous performance test called TOVA (Test of Variables of Attention).

A fixed interval test that is not language-based and requires no left-right discrimination, TOVA measures inattention (errors of omission), impulsivity (errors of commission), response or processing time (usually slower than normal in individuals with ADHD), and variability (individuals with ADHD tend to be variable or inconsistent in their correct response times). TOVA has a sensitivity and specificity of 80% for the identification of attention disorders. It is a tool that must be used in conjunction with other relevant data for the diagnosis of ADHD.[9,10]

The American Academy of Child and Adolescent Psychiatry practice parameters do not recommend specific diagnostic testing except for rare instances of lead intoxication and generalized resistance to thyroid hormone.[11]

Procedure

Neurofeedback is a type of operant conditioning procedure. A patient is trained to modify his or her brain waves through the use of rapid computerized technology which can provide EEG information to the patient in a variety of easily understandable formats, such as color bars, games, or audio feedback.

A typical protocol emphasizes suppression of theta brain-wave activity and augmentation of beta or sensorimotor rhythm (SMR) brain-wave activity. Table 1 summarizes the types of brain-wave activities noted on the EEG.[12]

EEG recording of brain waves is accomplished by a specific standardized pattern of electrode placements (montages) on the scalp. EEG recordings can be analyzed quantitatively by computerized statistical tools and compared to normative EEG databases. This quantitative EEG (QEEG) can be used as measurable data for a given individual, and can provide objective, physiologically based information to supplement the subjective questionnaires, rating scales, and TOVA results currently used to identify children with ADHD.

Finally, the theta:beta ratio can be used to assess baseline and subsequent response to neurofeedback sessions. The ratio controls for the gradual EEG differences between the younger and older ADHD subjects. As individuals age, both theta and beta amplitudes decrease, but the theta:beta ratio remains relatively constant.[13]

Pathophysiology

EEG studies of ADHD patients have shown excessive slow-wave theta activity in the central and frontal regions of the brain.[14] Together with radiographic nuclear medicine studies, EEG studies support the hypothesis that behaviors in ADHD are related to deficits in prefrontal activation.[15] Since the prefrontal cortical areas are important biologic determinants of attention, disorders in these regions result in motor restlessness, inattentiveness, distractibility, and the inability to inhibit inappropriate responses.[16]

This reasoning may extend to adults as well. Zametkin et al performed a positron emission tomography (PET) study of 50 healthy adult controls and 25 adults with a history of ADHD as children or with offspring diagnosed with ADHD.[17] These adults had no history of other psychiatric disorders or substance abuse problems and no stimulant medication history. Independent research assistants who were blinded to the identity and diagnosis of the persons in the study interpreted the scans. Four regions in the premotor and superior prefrontal cortex were shown to metabolize glucose at significantly lower rates in the subjects than the controls.

Clinical Studies

Linden et al performed a randomized, controlled study of 18 children diagnosed with ADHD.[13] Nine

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subjects were randomly assigned to an experimental group, which underwent 40 sessions of the EEG biofeedback treatment over six months. Experimental subjects underwent standard neurofeedback with visual and auditory feedback. The biofeedback training was performed to suppress the theta bands and enhance the beta bands of the EEG. Nine were assigned to a waiting list group, which did not undergo EEG biofeedback during the same time period. IQ testing and parent behavior rating scales were collected prior to and after six months of treatment. The research assistants scoring the rating scales and the IQ examiners were blinded to the subjects' group assignments.

Experimental subjects showed significantly enhanced IQ scores at post treatment; the average IQ increase in the experimental group was 9 points greater than that of the waiting list control group ($P = 0.023$). Additionally, inattentive behaviors were significantly reduced in the experimental group ($P = 0.04$).

A retrospective study performed by Thompson and Thompson examined the results of neurofeedback training and metacognitive teaching strategies in 111 (98 children and 13 adults) subjects with ADHD.[18] Thirty percent of the children took stimulants at the beginning of the study. Each subject received twice weekly neurofeedback sessions (a total of 50 sessions). The feedback training was aimed at decreasing slow-wave activity (defined as 4-7 Hz, but occasionally 9-11 Hz) and increasing fast-wave activity (15-18 Hz for most subjects, but initially 13-15 Hz for those with impulsivity and hyperactivity). Metacognitive strategies were used to teach academic tasks when the feedback indicated patient focus. Some clients received peripheral biofeedback modalities during some of the sessions.

Pre- and post-test results of TOVA, Wechsler Intelligence Scales (WISCs), Wide Range Achievement Tests (WRATs), and the theta:beta ratio on QEEGs were available for 68%, 62%, 89%, and 59% of subjects, respectively. Significant improvements ($P < 0.001$) were found in ADHD symptoms (with regard to inattention, impulsivity, and variability of response times on the TOVA), on the WISCs, and on the WRATs. The average gain for full-scale IQ scores was 12 points. A decrease in the theta:beta ratio on the QEEG was observed as well as the number of children taking stimulants decreased by 24%. One- to 10-year follow-up of successfully treated patients suggests that EEG biofeedback leads to long-term ADHD symptom reduction.[19]

Table 1

Basic frequency bands of the EEG[12]

Band	Frequency	Clinical Significance
Delta	0.5-4 Hz	Deep sleep
Theta	4-8 Hz	Deep creativity; predominant frequency in day dreaming
Alpha	8-12 Hz	Relaxed, alert, unfocused state
SMR (Sensorimotor Rhythm)	12-14 Hz	Quiet body and active mind with external focus of attention; associated with information storage and retrieval
Beta 1	12-16 Hz	Higher cognitive processes; rational, analytical thinking and problem-solving
Beta 2	16-24 Hz	Physiological arousal and response to threat

Regulation

Neurofeedback and QEEG equipment are classified by the Food and Drug Administration as Class 2 prescriptive devices and, as such, should be sold only to professionals licensed in a health care field. The currently available QEEG equipment has not been approved for diagnostic purposes. Legally approved purposes for obtaining a QEEG include its use before patient training as a baseline and for comparison to normative databases.[12]

The Biofeedback Certification Institute of America (BCIA) manages and administers a formal certification program in EEG biofeedback. The certification requirements are listed on the BCIA web site (http://www.bcia.org), which also contains a registry of BCIA-certified practitioners.

Adverse Effects

Occasionally patients report headaches, the etiology of which is likely muscle tension during training, as it disappears rapidly once muscles are relaxed. Patients may experience fatigue from the training of the initial sessions but generally are more alert and awake after neurotherapy. There can be some minor discomfort as the electrodes are applied and removed from the scalp surface.

Conclusions

Neurofeedback can be useful as an adjunctive therapy for the multidisciplinary treatment of ADHD. With the proper guidance of a competent practitioner, patients can learn physiologic regulation skills necessary to cope

with the challenges of ADHD. Progress and response toneurotherapy can be quantitatively measured by continuous performance testing (TOVA), IQ, achievement testing, and QEEG. Success, however, requires a long-term time and financial commitment on the part of the patient, the patient's family, and the practitioner. A totalof 20-40 sessions, performed twice weekly over several months in conjunction with other forms of therapy, maybe required. The practitioner performing the neurofeedback should have experience in the diagnosis and treatment of ADHD and be certified by the Biofeedback Certification Institutes of America in neurotherapy.

Recommendations

EEG Biofeedback performed by a competent practitioner can be a powerful addition to the armamentarium of ADHD treatment regimens. There are good data to show that particular training protocols can affect improvements in behavior, IQ scores, and aptitude testing for individuals with ADHD. ❖

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Vitamin E for Treatment of Diabetic Retinopathy

By Robert J. Nardino, MD, FACP

EVERYWHERE YOU TURN THERE IS ANOTHER HEALTH-related product touting the alleged beneficial effects of antioxidants. Nevertheless, there may be some substance to the hype. One example is in the prevention and treatment of diabetic retinopathy. Continued insight into the origin of microvascular problems in diabetes mellitus and interest in the use of antioxidants in other retinal conditions, including age-related macular

Table 1

Comparison of interventions for diabetic retinopathy

Intervention	Outcome	Study	Reference
Intensive glycemic control	Reduced progression of retinopathy by 63%	Large RCT	15
Vitamin E supplementation	Improved retinal blood flow; no clinical endpoint	Small RCT	7
Aggressive blood pressure control	No effect on retinopathy	RCT	16
Aspirin	Improved retinal blood flow	Observational	17

Key: RCT = Randomized, controlled trial

degeneration, have led to further investigation of the use of antioxidants, particularly vitamin E, in the treatment of this devastating complication of diabetes mellitus.

Pathophysiology

There are a variety of explanations for how and why microangiopathy occurs in patients with diabetes mellitus, although the exact mechanism has yet to be elucidated. Just as carcinogenesis and cellular apoptosis appear to be related, free radicals and oxidative processes are linked.

Italian investigators found increased levels of free radicals in the retina of diabetic patients, with a greater concentration in those with more severe retinopathy.[1] A more recent U.S study confirmed increased levels of free radicals, as well as reduced levels of the important endogenous antioxidants, glutathione and superoxide dismutase, in 73 diabetic patients compared to controls.[2] However, there was no association between the level and the severity of retinopathy.

Chinese investigators looked at blood viscosity and lipid peroxidation in 13 patients with type 2 diabetes and retinopathy.[3] They found that giving 300 mg vitamin E tid reduced red blood cell deformability, attributable to decreased oxidative stress. There was no change in viscosity or red cell rigidity in this study.

Other evidence suggested that antioxidants could reverse endothelial dysfunction in humans. Vitamin C was shown to restore endothelium-dependent vasodilation in diabetic patients, further evidence that antioxidants play an important role in this regard.[4] Vitamin E (1,000 IU/d) improved endothelial function as assessed by brachial artery ultrasound in 41 type 1 diabetics.[5]

Mechanism of Action

Free radicals are reactive oxygen species that are generated under normal physiological processes, as well as in pathological situations. A free radical is simply a molecule with one unpaired electron, which determines its highly reactive nature. Cellular free radicals are generated constantly, but the body has a defense. Antioxidants like glutathione, vitamin E, and vitamin C lend electrons to render free radicals neutral. Thus, vitamin E inhibits lipid peroxidation, which prevents damage to cell membranes and also prevents modification of low-density lipoprotein to a more atherogenic molecule. Vitamin C regenerates vitamin E; that is, it restores the donated electron to vitamin E.

Clinical Studies

An epidemiologic study looked at the intake of antioxidants and the incidence of retinopathy in 387 patients with type 2 diabetes.[6] Dietary intake was assessed with a 24-hour recall interview, and supplements were assessed and confirmed by examining the labels of bottles brought in by the participants. Statistical analysis sought to associate intake of vitamin C, beta-carotene, and vitamin E (by quintiles) with the presence of retinopathy as classified by fundoscopic stereophotography. Overall, there was no beneficial effect. In fact, in patients not taking insulin, higher intake of vitamin E and beta-carotene was associated with more severe retinopathy.

There are limitations to the 24-hour recall method, however, which is specific only for that time period and does not account for the probable variation in dietary intake. Also, causation cannot be established. In fact, the negative association found between vitamin E and retinopathy could have resulted from supplementation in response to knowledge about incipient or progressing eye disease.

In 1999, investigators from Harvard Medical School and the Joslin Diabetes Center published the results of a randomized, controlled trial of vitamin E supplementation in patients with type 1 diabetes.[7] The study's objective was to determine if vitamin E had any effect on retinal blood flow. *(See Table 1 for a comparison of diabetic retinopathy trials.)*

Investigators enrolled 36 patients who had minimal or no retinopathy and type 1 diabetes for less than 10 years.

They also included nine nondiabetic control subjects. All were randomly assigned to receive vitamin E at a dose of 1,800 IU/d or placebo; after four months, they were crossed over to the other treatment for another four months. Retinal blood flow was determined with video flourescein angiography. At baseline, retinal blood flow was significantly reduced in diabetic patients compared to nondiabetics.

After treatment with vitamin E, retinal blood flow improved in the diabetic subjects to the point that it was comparable to that of the nondiabetic participants. In addition, the hyperfiltration associated with early diabetic renal disease also normalized. This is a short-term study, looking at a physiologic response rather than a clinical endpoint, but nevertheless the results are encouraging. Also of note is the dose used, which is higher than the doses seen in the studies of vitamin E and macrovascular disease (400-800 IU/d).

Adverse Effects

Vitamin E has been linked to bleeding complications when used in the treatment of retinopathy of prematurity.[8] A link with venous thromboembolism was reported in a case series.[9] Many of the patients had concurrent risk factors. An earlier body of literature proposed vitamin E as a possible preventive therapy for thromboembolic disease, potentially confounding these data.

Drug Interactions

There is some conflicting information about the interaction of vitamin E and warfarin. There are case reports of elevated prothrombin times and bleeding episodes in patients stabilized on warfarin who subsequently started vitamin E. On the other hand, a study of 21 patients on warfarin given 800 IU of vitamin E showed no effect on the international normalizing ratio (INR).[10] However, the study only lasted one month. There is speculation that vitamin E may interfere with the synthesis of vitamin K-dependent clotting factors. It is recommended that the prothrombin time/INR be closely monitored after initiation or discontinuation of vitamin E therapy.

The weight-loss agent orlistat (Xenical) is reported to block the absorption of vitamin E by up to 60%. The manufacturer recommends spacing the dose of orlistat from vitamin E by at least two hours.

Other Effects

Population-based studies have demonstrated a possible protective effect of vitamin E against age-related macular degeneration.[11] Several large prospective randomized trials are now in progress to examine further the benefits of vitamin E in the prevention of macular degeneration and cataracts.

Patients with documented coronary artery disease who supplemented with vitamin E (400-800 IU) had a decreased incidence of non-fatal cardiac events in the Cambridge Heart Antioxidant Study.[12]

Formulation

Vitamin E can be found in vegetable oils, margarine, nuts, seeds, avocados, and safflower oil. The recommended dietary intake of vitamin E is 30 IU/d. Dietary fat restriction can limit the consumption of vitamin E.

Vitamin E can be obtained as a supplement in natural (d-alpha-tocopherol) or synthetic (dl-alpha-tocopherol) form. It appears that the natural form is superior in terms of absorption and retention in the body, although there is ongoing debate as to the degree to which bioavailability differs.[13] Most supplements contain the synthetic form, but increasingly, natural supplements are available, although they are more expensive. *(See Table 2 for a price comparison.)* Further complicating the issue are data from a population-based study which indicated that women with greater dietary intake of vitamin E had fewer cardiac events, whereas those who supplemented did not (although the study was not designed to test the hypothesis that supplementation prevents cardiac events).[14]

Conclusion

The single randomized trial of vitamin E and diabetic retinopathy was a short-term study, and it used the surrogate endpoint of retinal blood flow rather than the progression of retinopathy. Mounting information about the origin of microvascular disease and the effect of vitamin E on these oxidative reactions provide theoretical support for its use. Questions remain, however. Does vitamin E provide benefit in addition to that of tight control? Since vitamin E has been associated with a risk of

Table 2

Price comparison of vitamin E supplements

Distributor	Dose	Form	Quantity	Price
Nature Made	800 IU	Natural	60	$14.99
Twinlab	400 IU	Natural	100	$16.09
Drugstore.com	400 IU	Synthetic	300	$10.39
GNC	1,000 IU	Natural	120	$29.99

Source: On-line mail-order companies.

hemorrhage, what is the risk of retinal hemorrhage and clinical worsening in the presence of proliferative retinopathy? Can vitamin E prevent the "early worsening" seen in some patients who begin intensive glycemic control (about 13% of intensively treated people in the Diabetes Control and Complications Trial[15]). Only further prospective controlled trials can provide answers.

Recommendation

The evidence for vitamin E use for the prevention or treatment of diabetic retinopathy is preliminary. A single randomized trial shows it to be safe for short-term use. Patients who are taking warfarin should use caution and their INR should be monitored closely. ❖

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Androstenedione for Performance Enhancement: New Research Reveals Only Harm

By Dónal P. O'Mathúna, PhD

ANDROSTENEDIONE (OR "ANDRO") WAS REVIEWED HERE shortly after its meteoric rise to fame in 1998.[1] That year Mark McGwire broke Roger Maris' home run record, announcing along the way that he used andro and other dietary supplements as performance-enhancing substances.[2] The next year, McGwire stated he no longer used andro, but its reputation and widespread use has persisted.

When McGwire made his announcement, few studies had examined androstenedione's effectiveness or safety. Many governing sports bodies banned andro as yet another anabolic steroid. Several studies have since demonstrated that androstenedione's potential harm far outweighs the slim chance of benefit. Athletes and their parents, coaches, and team physicians need to hear about these new results.

Background and History

Androstenedione has been studied as an anabolic-androgenic steroid (AAS) since the 1930s.[3] Interest was confined to researchers until the former East German sports establishment looked to it as an alternative to testosterone injections.[4] Athletes allegedly used an androstenedione spray, which was later patented in Germany after the fall of Communism.[5]

Since AASs were classified as Schedule III controlled substances in 1990, more athletes turn to "prohormones," substances allegedly converted into testosterone by the body.[6] These products are naturally occurring and can be sold virtually without restriction under the 1994 Dietary Supplement Health and Education Act. Androstenedione occurs naturally in Mexican yams and Scotch white pine. The United States is a primary source of andro for athletes around the world.

Pharmacology

Androstenedione is produced in the adrenal glands and gonads as part of the complex network of steroid hormones.[7] Androstenedione is the immediate precursor of testosterone (see Figure), although its direct anabolic-androgenic activity is weak. Athletes seek these anabolic effects in addition to increased physical aggressiveness and decreased body fat. Androstenedione is a precursor of testosterone, but also of estrogens, especially in males.[8]

Mechanism of Action

Androstenedione is alleged to act as a natural testosterone booster. Numerous studies have shown that testosterone increases muscle size, muscle protein synthesis, and muscle strength.[9] AASs also inhibit the catabolic effects of vigorous exercise, allowing faster recovery from intense training.[7] The question is whether androstenedione produces these effects.

Clinical Studies

Early research remains the basis of andro promotional materials. The earliest study gave two women 100 mg androstenedione.[10] After 60 minutes, one woman's testosterone level was 660% higher than baseline, and the other's was 433% higher. At 90 minutes, the levels remained elevated, but lower than at 60 minutes. The 1995 German patent for androstenedione nasal spray gave no methodological details but stated that after 15 minutes total serum testosterone levels increased 40-83% (after 50 mg orally), 111-237% (100 mg orally), or 34-97% (3.5-15 mg nasally).[5] Testosterone levels were 48-97% higher 3-4 days after discontinuing the nasal spray and remained elevated for another 6-7 days.

Our earlier review of androstenedione described in detail the only controlled study then available, by King and colleagues.[1] King reported two studies, one examining serum changes and the other investigating muscle and strength changes after exercise.[11] In the first, 10 healthy men were randomly assigned to either 100 mg androstenedione or placebo. Those taking androstenedione had significantly elevated blood levels of androstenedione, but unchanged levels of testosterone, follicle-stimulating hormone (FSH), and luteinizing hormone (LH).

Several other studies have since examined serum changes. In correspondence, King referenced two unpublished preliminary reports in which 100 mg androstenedione failed to increase testosterone levels.[12] An open-label, randomized study gave 42 healthy males (ages 20-40 years) androstenedione (either 100 or 300 mg/d) or placebo for seven days.[13] The 300 mg/d group showed a significant 14% increase in testosterone ($P < 0.01$) which differed significantly from both other groups ($P < 0.001$). Testosterone levels did not change in those two groups. Estrone and estradiol concentrations were significantly elevated after both 100 and 300 mg/d androstenedione ($P < 0.002$).

In a randomized, double-blind, cross-over study, eight males (average age 23.8 years) received a single dose of 200 mg androstenedione, 200 mg androstenediol, or placebo.[14] Androstenediol is similarly converted into testosterone and is frequently added to "andro" products.[15] Testosterone concentrations did not vary significantly, but when analyzed as mean area under the curve (AUC), the androstenedione group had a small but statistically significant elevation in testosterone ($P < 0.05$). Androstenediol supplementation increased serum androstenedione by 103%, but did not increase testosterone levels.

The impact of exercise on testosterone levels after androstenedione supplementation was examined in 10 men (average age 24 years) with several years of weight-lifting experience.[16] This double-blind, cross-over study randomly assigned the men to either 200 mg/d androstenedione or placebo for two days. Testosterone levels initially were unchanged, but after 90 minutes of

weight lifting, total and free testosterone levels transiently increased in both groups, but with non-significant differences. Estradiol levels were significantly higher in those taking androstenedione throughout the exercise period ($P < 0.05$).

Another study found no increase in testosterone levels after androstenedione supplementation (100 mg/d for five days).[9] This study also examined changes in protein metabolism in six males (average age 32 years) compared with a non-randomly selected control group. Protein synthesis did increase, but not with statistical significance, and there was an even greater increase in protein breakdown. Estradiol levels were significantly increased ($P < 0.05$).

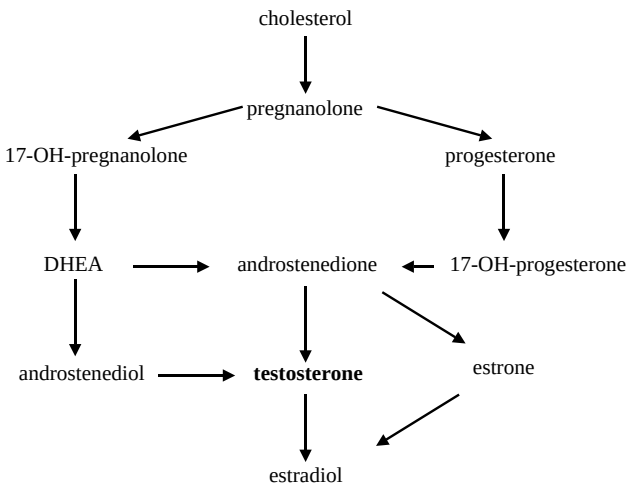
Androstenedione's impact on athletic performance was tested in the second study in King's original publication.[11] Twenty healthy men (ages 19-29 years) were randomly assigned to placebo or androstenedione (100 mg tid for eight weeks, skipping every third week to simulate "wash-out"). All subjects were supervised lifting weights for all major muscles three times weekly. No significant differences between the two groups were found in body composition, muscle size, muscle strength, and testosterone levels. The androstenedione group had significantly elevated estradiol, estrone, and estrogen levels ($P < 0.05$). Additionally, serum HDL cholesterol was 12% lower in the androstenedione group during weeks 2-8 ($P < 0.05$).

King's two studies were replicated using a product containing 300 mg androstenedione, 150 mg dehydroepiandrosterone (DHEA), and four herbs alleged to promote testosterone production and minimize estrogen formation.[17] Using identical study designs, results were obtained that were similar to those obtained with pure androstenedione (i.e., 100 mg androstenedione in the herbal product did not elevate testosterone levels in 10 men). In this double-blind, randomized trial, the herbal remedy (including 300 mg/d androstenedione) was administered for eight weeks to 20 men in their twenties who lifted weights three times a week. Serum testosterone, body composition, and muscle strength did not change significantly. The only significant lipid change was a 12% reduction in HDL ($P < 0.05$); estradiol and estrone levels increased significantly ($P < 0.05$).

Another double-blind, randomized study involved 40 middle-aged men (mean age 48.1 years) with at least one year of weight-lifting experience.[18] Each was assigned to take 50 mg androstenedione, 50 mg DHEA, or placebo bid for 12 weeks. Subjects maintained their usual exercise and dietary patterns. No significant differences were found in lean body mass, strength, or testosterone levels. No adverse effects were reported.

Figure

Androgenic human steroids



Finally, 50 men (ages 35-65 years) were randomized to receive either placebo, androstenedione (100 mg bid), or androstenediol (100 mg bid).[15] They exercised, under supervision, three times a week for 12 weeks. After four weeks, the androstenedione group had significantly elevated testosterone levels compared to androstenediol and placebo, but there were no differences after 12 weeks. The androstenediol group showed no significant increase in total testosterone, but at 12 weeks only, free testosterone levels were significantly elevated ($P < 0.05$). Both andro supplements led to significantly elevated levels of estradiol and estrone compared to placebo ($P < 0.01$) and pretreatment baselines ($P < 0.03$). No significant differences were found between the three groups in body composition or muscle mass. All three groups reported significantly increased muscle strength, with similar gains in each group.

Adverse Effects

Reduced HDL and elevated LDL were reported as increased cardiac risk profiles. This risk for abnormal lipid profiles increased 5.2% for androstenediol and 10.48% for androstenedione, and decreased 12.34% with placebo ($P = 0.05$).[18] Lowered HDL cholesterol levels are independently associated with higher risk for cardiovascular disease, as are elevated LDL levels.

No other adverse effects have been reported in studies, although elevated estrogen levels are associated with gynecomastia and increased risk of cardiovascular disease, breast cancer, and hirsutism in women, and pancreatic cancer in men.[11] Elevated androstenedione levels are associated with increased risk of prostatic and pancreatic

cancer.[19,20] No studies are available on the adverse effects of long-term androstenedione use.

The quality of andro products in the United States also is problematic. One study tested nine products.[21] Six failed the commonly accepted USP standard of containing between 90% and 110% of labeled quantities. One contained no androstenedione, and one contained 10 mg testosterone without revealing this on its label.

Regulation

Androstenedione is banned by the National Football League, National Collegiate Athletic Association, and the International Olympic Committee. Consuming these products will, in most cases, lead to positive urine tests for nandrolone, another banned anabolic agent.[21] The American College of Sports Medicine has called for regulatory reform because drugs like androstenedione are so readily available.[22]

Drug Interactions

One review claimed that all AASs increase sensitivity to oral anticoagulants and antidiabetic medications, but did not elaborate.[6] Drug interactions with androstenedione have not been reported.

Formulation

Tablets and capsules contain 50 or 100 mg androstenedione. Manufacturers recommend 100-300 mg/d, though some recommend 1,200 mg/d.[2] Androstenedione is available as a nasal spray, sublingual spray, and percutaneous gel. The nasal spray patented in Germany delivers 3.5-15 mg androstenedione per pump.[5]

Conclusion

Several new androstenedione studies recently have been published. Studies giving 100-200 mg/d androstenedione rarely found increased testosterone levels, but 300 mg/d did increase testosterone levels in some, but not all, studies. However, even 100 mg/d consistently increased estrogen levels and negatively affected blood lipids. Four controlled studies failed to demonstrate any beneficial effects on body composition or strength from androstenedione and related products.

The subjects in these studies differ in important ways from trained athletes who use AASs. Proponents claim anabolic steroids only benefit well-trained athletes because they reverse the catabolic state induced by intense exercise, thus allowing significant gains in strength and lean body mass.[7] Recent research has only involved men, whereas early German research involved female athletes. A 1966 study with radioactive tracers found that androstenedione leads to only 0.3% of the testosterone produced in males, but to about 60% of that produced in females.[16] Thus, it appears theoretically unlikely that untrained men will experience any anabolic benefit from androstenedione supplements. Androstenedione's effects may be different in trained athletes and in females.[7]

Recommendation

Although research is somewhat limited, androstenedione thus far produces none of the advantages athletes seek, and has all the dangers inherent to anabolic steroid abuse. It raises LDL cholesterol and lowers HDL cholesterol. Given the lack of demonstrated efficacy, the significant potential for adverse effects, and concern about product quality, clinicians should actively discourage any use of androstenedione. ❖

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CME Questions

12. Children with ADHD have been noted to have EEG and PET scan abnormalities with cognitive tasks in which area of the brain?
a. Prefrontal cortex
b. Frontal lobes
c. Prefrontal cortex and frontal lobes
d. None of the above

13. Neurofeedback should be avoided in which of the following conditions?
a. Bipolar disorder
b. Psychoses
c. Major depression
d. Mental retardation
e. All of the above

14. Which of the following most effectively prevents progression of diabetic retinopathy?
a. Tight blood pressure control
b. Intensive glycemic control
c. Vitamin E
d. Aspirin

15. Adverse effects of vitamin E include which of the following?
a. Interaction with warfarin to increase risk of hemorrhage
b. Fat malabsorption
c. Worsened glycemic control
d. All of the above

16. Androstenedione is regulated as a dietary supplement because:
a. it is found in the human body.
b. it is found in Mexican yams and other herbs.
c. it is required in a balanced diet.
d. it is a precursor of testosterone.

17. Research demonstrates that androstenedione supplementation has a negative effect on serum levels of:
a. estradiol.
b. estrone.
c. HDL.
d. All of the above

Clinical Briefs

With Comments from John La Puma, MD, FACP

Beta-Carotene Use and Cystic Fibrosis

Source: Renner S, et al. Effects of beta-carotene supplementation for six months on clinical and laboratory parameters in patients with cystic fibrosis. *Thorax* 2001;56:48-52.

PATIENTS WITH CYSTIC FIBROSIS (CF) have significantly decreased plasma concentrations of nutrient antioxidant vitamins, especially of beta-carotene, which is thought to result from fat malabsorption and chronic pulmonary inflammation. The aim of this double-blind, placebo-controlled study was to investigate the effect of oral beta-carotene supplementation for six months on clinical parameters.

Twenty-four CF patients were randomized to receive 1 mg/kg/d beta-carotene (maximum 50 mg/d) for three months (high-dose supplementation) and 10 mg/d for a further three months (low-dose supplementation) or placebo. At monthly follow-up visits, the plasma beta-carotene concentration, total antioxidant capacity, malondialdehyde (MDA) as a marker of lipid peroxidation, and clinical parameters (Shwachmann-Kulczycki score, body mass index [BMI], height, and lung function

[FEV1]) were assessed. The number of pulmonary exacerbations requiring antibiotic treatment three months before and during the study were evaluated.

Plasma concentration of beta-carotene increased significantly to the normal range during the three months of high-dose supplementation (baseline 0.08 [0.04] micromol/l to 0.56 [0.38] micromol/l; $P < 0.001$), but decreased to 0.32 (0.19) micromol/l in the period of low-dose supplementation. Initially raised plasma levels of MDA fell to normal levels and the total antioxidant capacity showed a non-significant trend toward improvement during high-dose supplementation. Antibiotic treatment decreased significantly in the supplementation group from 14.5 (14.9) days/patient during the three months before the study to 9.8 (10.3) days/patient during high-dose supplementation ($P = 0.0368$) and to 10.5 (9.9) days/patient during low-dose supplementation, but increased in the placebo group. The Shwachmann-Kulczycki score, lung function, and BMI did not show any changes in either of the treatment groups. No adverse events were observed during the study period.

The authors conclude that oral beta-carotene supplementation in a dose of 1 mg/kg/d was effective only in normalizing the plasma concentration of beta-carotene and resulted in a decrease in pulmonary exacerbations. These data suggest that patients with CF may benefit clinically from supplementation with beta-carotene and further studies are warranted.

COMMENT

Beta-carotene has been tested for effectiveness and safety in a number of medical conditions, most famously in the prevention of coronary artery disease. In that study, and in another study, an increase in the incidence of lung cancer was discovered in smokers after 5-8 years of supplementation. Beta-carotene as a supplement is not recommended for routine use and the beta-carotene arm of the Women's Health Initiative has been discontinued.

For patients with CF, however, the benefits may outweigh the risks. In this well-designed randomized, double-blind, placebo-controlled study from Vienna, Austria, CF patients started with significantly lower mean plasma beta-carotene concentrations, had six months of supplementation, and markedly reduced their dependence on antibiotics to treat an acute pulmonary exacerbation. No significant change in FEV1, percent predicted, and total antioxidative capacity was noted between the groups.

The baseline low levels of beta-carotene are postulated to result from malabsorption, and chronic pulmonary inflammation, which perhaps chews up antioxidants.

The authors advise caution in interpretation, as the number of patients is small. However, for this select group of patients with progressive lung disease that invariably results in death, these data should be strongly considered.

Recommendation

Consider beta-carotene supplements in patients with cystic fibrosis in a dose of 1 mg/kg/d with a clear understanding in the informed consent process of the known risks and benefits. ❖

Peppermint Oil for Pediatric IBS

Source: Kline RM, et al. Enteric-coated, pH-dependent peppermint oil capsules for the treatment of irritable bowel syndrome in children. *J Pediatr* 2001;138:125-128.

FORTY-TWO CHILDREN WITH IRRITABLE bowel syndrome (IBS) were given pH-dependent, enteric-coated peppermint oil capsules or placebo in this randomized, double-blind, controlled trial. After two weeks, 75% of those receiving peppermint oil had reduced severity of pain associated with IBS. The authors conclude that peppermint oil may be used as a therapeutic agent during the symptomatic phase of IBS.

COMMENT

From researchers at the University of Missouri in Columbia, Hahnemann University in Philadelphia, and a private medical group in Charleston, South Carolina, this well constructed, small trial tested the hypothesis that peppermint oil capsules may ameliorate the recurrent abdominal pain of IBS. The authors note that studies of adults with IBS have recorded variable results, and IBS has been "clarified as a neurobiologic disorder affecting the autonomic, neuroendocrine and pain mechanisms." Many physicians are all too familiar with its effects on patients—diarrhea, constipation, distension, bloating, urgency, and often daily nagging abdominal pain.

Peppermint's physiologic effects are well known to anyone who has sucked on an after-dinner mint to relieve dyspepsia, reduce flatulence, and relax the lower esophageal sphincter. Does the latter effect result in reflux? Yes, sometimes. And that's the reason for pH-dependent, enteric-coated capsules.

In this study, 50 children met the Manning or Rome criteria for IBS, and were excluded if they were younger than 8 years of age or were receiving medication for the treatment of IBS. Both clinicians and patients ranked pain severity—parents did not complete the diaries. The placebo was arachis oil, and the treatment group received 187 mg of peppermint oil three times daily (and twice this dosage if the patient weighed more than 45 kg).

Only eight children withdrew (four of the eight patients could not swallow pills). Mean age was 12 years; 60% were females, and 83% were white. No side effects were reported by either the investigator or patients, and neurological exams were normal at the beginning and end of the study. Only pain was affected—no other symptoms of IBS were reduced.

Peppermint oil is a calcium channel blocker and a mild topical analgesic. Of note, because overall placebo response rate is about 30%, and as high as 40% in IBS research, these data showing 75% improvement are especially impressive. Of course, this is a pilot study, and a larger study is warranted.

Recommendation

If children can take medication three times daily and have recurring, abdominal IBS pain, peppermint oil seems worth a short, two-week trial. Longer use requires regular monitoring. ❖

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Complementary and Alternative Medicine for Athletes

Part 2: Treating Sports Injuries

By Dónal P. O'Mathúna, PhD

IN THE FIRST PART OF THIS MONOGRAPH, ATTENTION WAS FOCUSED ON THE DIETARY supplements and herbal remedies used to enhance athletic performance.[1] The second part of the monograph will focus on the integrative medicine approach to the treatment of sports-related injuries. Estimates in the early 1990s suggested that in the United States there were 100 million regular swimmers, 75 million cyclists, and 25 million runners and joggers.[2] In spite of the many benefits of these various forms of exercise, between 45% and 70% of those who regularly exercise are likely to suffer from an injury during the course of a year.[3] Highly competitive athletes always walk a fine line between intense and appropriate exercise and over-training and subsequent injury.

When injuries strike, recreational and competitive athletes alike seek whatever methods will assist in their recovery. Competitive athletes resort to whatever they think will return them to full fitness in the shortest time. The British sports medicine community reacted with astonishment when the coach of the English national soccer team recruited a faith healer to care for his athletes during the World Cup.[3] The injuries themselves and the required recovery periods often result in relatively rapid loss of muscle strength along with muscle stiffness and soreness. If athletes perceive that conventional medicine is not treating them adequately or rapidly enough, they often turn to complementary and alternative therapies.

Little evidence exists to help physicians, coaches, and athletes make decisions about those alternative therapies that might treat sports injuries. Stories spread rapidly among athletes about a particular complementary therapy that provides complete pain relief or returned a well-known champion to a full training regimen in record time. The problem with such anecdotal evidence is that a myriad of other factors could have contributed to the results attributed to the therapy. Only high-quality, controlled studies can demonstrate with reliability if a putative therapy is both safe and effective. Unfortunately, many of the most popular alternative therapies used for sports injuries have very little scientific data to support their efficacy, or are believed to work via some controversial mechanism of action.[4]

The treatment of muscle strains is extremely important because of the long-term negative effects of repeated injuries. Muscles that have had minor strains are more susceptible to subsequent major strains.[5] If rehabilitation is attempted too rapidly, more serious injuries may result. Medications taken or injected for local pain relief can bring short-term benefits, but may lead to further long-term

INSIDE

damage. Animal studies have shown that using anti-inflammatory medications after muscle strains allowed greater activity on the day after injury.[6] However, in the following seven days, the animals receiving medication had more serious tissue damage as seen in histological studies. Similarly, care must be taken with alternative therapies to ensure they are not just masking the symptoms of a minor underlying injury or biomechanical problem that may go untreated or may end in a serious injury. Ineffective or inappropriate therapies, whether conventional or alternative, may cause further damage in addition to slower healing; sports injuries should be treated with the most effective therapies available.

Acupuncture

Acupuncture is an integral part of traditional Chinese medicine (TCM) and has been growing in popularity within conventional medicine. Approximately 10,000 acupuncturists practice in the United States, one-third of whom are physicians.[7] Although acupuncture is used for a wide variety of ailments, some scientific evidence supports its effectiveness in relieving pain.[8] Acupuncture most often is used by athletes for the relief of pain, especially pain associated with tendonitis.

One of the areas of controversy surrounding acupuncture involves its proposed mechanism of action. TCM is based upon the belief in a nonphysical "life energy" called *qi* (pronounced "chee") that circulates throughout the body via invisible channels called meridians.[7] Health is said to require a balanced flow of qi, or energy. Illness or pain results when the flow of qi is obstructed or unbalanced. Acupuncture needles are inserted into the skin at specific locations on the body (acupuncture points). TCM practitioners believe this restores normal flow of qi through the meridians. Other physiological changes are elicited by needle insertion which conventional medicine believes underlie any benefits acupuncture may have. Needle insertion has been shown to release endorphins and serotonin which may account for an analgesic effect.[9] Acupuncture also may have an anti-inflammatory effect by causing the release of endogenous corticosteroids.[10]

In Western societies, acupuncture has two schools of practice: classical and formula.[11] *(See Table 1 for a list of the different types of acupuncture and acupressure.)* Classical acupuncturists are TCM practitioners who evaluate patients individually and vary acupuncture points for the same condition between patients. This school views acupuncture as inseparable from other elements of TCM, such as pulse diagnosis, yoga, and herbal remedies. The formula school uses standard acupuncture points for specific disorders and isolates acupuncture from other TCM therapies. This approach makes possible the design of randomized controlled trials (RCTs), although classical acupuncturists criticize this as a "recipe book" form of acupuncture, unrelated to real practice.[11] This controversy hinders any attempt to objectively demonstrate whether acupuncture is effective by conventional standards.

Nevertheless, several RCTs have been conducted using formula acupuncture for sports-induced tendonitis. Tennis elbow (or lateral epicondylitis) is a relatively common form of tendonitis. Half of all tennis players experience prolonged pain and disability from this injury, which also affects almost 1% of industrial workers.[12] Many therapies have been studied for treating this type of tendonitis, of which acupuncture is a commonly recommended alternative. A total of 48 patients who experienced tennis elbow pain for 15 months, on average, were randomly assigned to receive true acupuncture or sham acupuncture.[9] After one treatment, 79.2% of the true acupuncture group experienced at least a 50% reduction in pain, compared to 25% of the control group ($P < 0.01$). Most patients who benefited from acupuncture reported 70% relief that lasted 20 hours, on average. The relief experienced from the placebo lasted 1.4 hours, which was significantly less ($P < 0.001$).

Conventional therapy for tennis elbow generally consists of steroid injections, which often are effective. However, some people are refractory to steroids, or receive only short-lived relief. In a study of 34 patients for whom steroid injections had previously been of little benefit, acupuncture brought complete relief of pain for 21 patients.[13] Treatment consisted of five to eight acupuncture needles around the elbow and was given on average six times over four weeks. When compared to a control group of 26 patients who received steroid therapy, the acupuncture group did

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Table 1

Types of acupuncture and acupressure

Acupuncture: The use of fine needles at specific points on the body to balance or correct the imbalance or circulation of energy flow (qi).

Moxibustion: The burning of an herb or needle at an acupuncture point.

Electroacupuncture: The use of electric stimulation at acupuncture points.

French Energetic Acupuncture: The use of needles as electrodes to release blockage of electrolytes.

Five Element Acupuncture: The use of wood, fire, metal, water, and earth as five basic qualities to describe personality and organ dysfunction and aid in the choice of acupuncture points.

Auricular Acupuncture: A French tradition of using ear acupoints.

Myofascial Acupuncture: The palpation for tender points along meridians (energy pathways), which signify a blockage of energy flow.

Acupressure: The use of deep fingertip pressure massage along meridians.

Korean Hand Acupressure/Acupuncture: The use of needles or pressure on pressure points of the hands and feet.

Shoni Shin: A Japanese system of acupuncture that uses small tools such as tapping needles, press needles, and round edged rakes instead of more traditional acupuncture needles.

Source: Nicholson S. Alternative medicine: Acupuncture. *Clinician Reviews* 1999;9:87-92.

significantly better ($P < 0.005$). Four patients receiving steroid therapy reported worsening of their condition, while none receiving acupuncture reported worsening. The duration of pain relief was the same for both groups.

Other forms of tendonitis also have been treated with acupuncture. One study used a different form of placebo therapy consisting of a specially designed blunt needle that gave the patient the sensation of pricking the skin, but did not penetrate the skin.[14] Fifty-two patients with rotator cuff tendonitis were randomly assigned to true or sham acupuncture groups. Patients received eight treatments over four weeks using TCM acupuncture points. Those receiving true acupuncture reported significantly less pain using the Constant-Murley rating system ($P = 0.014$). A similar number of patients in both groups reported adverse effects such as fainting, headaches, dizziness, increased muscle tension, and loss of strength in the legs.

In conclusion, although only a limited number of studies have examined the use of acupuncture for tendonitis, the results generally have been favorable. The analgesic effect of acupuncture is among its better-established indications, although controversy undoubtedly will continue until its mechanism of action can be better elucidated. Especially when conventional therapy for sports tendonitis proves ineffective, a trial with acupuncture appears warranted. Acupuncture is relatively free of serious adverse effects, although classical acupuncturists warn that symptoms may become worse before they improve. In a review of 16 acupuncture studies, 23 of the 320 subjects (7%) reported side effects such as fainting, earache, mild nausea, and dizziness.[11] Case reports of more serious adverse effects have been published, although these typically involve the use of unsterilized needles or pneumothorax from needle insertion to the chest wall.[15] Caution should be exercised in choosing a practitioner since great variability exists in the training and experience of acupuncture practitioners. *(See Table 2 for a list of acupuncture organizations.)*

Table 2

Acupuncture organizations

National Acupuncture and Oriental Medicine Alliance, 638 Prospect Ave., Hartford, CT 06105-4298. Telephone: (203) 586-7509.

American Association of Acupuncture and Oriental Medicine, 433 Front St., Catasauqua, PA 18032. Telephone: (610) 266-1433.

American Acupuncture Association, 4262 Kissena Blvd., Flushing, NY 11355. Telephone: (718) 886-4431.

American Academy of Medical Acupuncture, 4929 Wilshire Blvd., Suite 428, Los Angeles, CA 90010. Telephone: (323) 937-5514.

Applied Kinesiology

A chiropractor named George Goodheart noted in 1964 that weaknesses in certain muscles could be corrected by massaging seemingly unrelated muscles. Various muscle groups are believed to be connected to other muscles and organs through interconnected "energy circuits" similar in concept to the meridians found in traditional Chinese medicine. This led to associations between each muscle and acupuncture points. In addition, applied kinesiology holds that each muscle is associated with a specific nutrient. (Applied kinesiology should not be confused with kinesiology, which is the scientific study of the principles of human movement.) Thus, of particular relevance for athletes, a muscular weakness may be traced by a practitioner of applied kinesiology to dysfunction in an organ or gland, which may be related to a nutritional deficiency.[16] Table 3 provides some examples of the relationships proposed by applied kinesiology to exist between various muscles and nutrients, organs or glands, the nervous system (for spinal manipulation), and acupuncture points. Applied kinesiology claims that these connections apply in only one direction. Thus, localized injury to a muscle will not affect its associated gland or organ.

If an athlete were concerned about muscular weakness, applied kinesiology would involve the application of various

Table 3

Applied kinesiology relationships

Muscle	Nutrient	Organ/Gland	Spine	Acupuncture Point[16]
Abdominal muscles	L-glutamine	small intestine	T5-12	SI 3, 19
Deltoids	vitamin C	lungs	C5, 6	LU 9
Gastrocnemius	vitamin C, pantothenic acid	adrenals	S1, 2	CX 9
Hamstrings	vitamin E	rectum	L5-S	LI 11, 20
Quadriceps	L-glutamine	small intestine	L2-4	SI 3, 9
Tricepts brachii	vitamin A, chromium	pancreas	C7, 8	SP 2, 3

challenges and muscle testing. These terms have specific meanings in applied kinesiology that differ from those in conventional medicine. The challenges are better known for their role in the diagnosis of allergies and dietary insufficiencies. Patients are asked to hold their arms out straight and practitioners apply firm but gentle pressure with their fingers to the patients' arms. If the resistance to this pressure feels normal to the practitioner, the patient's systems related to that arm muscle is considered normal. However, a dysfunction would be indicated if the patient's muscle feels weak to the practitioner. Further tests then are carried out on other muscles to pinpoint the problem.

Once a dysfunction is identified, the second phase is to determine the source of the problem. According to applied kinesiology theory, the etiology lies in either a dysfunctional organ or a nutritional imbalance. The muscle testing is repeated, except this time the patient holds or tastes a sample of various nutrients or minerals. Changes in the detected muscle strength from the earlier muscle testing help identify the role of that nutrient in the dysfunction. Three outcomes are viewed as possible:[16]

- If the initial test revealed muscle weakness, and the subsequent test with the nutrient restored the strength to normal, that nutrient would benefit the patient.
- If the muscle strength was normal in the initial test, and now became weaker with the nutrient, the patient should not use it as a supplement.
- If no change in muscle strength occurs, the nutrient is benign and others should be tested.

The result of this approach is a highly individualized regimen of recommended and discouraged nutrients and supplements. This individualized attention is well received by many. The approach also is holistic.

Another aspect of applied kinesiology involves the use of emotional and mental challenges. The testing procedures are similar, except that instead of using nutrients, certain words or images are used to elicit responses. If the athlete thinks of a certain situation or person, and the practitioner detects weakening of the muscles, alternative thoughts or images are suggested until the muscle strength returns to normal.[16] Thus, the replacing of one thought or image by another is believed to restore normal muscular function and permit maximal athletic performance.

Although the general approach to applied kinesiology forms a consistent viewpoint, very little if any of the theory has been verified scientifically. No compelling scientific evidence has been published demonstrating that applied kinesiology works for diagnosing or treating any health problems. While anecdotal successes are reported, a search of MEDLINE revealed no controlled studies of the effectiveness of diagnosing or treating muscular weakness with applied kinesiology. A major problem with the approach is the subjective nature of the muscle testing. The outcomes have been shown to vary depending on the amount of pressure applied to the muscle, the angle at which pressure is exerted, and whether the patient or the practitioner pushes first. Practitioners have attempted to develop instruments to standardize the muscle-testing method, with no success.

One published study assessed the consistency between different practitioners.[17] Three practitioners, all with at least 10 years of experience using applied kinesiology, participated in two separate trials. In the first, they tested 32 healthy individuals for the strength or weakness of their piriformis and hamstring muscles. The practitioners demonstrated significant agreement with the piriformis muscles, but not with either of the hamstring muscles. In the second part, 53 subjects were examined for the strength or weakness of their pectoralis and tensor fascia lata muscles. Again, significant agreement occurred with the diagnoses for one muscle (pectoralis), but not for the other. This study demonstrated the problems with lack of consistency among even experienced practitioners.

Another study demonstrated more significant limitations with this therapy. Eleven subjects were evaluated for their nutritional status regarding thiamin, zinc, vitamin A, and ascorbic acid.[18] Three experienced practitioners examined all subjects, who also were evaluated using standard laboratory tests for those nutrients. No statistically significant correlation was found among the results of the three practitioners, nor between their results and those of the lab tests. A computerized isometric muscle testing apparatus also revealed no correlation between its results and those of the applied kinesiology muscle testing. Finally, the subjects were randomly assigned to receive supplements of whichever nutrients applied kinesiology determined they lacked or a placebo. No statistically significant differences were found between those who received the placebo and those who received the actual nutrient. The authors concluded that applied kinesiology was no more reliable than random guessing.

Applied kinesiology is a complicated system that involves much personal attention. When athletes are unable to understand their poor performance, applied kinesiology holds out some hope for identifying a cause that can be corrected with relative ease. However, the small number of scientific studies that have been published on this therapy offer very little support for its effectiveness or reliability. Although the therapy is relatively benign, following the recommendations may lead to inaccurate nutritional advice. Some nutrients, which the athlete actually needs, may be discouraged, and others may be taken in amounts beyond what is necessary. There is no scientific evidence to recommend the use of applied kinesiology for any problem athletes may have.

Chiropractic

Chiropractic manipulation is based on the theory developed by Daniel David Palmer during the 1890s. His primary assumption was that all illness has its origins in how well the spine and joints are aligned. Palmer was initially interested in magnetic healing, but is reported to have manipulated the spine of a man who had been deaf for 17 years and completely restored his hearing. Although Palmer coined the term chiropractic from the Greek words *cheerio* and *prakrios*, which mean "done by hand" or "manipulation," the general approach is said to be traceable to Hippocrates who stated, "Look well to the spine for the cause of disease."

Although chiropractic manipulation has been controversial throughout the twentieth century, it has grown in popularity and acceptability *(see Table 4)*. Chiropractors are licensed in all 50 states of the United States, and 45 states have mandated benefits for chiropractic services.[19] One of the more controversial aspects of chiropractic care relates to its proposed explanation for musculoskeletal pain and discomfort. The underlying causes are believed to be mechanical lesions on the spine and peripheral articulations that interfere with the normal activity of the nervous system.[16] This interference can lead to physical, chemical, or emotional dysfunction. These lesions generally are called "subluxations" and can be felt manually by the trained practitioner. Whereas in conventional medicine a subluxation refers to a partial or incomplete dislocation, a chiropractic subluxation refers to any form of dysfunction within a joint's normal range of motion.[16] The subluxation also can be referred to as a spinal joint strain or sprain, which results in local and referred pain, muscle spasm, and reduced motion or misalignment at the affected joint.[19]

Table 4

Alternative therapies most commonly reimbursed by health insurance organizations

Therapy	Organizations Reimbursing
Chiropractic therapy	37%
Acupuncture/acupressure	16%
Nutrition therapy	13%
Massage therapy	10%
Stress management	10%
Biofeedback	3%
Herbal supplements	2%
Homeopathy	2%
Naturopathy	2%

Source: Albertson D. Alternative medicine benefits on the rise. *Employee Benefit News* 2000;14:60.

The dysfunction can be treated by either of two approaches, called adjustments or manipulations. A long-lever manipulation uses high-velocity forces on a part of the body that is relatively far from the dysfunction. The short-lever technique applies high-velocity thrusts directly onto the area of dysfunction. Both techniques result in the characteristic popping or cracking sounds of chiropractic adjustments. A procedure related to manipulation is called mobilization, in which pressure is applied to the joint but without the application of the chiropractic thrust.

Hundreds of studies have examined the efficacy and safety of chiropractic manipulation, and these have resulted in more than 50 systematic research reviews. However, little attention has been given to the use of chiropractic specifically for sports-related injuries, in spite of the growing use of chiropractic by athletes.[19] The best-supported uses of chiropractic are for low back and neck pain, but not necessarily pain resulting from sports injuries. However, reviews have consistently pointed out that many of the primary research studies have significant methodological flaws that make overall conclusions very difficult. In spite of this, there is growing consensus that chiropractic manipulations are effective in relieving at least some forms of low back pain.[20]

When compared to treatment by primary care physicians, physical therapists, or neurosurgeons, little difference has been noted in their relative effectiveness or speed of recovery, although patients generally report being more satisfied with chiropractors. One study found no significant differences between physical therapy and chiropractic manipulation on all measured outcomes of relief of low back pain.[21] The benefits of either therapy were only marginally better than that experienced when patients were simply provided an educational booklet. However, the cost of the booklet was about one-third of the cost of either therapy (which cost practically the same).

The evidence for chiropractic treatment of neck and shoulder pain is much less convincing than that for low back pain.[22] In addition, one review found 32 case reports of death following manipulation of the cervical spine.[23] While the risk of serious injury from chiropractic manipulation cannot be estimated because of the unknown number of total manipulations, there appears to be greater risk of adverse effects when manipulation is carried out higher on the spine. Mobilization, as opposed to manipulation, seems to carry lower risks, but also may be less effective.[19]

Many professional, collegiate, and amateur teams now incorporate chiropractic care into their sports medicine

programs.[16] Athletes involved in contact sports and those that include jarring movements are particularly susceptible to back and joint problems that can be very painful. Many report effective, rapid relief from chiropractic manipulation. Controlled clinical trials have not been conducted for many of the ways chiropractic care is used by athletes.

One recent study did find that chiropractic manipulation of the ankle after inversion sprains produced significantly greater improvement than ultrasound therapy.[24] Both groups showed improvements in pain reduction, ankle range of motion, and ankle function. Thirty patients were randomly assigned to either treatment; because of the intervention, the study was not blinded.

Studies on the long-term effectiveness and safety of chiropractic care are needed, especially because athletes often receive on-going manipulation for the musculoskeletal and joint pain associated with their sports. Although the short-term relief is welcome, the long-term effects should be investigated.

Magnet Therapy

Magnet therapy is based on the belief that permanent magnets have healing properties. The concept dates back to Paracelsus, the physician and alchemist who lived in the 1500s. He reasoned that since magnets attract iron, they also might attract toxins or diseases and remove them from the body. At the same time, though, he wrote that while the course of a disease could be influenced by many factors, "The imagination produces the effect." Probably the best-known proponent of magnetic healing was Franz Mesmer, an 18th-century Austrian doctor. Mesmer claimed that all illness had its origin in problems related to the flow of "animal magnetism." He moved magnets around a patient's body, allegedly to correct the flow of this magnetic energy. However, Mesmer later modified his therapy, believing that the magnets were not essential and developing a form of hypnosis (from which we get the term "mesmerized").

Mesmer moved to Paris to practice his form of hypnotism and magnetic healing, and soon attracted professional attention. At the urging of King Louis XVI, the French Royal Academy of Medicine appointed a committee to evaluate Mesmer's claims. The report produced by this committee (with Benjamin Franklin as the committee's chairperson) describes some of the first documented "blinded" tests. These involved groups of women who literally were blindfolded. When the women could see they were being treated with "magnetic energy," they reported sensing the energy. When they were blindfolded, there was no correlation between when they thought they were being treated and when they actually were being treated.

The committee concluded that the patients believed the therapy worked because of a complicated set of conditions that today would be grouped under the placebo effect. The report stated that any observed effects were explained better "by the touches of the operator (i.e., therapist), the excited imagination of the patient, and by the involuntary instinct of imitation."[25] Although not without limitations compared to modern clinical tests, these studies formed the beginnings of what would later be called the single-blind method in clinical research.[26] Many agreed with Thomas Jefferson, who declared, upon reading the commission's report, "Animal magnetism is dead, ridiculed."

Yet since that time, magnetic therapy has gone through cycles of ridicule followed by resurgence in interest. Currently, we are in the midst of a phase of popularity. Developments in magnet engineering have allowed permanent magnets to be made in many shapes and sizes. This allows magnets to be molded to fit onto various parts of the body, or shaped into insoles for insertion into shoes. A huge industry has materialized selling magnets in mattresses to promote sleep and ease back pain, in insoles to prevent tiredness from walking or standing, and in jewelry for promoting general health. Athletes are attracted to magnets for all of these purported benefits. One particular company increased its annual U.S. sales of magnets from $3 million in 1989 to $150 million in 1997.[27]

The form of magnet therapy that places permanent magnets next to the body must be clearly distinguished from pulsating electromagnetic field (PEMF) therapy, which will be described in a subsequent section. The pulsing of the magnetic field is essential for this effect and thus is completely different from a permanent magnet. However, promotional materials for permanent magnets sometimes inappropriately cite the promising results of PEMF therapy to support their approach to magnet therapy.

Permanent magnets are believed to act therapeutically by promoting blood flow to the injured tissues. Some claim this is due to attraction of iron in red blood cells, but this is highly unlikely because of the way individual iron atoms are held within hemoglobin in the blood.[28] Also, with the advantage of newer permanent magnets being thin and malleable comes a significant limitation: The magnetic field drops off rapidly. This can be seen in the way refrigerator magnets can hold very few sheets of paper. The magnetic field of many magnets used in therapy would barely penetrate clothes or skin.[27] This makes the influence of magnets on blood flow or any other metabolic process very questionable. Nevertheless, even if the mechanism of action is not understood, a therapy's effectiveness still can be tested in clinical trials.

Athletes use magnets primarily to relieve the aches and pains of exercise and competition. Interest among golfers has been particularly high. This popularity received a major boost when a well-controlled study was published in a mainstream medical journal in 1997.[29] This study reported better pain relief from magnets than from a placebo in patients with chronic postpolio pain of a muscular or arthritis-like type. The 50 patients were randomly assigned to active or control groups, and a device was placed over a pain trigger point for 45 minutes. Patients in both groups reported significant pain relief, but the group treated with permanent magnets had significantly greater relief than the control group ($P < 0.0001$). This benefit contrasts with the results of most other studies.

One of the few earlier double-blind studies involved 101 subjects with shoulder and neck pain.[30] The patients were

randomly assigned to wear either a magnetic necklace or a control necklace. Patients wore the necklace 24 hours per day for three weeks. At that time, both groups of patients reported decreased frequency and intensity of pain, but there was no statistically significant difference between the magnetic necklace and the nonmagnetic necklace.

A more recent randomized, double-blind study examined 20 patients with chronic low back pain.[31] Permanent magnets or a similar placebo were worn for six hours per day, three days a week, for one week. After a wash-out period, subjects crossed over to use the other device. No statistically significant differences were found between the two groups.

Another popular use of magnets is in insoles for the relief of foot and heel pain, and to relieve generalized fatigue. A double-blind study randomly assigned 34 patients with heel pain to wear either a magnetic or nonmagnetic insole.[32] Sixty percent of the patients in both groups reported improvement, with no statistically significant differences between the two groups.

A preliminary report has been published in which magnetic insoles showed some benefit in treating older adults with postural instability.[33] Twenty-eight adults, 14 older and 14 younger, were randomly assigned to wear magnetic insoles for a single test, and nonmagnetic insoles in another test. Only the older adults showed a significant reduction in swaying when wearing the magnetic insoles.

The popularity of magnets for many types of healing has waxed and waned over the centuries. Many people, including many athletes, are convinced that magnets are effective in relieving a variety of conditions, especially generalized aches and pains. The result has been an industry with annual sales of more than $5 billion. However, simply wearing a belt, pad, or insert may be enough to produce a beneficial effect, especially since many of the conditions for which magnets are recommended are strongly influenced by the placebo effect. Nevertheless, at least one study has found magnets more effective than placebo. However, given the lack of a plausible mechanism of action and the results of several studies finding magnets no more effective than placebo, skepticism toward the numerous claims made regarding magnet therapy is warranted until the one positive study is replicated and confirmed.

Massage Therapy

Massage therapy has long been a part of sport, both prior to competition as part of an athlete's warm-up and after exercise for the prevention or treatment of muscle soreness and injury. Among British athletes at the 1996 Olympic Games in Atlanta, 47% of all the treatments given to athletes from all sports consisted of massage.[34] The role of massage in medicine has long been recognized, with Hippocrates having written, "The physician must be experienced in many things, but assuredly in rubbing."

Athletes use several types of massage, with effleurage, petrissage, and tapotement being the most common techniques.[35] *(See Table 5 for a list of the different types of massage.)* Effleurage involves long, gliding strokes along the length of the muscles, and can be either superficial or deep. Petrissage is the name given to the kneading or muscle rolling aspects of massage. Tapotement involves light, rapid blows to the muscle using the therapist's relaxed hands, and

Table 5

Types of massage

Cranio-Sacral: is a technique for finding and correcting cerebral and spinal imbalances of blockages that may cause sensory, motor, or intellectual dysfunction.

Deep Tissue: releases the chronic patterns of tension in the body through slow strokes and deep finger pressure on the contracted areas, either following or going across the grain of muscles, tendons, and fascia. It is called deep tissue, because it also focuses on the deeper layers of muscle tissue.

Effleurage: is a stroke generally used in Swedish massage treatment. This smooth, gliding stroke is used to relax soft tissue and is applied using both hands.

Friction: is the deepest of Swedish massage strokes. This stroke encompasses deep, circular movements applied to soft tissue causing the underlying layers of tissue to rub against each other. The result causes an increase in blood flow to the massaged area.

Myofascial Release: is a form of bodywork that is manipulative in nature and seeks to rebalance the body by releasing tension in the fascia. Long, stretching strokes are utilized to release muscular tension.

Petrissage (also called kneading): involves squeezing, rolling, and kneading the muscles and usually follows effleurage during Swedish massage.

Reflexology: is based around a system of points in the hands and feet thought to correspond, or "reflex," to all areas of the body.

Rosen Method: utilizes gentle touch and verbal communication to help clients release suppressed emotions and subsequently muscular tension.

Shiatsu and Acupressure: are Oriental-based systems of finger pressure that treat special points along acupuncture meridians (the invisible channels of energy flow in the body).

Sports Massage: focuses on muscle systems relevant to a particular sport.

Swedish Massage: is a system of long strokes, kneading, and friction techniques on the more superficial layers of the muscles, combined with active and passive movements of the joints.

Tapotement: is executed with cupped hands, fingers, or the edge of the hand with short, alternating taps to the client.

Trigger Point Therapy (also known as Myotherapy or Neuromuscular Therapy): applies concentrated finger pressure to "trigger points" (painful irritated ares in muscles) to break cycles of spasm and pain.

Source: American Massage Therapy Association. Available at: www.amtamassage.org/about/terms.htm.

is the most common technique used in pre-competition massage.

Massage is reported to assist in recovery from muscle injuries through some combination of increased blood and lymph flow, reduced muscle tension, release of biochemical healing factors, pain relief, and stimulation of the immune system.[16] In spite of the widely held belief that massage increases muscle blood flow, recent ultrasound and radiotracer studies have not confirmed this claim.[36] The same result was found regardless of the massage technique used or the size of the muscle involved. Instead, light exercise was found to increase blood flow more significantly, and therefore was recommended over massage for pre-exercise warm-up or post-exercise muscle recovery.

Similar types of studies have failed to demonstrate that massage increases lymph flow, although this measurement is difficult to make accurately.[35] In fact, very little evidence supports the belief that massage helps eliminate the biochemicals most commonly associated with muscle soreness and damage. For example, several studies have failed to demonstrate that massage increases the rate of removal of lactate from muscles after exercise. One study found that 10 minutes of post-exercise massage was no more effective at removing lactate than passive rest, and light exercise was significantly more effective than both at reducing blood lactate levels.[37]

One of the symptoms of muscle damage is prolonged loss of strength, which can exist even before soreness is noted and persist after soreness diminishes.[38] Massage is reported to be beneficial in aiding recovery from damage related to muscle strength loss. However, reviews of the controlled research in this area have found contradictory results. Some studies have found massage beneficial, some found no effect, and others found it slowed recovery.[39]

Massage often is recommended for athletes to prevent post-exercise soreness and to shorten the recovery period after intense exercise. A study using underwater jets of warm water to massage athletes' legs has received considerable attention because of its beneficial results.[40] Fourteen elite track and field athletes underwent five days of intense training during which their performances were expected to decline due to fatigue and muscle soreness. The athletes were randomly assigned to two groups; one group received warm-water massage after each training session and the other group did not. The groups were then crossed over. No significant difference was found in the levels of muscle soreness, but the athletes showed significantly less performance deterioration during the weeks they received the warm-water massage ($P < 0.05$). However, this technique differs significantly from manual massage, and the benefits may have been due to the higher temperature of the water, or to being immersed in water.

Delayed-onset muscle soreness is a significant problem for athletes, leading to slight stiffness or even debilitating pain. Biomechanical changes undertaken to compensate for the soreness may lead to other injuries. This soreness tends to appear between eight and 24 hours after exercise, peaks at around 48 hours, and dissipates over the course of the next few days.[41] Several studies administering massage immediately after exercise, or 24-48 hours later, have found it ineffective in reducing muscle soreness. However, a study using massage two hours after exercise found significantly less soreness in those treated compared to the control group ($P = 0.0477$).[41] Biochemical markers for tissue damage also were higher in the control group.

A recent review of this application of massage found seven controlled trials.[42] Most of the studies had serious methodological flaws. All but one had fewer than 20 subjects. The results were variable, although there did seem to be a pattern indicating massage was effective in reducing muscle soreness. However, the review concluded that "its effectiveness has not been demonstrated convincingly." Although not limited to athletes, massage as a treatment for low back pain has gained much popularity. Again, the controlled research available to support this use is scant and of poor methodological quality.[43]

In contrast to the lack of conclusive evidence for massage's effect on muscle healing and recovery, a growing body of evidence supports its benefit for connective-tissue, tendon, and collagen healing.[35] A recent animal study has demonstrated beneficial effects on tendonitis using a form of massage called augmented soft-tissue mobilization (ASTM).[44] This technique uses specially designed solid instruments to apply considerable pressure to the injured tissue. This study showed significantly more fibroblasts in the injured tissues treated by ASTM ($P < 0.05$). Also, greater response was seen when the pressure applied was greater. If this finding is confirmed in athletes, it may explain the variability found in massage studies as the applied pressure varies considerably among therapists.

In conclusion, massage is likely to remain popular among athletes. It is primarily used to prepare for competition and

Table 6

Choosing a massage therapist

When selecting a massage therapist, the American Massage Therapy Association (AMTA) recommends asking the following questions:

- Where did you receive your massage therapy training?
- Are you a graduate of a training program accredited by the Commission on Massage Therapy Accreditation or that is a member of the AMTA Council of Schools?
- Are you certified by the National Certification Board of Therapeutic Massage and Bodywork?
- Do you have advanced training in any specific massage techniques?
- Are you currently licensed as a massage therapist in this state (if applicable)?
- Are you a member of the American Massage Therapy Association?

Source: American Massage Therapy Association. Available at: http://www.amtamassage.org/news/presskit.pdf.

prevent muscle soreness and injury. These uses are more firmly based on anecdotal evidence and tradition, rather than scientific studies. However, massage has a relaxing effect that can be of clear benefit in preparation for competition and in facilitating healing in general. Meanwhile, controlled studies are revealing that a form of high-pressure massage (ASTM) may have more clear-cut benefits in treating tendonitis and other connective-tissue injuries. Given that the popularity of massage among athletes is unlikely to wane, better studies are needed to ensure that the best forms of massage are used for specific muscle or tendon conditions. *(See Table 6 for a guide to choosing a massage therapist.)*

Pulsed Electromagnetic Field Therapy

Pulsed electromagnetic field (PEMF) therapy is based on the well-established fact that biological structures contain electric dipoles. All living organisms contain endogenous electric, magnetic, and electromagnetic fields that may be affected by externally applied fields.[45] The endogenous fields play an important role in tissue growth and repair, which has led to much speculation, and some experimentation, concerning the potential benefits of electromagnetic fields in healing.

Although some would question the inclusion of this therapy within complementary and alternative medicine, many aspects of this approach have not yet become widely accepted within conventional medicine.[46] An understanding of developments within this field is important because of the frequent mention of "energy fields" among proponents of alternative medicine. The developments with electromagnetic field therapy are sometimes cited to support the efficacy of other therapies.[28] If these other therapies involve nonphysical "life energies" or static magnetic forces, these associations are unwarranted. Clear distinctions should be drawn between therapies based on electromagnetic fields and forces and those based on unrelated fields and forces.

Pulsed electromagnetic fields can be generated at different frequencies and power outputs. PEMF therapy must be clearly distinguished from the use of static magnets, which have been considered in an earlier section. The pulsed field is believed to alter the cell membrane potential that influences the flux of ions in and out of the cells.[45] Repair of damaged tissues involves much proliferation and migration of many cells, all of which could be influenced by these changes.[46] The apparatus used in PEMF therapy consists of copper wires twisted into a coil that is then shaped to fit the area of treatment. Straps hold the coiled wire in place, which usually is used for several hours each day for a number of weeks. The wires are connected to a pulse generator that is set to deliver the appropriate frequency and power output. Much variability occurs in the frequency, power output, and duration of treatment recommended.

One of the first applications of PEMF was its use in promoting the healing of bone fractures, especially those that were slow to respond to conventional care. A substantial body of literature has examined the role of PEMF in calcium metabolism and bone healing. A multicenter, randomized, double-blind trial involved 45 patients with delayed bone union.[47] All were immobilized in plaster casts; 20 received PEMF units and 25 received control units. Healing was assessed using x-rays read by a blinded radiologist and an orthopedic surgeon. After 12 weeks, nine of the 20 PEMF fractures showed union, whereas only three of the 25 control fractures showed union. This difference was statistically significant ($P = 0.02$).

A review of the controlled trials of PEMF with delayed or non-uniting bone fractures showed it to be essentially equivalent to surgical repair.[48] Many of these studies had high success rates for PEMF with fractures that had previously been treated unsuccessfully by surgery. Overall, PEMF had an 81% success rate, compared to 82% for surgery. However, PEMF is non-invasive and thus spares patients the risks of surgery and the additional healing time.

PEMF therapy has been examined with a number of specifically sports-related conditions, but few studies are available for any one condition. Rotator cuff tendonitis is a very common form of shoulder injury. A double-blind study was conducted with 29 patients whose rotator cuff tendonitis was refractory to conventional therapy, including steroid injections.[49] After four weeks, the patients receiving PEMF reported significant improvements in pain levels compared to the control group ($P < 0.02$). For a subsequent four weeks, both groups were given PEMF, and there was no significant difference in pain levels between the two groups.

Another double-blind study examined the impact of PEMF on 30 patients with chronic tennis elbow.[50] Pain levels were measured using various lifting and twisting procedures every two weeks for eight weeks. Statistically significant differences were found in favor of PEMF at six weeks only ($P < 0.05$), and not at the conclusion of the study. A more recent animal study found beneficial effects from PEMF on experimentally induced Achilles tendonitis.[45] The tendons of those animals treated with a pulsed magnetic field (PMF) had less inflammation and were more histologically normal. PMF and PEMF are believed to produce similar effects. This study also used different field frequencies, with PMF 17 Hz being the most beneficial, PEMF 46 Hz showing better results later in the study, and PMF 50 Hz being most beneficial during the acute phase of inflammation.

The latter results show how much is yet to be learned about PEMF therapy before it can be widely recommended. More research is needed to determine the best frequency to use, and whether this should be varied over the course of treatment. The most effective duration of exposure to the field also is poorly understood. There may be differences in the responses of various tissues and types of injuries to the various fields. Until more is known, PEMF may be useful on an experimental basis when sports injuries are refractory to conventional therapy.

Water Intake

Water is the most important natural substance that athletes need to ingest. Yet its importance often is overlooked even by professional athletes, which then can lead to a variety of injuries, including death. Water plays many roles in the body,

but for athletes, one of its most crucial ones is in heat regulation. Working muscles generate much heat, which must be eliminated. Sweating dissipates some of this heat, but the fluids lost this way then must be replaced. If fluid consumption is not adequate, the risk of dehydration increases. *(Table 7 lists the most common symptoms of dehydration.)*

Athletes can lose 2-3 liters of water per hour if exercising vigorously in hot weather. As the body dehydrates, blood volume drops, requiring the heart to pump faster to get oxygen around the body. Body temperature increases further, the athlete begins feeling more tired and performance starts to deteriorate. More severe dehydration can lead to heat exhaustion and to heat stroke, which can be fatal *(see Table 8)*.

For normal sedentary adults, eight to ten 8-ounce glasses of fluids per day are commonly recommended to replace normal water loss. Athletes require much more, especially when exercising in warm weather. Fluids should be consumed prior to, during, and after exercising, although adequate consumption during exercise can be awkward, if not impossible, during some sports. For endurance events, fluid loss can be 2 L/hr, while maximal stomach emptying averages 1 L/hr.

The following general guidelines can be helpful:[51]

- About 20 minutes before exercising, drink 12-20 ounces of fluids.
- During exercise, drink 4-8 ounces every 20 minutes.
- After exercising, athletes should consume about 20 ounces of fluids for every pound of body weight lost. Every pound lost represents a loss of 15 fluid ounces.

Athletes should not use their thirst level to indicate whether or not they are adequately hydrated. Calculating how much water is lost on average and drinking the needed replacement fluids in the hours following exercise is a more reliable guide to adequate rehydration.

Table 7

Common symptoms of dehydration

- Thirst, dry mouth
- Dark-colored urine
- Flushed skin
- Reduced performance, weakness, fatigue, headache
- Labored breathing
- Increased breathing and pulse rate
- Increased body temperature
- Nausea, vomiting
- Muscle spasms, dizziness, delirium
- Poor circulation, failing kidney function
- Heat stroke: thermoregulatory failure; dry, hot skin; lack of sweat

Injury Prevention Strategies

Scientific research into the prevention of sports injuries is still in its infancy. However, some patterns are beginning to emerge. Stretching prior to exercise appears to have some benefit in preventing muscle strains. However, two cautions are needed here. Stretching must be limited, as muscle injury experiments in animal models have demonstrated. When muscles were stretched 10 times to 50% of their maximum, strains were less prevalent.[5] However, when the muscles were stretched to 70% of maximum, strains occurred more frequently. Recent research is establishing that the stretching itself may not be what is most important, but the way stretching contributes to warming up.[52] When stretching is the only component of a warm-up, the incidence of muscle strains is unchanged. But when stretching is one component of an overall warm-up prior to vigorous exercise, muscle strains were reduced. Exactly what leads to an effective warm-up is still a matter of some debate, although it seems to involve increasing muscle temperature and stretching only within certain limits.[5]

An important aspect of preventing injuries is to avoid common training errors.[2] Continuous, high-intensity training can lead to overuse injuries, as can the failure to alternate hard training days with easy (recovery) days. Another error is to increase the training intensity too rapidly. Among runners, for example, a 10% rule is commonly cited: A week's mileage should not increase by any more than 10% of the previous week's mileage.[2] A similar rule of thumb could be developed for other sports. When competitive athletes are recovering from injury, however, this schedule can be too prolonged, resulting in further loss of fitness. Nonetheless, the risk of re-injury warrants patience and close monitoring during recovery.

At the same time, remedial exercise with pain-free stretching and strengthening should be started as soon as possible to avoid unnecessary muscle atrophy.[12] Cross-training may be helpful here, where losses in cardiovascular fitness can be minimized by exercising muscles that are not injured. Physicians who call on injured athletes to cease exercising completely may end up losing their opportunity to help the athlete. Some athletes avoid physicians when injured, on the assumption the physicians will just tell them to rest and take pain pills. Among 364 runners who competed in the Montreal International Marathon, 21% suffered an injury while training for the event.[53] Of those injured, 69% consulted a physician and almost half of these were told to stop running. More than one-third disregarded this advice, on the belief that the doctor "knew nothing about running." However, 36% of those who suffered injury while training were still injured on the day of the race, and competed anyway.

Clearly, telling injured athletes to stop training may not always be the best advice, either physiologically or psychologically. The advice often may be ignored anyway, leading to further breakdown in communication between physician and athlete. If your patients include athletes, keeping them active and staying apprised of developments in the treatment of common sports injuries will be beneficial for all involved.

Athletes also are susceptible to other, less-common training errors, including the use of inadequate or worn-out equipment, training on inappropriate surfaces, or poor technique.[2] Although attention often is focused on training, an athlete's

Table 8

Heat-stress index for evaluating risk of heat injury[51]

Relative Humidity	Air Temperature (°F)										
	70	75	80	85	90	95	100	105	110	115	120
	Heat Sensation (°F)										
0%	64	69	73	78	83	87	91	95	99	103	107
10%	65	70	75	80	85	90	95	100	105	111	116
20%	66	72	77	82	87	93	99	105	112	120	130
30%	67	73	78	84	90	96	104	113	123	135	148
40%	68	74	79	86	93	101	110	123	137	151	—
50%	69	75	81	88	96	107	120	135	150	—	—
60%	70	76	82	90	100	114	132	149	—	—	—
70%	70	77	85	93	106	124	144	—	—	—	—
80%	71	78	86	97	113	136	—	—	—	—	—
90%	71	79	88	102	122	—	—	—	—	—	—
100%	72	80	91	108	—	—	—	—	—	—	—

Heat Sensation	Risk of Heat Injury
90-105	Possibility of heat cramps
105-130	Heat cramps or heat exhaustion likely; heat stroke possible
130+	Heat stroke a definite risk

performance also is influenced by the general activities in his or her life. Athletes must ensure they get adequate nutrition, hydration, and rest if they are to avoid injury and perform at the maximum of their potential.

Conclusion

Unfortunately, accidents happen and injuries will occur. Informed physicians can help athletes receive the care they need. When reduction in training is needed, the goal of returning the athlete to full training should, if possible, be clearly expressed. Although conventional medicine has much to offer the injured athlete, care must be taken to avoid simply masking the symptoms. Getting at the underlying causes will be essential to a full recovery. Some complementary and alternative therapies have little scientific evidence to support their use; others are demonstrating that they can play a role in helping injured athletes recover. Much more basic research is needed in this interesting area. To promote their best interests in the long run, athletes should be treated with therapies that are demonstrated to be effective and safe. ❖

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ALTERNATIVE MEDICINE ALERT™
A Clinician's Evidence-Based Guide to Alternative Therapies

Iron

ALTHOUGH MOST COMMONLY USED TO TREAT IRON DEFICIENCY, RECENT ATTENTION HAS focused on the possible association between high iron stores and heart disease. For instance, the incidence of heart disease seems to increase in women when monthly periods cease. In addition, researchers have suggested a possible association between low iron levels of people living in developing countries and their lower rates of heart disease. However, data from recent clinical studies have not provided convincing support for this relationship.[1]

Recommended Dietary Allowances (RDA)

6 mg/d for children 0-6 mo
10 mg/d for children 6 mo-10 y
12 mg/d for males 11-18 y
15 mg/d for females 11-50 y
10 mg for males 19 y and older
10 mg for females 51 y and older

Food Sources

Dietary sources of iron include beef, poultry, pork, shellfish, fish, fortified cereals, soybeans, beans, raisins, and cooked asparagus, broccoli, cabbage, peppers, spinach, and tomatoes.

Formulation and Dosage

- Iron supplements come in ferrous and ferric forms. The ferrous form is absorbed better by the body and is preferred for use in iron deficiency.
- The amount of elemental iron varies depending upon the iron formulation: 1 g of ferrous gluconate = 120 mg (12%) elemental iron; 1 g of ferrous sulfate = 200 mg (20%) elemental iron; 1 g of ferrous fumarate = 330 mg (33%) elemental iron.
- Although overall dietary iron absorption usually ranges from 10% to 15%, absorption can vary significantly depending on the person and the iron needs of the body.
- In iron deficiency anemia: adults, 50-100 mg elemental iron tid for six months; children, 4-6 mg/kg/d in three divided doses for six months. Iron deficiency in individuals with chronic bleeding disorders requires continuous iron therapy.

Mechanism of Action

- Iron is an essential trace mineral found in hemoglobin in red blood cells and myoglobin in muscle cells where it is required for oxygen and carbon dioxide transport.
- Iron is an electron carrier in cytochromes, is found in enzymes that assist biochemical reactions in cells, and is involved in the regulation of dopamine activity.

Clinical Uses

- To treat and prevent iron deficiency and iron deficiency anemia.
- To treat attention deficit disorder.
- To improve athletic performance in athletes who are iron deficient.
- To treat oral canker sores; the diets of patients with recurrent aphthous ulcers often are deficient in iron and a number of other nutrients.
- To treat Crohn's disease.
- To treat infertility in women who are iron deficient.
- To treat the consequences of menorrhagia.

Adverse Effects/Toxicity

- When normal iron storage sites are full, iron can accumulate in body tissues and organs, damaging the liver and intestines.
- The estimated lethal dose of iron is 180-300 mg/kg; however doses as low as 60 mg/kg also have been lethal and doses of 30 mg/kg have been associated with acute toxicity.
- Iron is the most common cause of pediatric poisoning deaths and acute toxicity can occur in children from ingestion of medicinal iron. Doses of 1-3 g of iron can be fatal to children younger than age six.
- Large doses of supplemental iron can cause constipation, dark stools, nausea, vomiting, and diarrhea. Adverse gastrointestinal effects may be avoided by gradually increasing to the full dose, taking the iron in divided doses, and taking supplements with meals.
- Iron overload is associated with several genetic and hemoglobin diseases, including hemochromatosis. Iron supplementation may accelerate the effects of these diseases and should be avoided.
- Because of the risks associated with iron overload, adult men and postmenopausal women who are not iron deficient should not take iron supplements.
- Individuals who require frequent blood transfusions also are at an increased risk of iron overload and should avoid iron supplements.
- Long-term use of high doses of iron can cause hemosiderosis that clinically resembles hemochromatosis.
- Iron can exacerbate peptic ulcer disease, regional enteritis, and ulcerative colitis.

Populations at Risk

- Women of childbearing age, pregnant women, older infants and toddlers, and teenage girls are at greatest risk of developing iron deficiency anemia.
- Patients with renal failure, especially those receiving dialysis, are at high risk of developing iron deficiency anemia.
- Iron deficiency is more common among women with heavy menstrual losses, minority women, women of low-income status, and women with more than one child.
- Women using an intrauterine device may have an increased risk of developing iron deficiency due to an increased risk of bleeding.
- Pregnancy increases a woman's need for iron due to increased blood volume, increased needs of the fetus, and blood losses that occur during delivery.
- Vegetarians who exclude all animal products from their diets may need supplemental iron.
- Individuals who engage in regular intense exercise may have an increased need for iron.

Interactions/Nutrient Depletion

- Use of oral iron preparations in premature infants with low serum vitamin E levels may cause hemolysis and hemolytic anemia. Vitamin E deficiency should be corrected before administering supplemental iron.
- When taken on an empty stomach, iron may decrease the absorption of zinc, calcium, and copper.
- Low vitamin A status can limit the body's ability to use stored iron and cause iron deficiency.
- Concomitant use of iron and vitamin C (in doses greater than 200 mg) can increase iron absorption. Separate doses to limit toxicity
- Iron absorption is decreased with concomitant use of antacids, calcium, soy, caffeine, proton pump inhibitors, ACE inhibitors, or H2-blockers, and in individuals with malabsorption diseases.
- Concomitant use of iron decreases the absorption of ciprofloxacin, fluoroquinolones, methyldopa, norfloxacin, ofloxacin, penicillamine, and thyroxine replacement therapy.
- Concomitant administration decreases absorption of iron and tetracyclines.
- Use of chloramphenicol may delay response to iron therapy.
- Concomitant administration with oral iron enhances the effect of erythropoietin on hemoglobin.
- The guaiac test for occult fecal blood may give a false-positive result in individuals taking iron.

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