Sports and Exercise: Nutritional Augmentation and Health Benefits

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Benefits of Exercise

The Historical Benefits of Exercise

Athletic prowess and strength have always been values respected by our society, even in Biblical times. Jacob wrestled with an angel and prevailed, and rolled a large stone off the mouth of the well, and was marvelled at for his strength (Genesis 25:27,32:36,29:10). Exercise was recognized as the great soporific, and sleep of the laboring man was described as sweet (Psalm 27). Strength as the glory of young men was praised (Proverbs 20:29), and even God is characterized as strong and mighty (Psalm 24:8). Learning the sport of archery at 20 years of age is described in Numbers 1:4 and II Samuel 1:18. And men were trained to be equally adept in shooting arrows using the right and left hands (I Chronicles 12:2). Many athletes, as described in the Bible, were able to sling stones at a hairbreadth and not miss, (Judges 20:16) and shoot arrows and great stones from towers (II Chronicles 26:15). Shooting arrows at specific targets is described in I Samuel 20:20, as is the bending of the bow in Lamentations 3:12, thrusting one's enemy with a sword (II Samuel 2:15), and scaling walls (Psalms 18:30), which were probably part of the sports/war training process.

In Christian and Talmudic times (Rosner, 1989), it is well described that oil rubs and light massage were employed to improve physical performance and relaxation. Numerous examples of the benefits of great running feats, dancing, walking, ball playing, swimming can be found throughout the Bible. This led the great physicians Moses Maimonides and Hippocrates to recognize the benefits of moderate and severe exercise and describe both great physical and mental health benefits. Hippocrates stated that the maintenance of health lies in forsaking the disinclination to exertion: "Nothing is to be found that can substitute for exercise in any way because *in* exercise the natural heat flames up and all the superfluities (impurities) are expelled. Exercise will expel the harm done by most of the bad (dietary) regimens that most men follow." Maimonides also concluded that exercise, because of its impact on the brain's neurotransmitters and the body's metabolism and human moods, can cover, at least for a while, a multitude of dietary sins.

Maimonides termed exercise as powerful or rapid motion or a combination of both that is vigorous with which the respiration alters and one begins to heave sighs. Whatever exceeds that is exertion. That is to say that very strong exercise is called exertion. Although not everyone can endure exertion or needs it, it is nonetheless better in the preservation of health than the omission of exercise. Maimonides described adequate warm-up and cooling down phases as part of exercise regimens. Even Paul of Tarsus wrote that physical fitness had benefits (of course not equal to spiritual fitness) and that the body was a temple; thereby worthy (and even required by God) to be maintained. Hence, Western and Judeo-Christian traditions have a long history of describing sports and exercise (war training in some cases) as beneficial to health.

Health Benefits of Exercise

The health benefits of exercise are numerous, i.e., cancer prevention, lower cholesterol, regulation of sugar metabolism, anti-anxiety or depression, improved quality of life with age, and anti-degenerative diseases such as arthritis. Exercise is not a panacea, but any technique that reduces stress will have benefits in virtually all

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categories of disease. Hence, exercise has many benefits because it improves overall health and brain chemistry. Researchers theorize that physical activity may cause food byproducts and carcinogens to be removed more quickly through the colon. Recently it was shown that men and women who exercise have a reduced colon cancer incidence in a study that interviewed 229 men and women with colon cancer and compared them to their healthy controls. Another recent study suggests the benefits of exercise in preventing breast cancer in young women (Kritchevsky, 1990) because exercise reduces caloric intake and appetite. Exercise produces more health and healthy people feel more motivated for exercise.

Other studies suggest that exercise has benefits on lipid levels, and this benefit can probably be augmented by the addition of nutrients. There is an improvement in HDL, as well as cholesterol and triglyceride lowering as much as 30 percent in body builders (Baldo-Enzi, et al, 1990).

Exercise, Sugar Metabolism and Weight Loss

Another benefit of exercise may be to improve sugar metabolism. Glucose tolerance was found to improve over an 18-week study in individuals undergoing aerobic exercise. Three out of four pre-diabetic people who had strength training saw their glucose tolerance return to normal. Exercise itself may include individual requirements for nutrients but has benefits to contribute to better sugar metabolism which is particularly relevant to long-term training. Exercise may even improve the efficiency of absorption of nutrients from food and may be beneficial for weight loss as well (King, et al, 1989).

Benefits of Exercise for All Age Groups

It is suggested that both strength training in children and strength training in the elderly has beneficial effects. The best approach to teach exercise in society is to start exercise education at a very early age and continue to a very late age. There are benefits to preserving muscle mass with age if exercise is continued. Exercise in the young and elderly builds confidence, and in the elderly probably slows the progression of osteoporosis and other degenerative diseases, i.e., arthritis. Walking with handheld weights can be a beneficial form of exercise for the elderly. The elderly can continue to build muscle with exercise and thereby have a more vigorous geriatric life. Furthermore, severe illness is better tolerated in the conditioned athlete or individual with better fitness (Webb, 1990). Studies suggest that "young" old people (age 60-72) can increase their thigh muscle strength by almost 200 percent and their muscle mass by 15 percent with exercise. At Tufts University, researchers have shown that weight training can occur in young old men and women aged 60 to 72 and even in men and women aged 86 to 96 to improve body muscle. Medical wisdom in this area seems to show us once again that we underestimate what things are possible (White, et al, 1987; Ekelund, et al, 1988; Blackburn, et al, 1988; Blair, et al, 1989; Leon, et al, 1987; Paffenbarger, et al, 1986; Powell, et al, 1987; Blair, et al, 1984).

Psychiatric Benefits of Exercise

A Stanford University study showed that the mental state of juvenile delinquents is improved by exercise. Those who exercised three times a week improved their scores in measures of depression and self-esteem. Obviously exercise can be a distraction from worries and social pressures, and using your body can provide a sense of greater mastery and control over life. During exercise, changes may occur in the levels of circulating endorphins and other neurotransmitters. It was suggested by a study at the National Institute of Mental Health that exercise increases noro-penepherine, serotonin, dopamine, endorphins (high or euphoria effect), and possibly all neurotransmitters thought to be low in depressed people. The beneficial effects of exercise on mood may not be long-lasting but primarily short-term. Exercise is a mild antidepressant (and anti-anxiety) and is often the driving force behind highly motivated athletes. These athletes frequently need to add neurotransmitter precursors when not in training to maintain optimum mental health. Cranial electrical stimulation of the brain may simulate some of the brain chemistry effects of exercise (MacMahon, et al, 1980; Lennox, et al, 1990).

Dangers of Strenuous Exercise and Their Prevention

Lack of stretching, taut muscles, and long-term, high intensity, high mileage running is a potential risk factor for premature osteoarthritis. It may be true that any regular exercise without exercise rotation (running one day, swimming the next day, tennis the next day, etc., or running in the summer, swimming in the winter) puts an individual at high risk for various injuries. The fears about aerobic exercise during pregnancy are not warranted (Sumida, et al, 1989; Marti, et al, 1989; Kleiner, et al, 1989).

Insufficient Exercise in America

It is concluded that 79 percent of all Americans do not get enough exercise to have any significant beneficial effect upon heart function and disease. Therefore, possibly the most important question we have to ask is what is required to motivate an individual to do exercise? Such an answer would probably be found primarily in brain chemistry and the depletion of various neurotransmitters which can motivate an individual. It is certainly now well recognized that a low *level* of physical fitness is associated with a high risk of death from coronary heart disease. Not to exercise is self-destructive, even suicidal behaviour! Depletion of neurotransmitters, especially the adrenaline builders, i.e., tyrosine, methionine, and DL phenylalanine, may lead to low energy and lack of motivation for exercise. In a sense, a vicious circle is often created, i.e., low mood leads to reduced frequency of exercise, which in turn leads to less exercise, which further promotes low mood. Cranial electrical stimulation may be another natural way to break this cycle (Grinenko, et al, 1988; Braverman, et al, 1990).

Nutrition and Athletic Performance

Athletes Use Supplements

According to a recent study at Johns Hopkins reviewed in *Prevention* magazine, athletes, marathon runners in particular, believe that supplements can be beneficial. As many as 48 percent report use of at least one type of supplement within a 3-day period. Athletes are already using supplements but are not yet aware that scientific testing can contribute a fine tuning of their nutritional programs (Hickson, et al, 1989; Nieman, et al, 1989).

Nutritional Deficiencies in Athletes

One thing for certain, according to Keith and colleagues (1989), is that trained female cyclists take in RDA's well below the appropriate level, such as 76 percent reduction in folic acid, 81 percent reduction in magnesium, 59 percent iron, 48 percent zinc, compared to normal. Many athletes have nutritional deficiencies but have not been educated about how easy it is to identify the deficiencies and treat them (Van Erp-Baart, et al, 1989; Keith, et al, 1989).

Increased Nutritional Requirements of Heavy Exercise

It is clear that the body requires more nutrients during exercise and the body responds to intense aerobic exercise by preserving and reducing excretion of magnesium, zinc, and copper. Vlcek (1989) studied thirteen healthy men, ages 17 to 35. There was a rapid drop in plasma magnesium following significant exercise and a rapid increase in copper. These studies suggest the need for nutritional supplements during the process of exercise.

According to Hood and colleagues (1990), branch chain amino acids, particularly leucine, increase metabolism during rigorous exercise. In fact, their work is probably the strongest that clearly documented that the dietary intake of leucine be increased to a level commensurate with whole body rate oxidation. Possibly all strenuous exercise requires supplementation of leucine and other branch chain amino acids. Leucine may be as close as we can come to a natural steroid inducer. As high as 11 percent of high school athletes have tried anabolic steroids (Zuliani, et al, 1988). There is clear evidence that branch chain amino acids are increasingly utilized by exercise. This should be no surprise since numerous studies document the fact that branch chain amino acids are the most important amino acids utilized during

trauma, sepsis, surgery, and any acute stress on the body (Braverman, et al, 1990). Branched chain amino acids, particularly leucine, are already proven to preserve muscle mass during acute stress. Body building and strenuous exercise are cata-bolic events similar to trauma, surgery, etc.; hence, branched chain amino acids are likely to be beneficial supplements, especially in high doses. Leucine and to a lesser extent isoleucine are uniquely metabolized amino acids through the fat oxidation pathway. Eating leucine is like getting the energy benefits of fat without eating fat! These principles regarding sports nutrition can also be applied to the stress of war and post-traumatic illnesses of many types. The nutrient carnitine (in conjunction with branched chain amino acids) may also improve muscle functioning and, although controversial, has potential benefits to endurance. Carnitine levels also can be measured in the blood to optimize supplement levels (Soop, et al, 1988; Jaspers, et al, 1989; Elam, et al, 1989; Jacobson, 1990; Maes, et al, 1990).

Benefits of B Complex

Athletes throughout the world, according to a study in the *Journal of Obesity,* suggest that B-complex, particularly $B_{1;}$ B_6, and B_{12}, have a calming effect and reduce slight, almost unnoticeable tremor in pistol shooting, possibly by inducing natural neurotransmitters in the brain. It has even been suggested that caffeine be banned by the International Olympic Committee because of its ability to increase basal metabolic rate, work as a diuretic, and produce slight tremor, possibly because it increases excretion and utilization of B vitamins. B complex supplementation is certainly a reasonable idea for athletes of many types that require steadiness of hands. Vitamin B complex supplementation, according to Maretti, particularly B_6, will increase the plasma levels of growth hormone induced by exercise. Hence, exercise is probably a good growth hormone releaser by itself, possibly even better than arginine or branch chain amino acids (Braverman, 1987). B complex may augment the effect of exercise on growth hormones.

B_6 and exercise increase growth hormone and low glutamine, and high glutamic acid increases muscle synthesis. B_6 decarboxylases glutamine to glutamic acid. Pantothenic acid may increase endurance; in one mice exercise study (swimming in water) nonsupplemented mice sank to the bottom of the jar quicker than those who received extra pantothenic acid.

Magnesium and Endurance Athletes

According to Goodman and information gathered in 1985 at the University of Oregon from a group of elite, all longdistance athletes including Alberto Salazar (former world record holder in the marathon), runners lose magnesium in perspiration. Because long-distance runners perspire a great deal more than sprinters, long-distance runners' magnesium levels tended to be lower. On the other hand, sprinters can normally possess elevated calcium readings and, because of the need for calcium in muscle contraction, they require more of it than long-distance runners. The question of whether or not magnesium supplementation could improve athletic performance and endurance has been suggested by numerous studies.

A convincing example of the benefits of magnesium was provided by Matt Biondi, one of the world's fastest swimmers and holder of the 50 meter and 100 meter freestyle records. From 1985 through 1987, while a student at Berkeley, Biondi underwent mineral analysis which showed a definite magnesium deficiency. He handled sprinting races easily but had been experiencing difficulty in the 200 meter freestyle, an event which required considerable endurance. After several weeks of magnesium supplements, Biondi's strength and endurance improved significantly during long-distance performance. Possibly other athletes can benefit from magnesium supplements. Red blood cell and white blood cell magnesium tests can easily identify subtle deficiencies.

Other Trace Elements in Endurance Athletes

Other athletes provide evidence similar to that of Biondi, not only about macroelements like magnesium, but also a range of trace minerals including but not limited to zinc, iron, copper, and chromium. Mac Wilkins, Olympic athlete and

former world record holder in discus, has stated that the benefits of chemical element analysis in athletes and their supplementation can be so dramatic he is amazed it is legal! Athletes typically report that nutritional supplements improve their leg cramps and reduced or eliminated their time in competitions where shaving 1/10 of a second off a time can spell the difference between winning and not placing at all. Obviously the effects can be very subtle (Keen, et al, 1984; Vlcek, et al, 1989).

The Department of Agriculture suggests that as much as 90 percent of the United States population may not be getting adequate chromium, zinc, or magnesium. A recent study of U.S. Navy Seal trainees showed that during training they also had a reduced intake of magnesium, zinc, and copper (34, 44, and 37 percent respectively). Supplementation of these nutrients to maintain baseline levels may not be a bad idea. Obviously athletes may benefit from macro- and microelement supplements, especially if deficiencies can be identified by red blood cell testing. Recent studies by Campbell suggested that increased levels of dietary chromium may have beneficial effects on glycogen and glycogen synthesis. This effect may not be limited to athletes that are deficient, but there may be benefits to even higher levels of supplementation. Chromium supplementation may be one of the most important factors in weight control and may be one of the key dimensions of why most diets for weight loss fail. Chromium, which is also frequently deficient in diabetics, may be a necessary supplement for maintaining level sugar metabolism and lean body mass (Campbell, et al, 1989; Singh, et al, 1989; Goodman, 1990).

Iron Deficiency

According to Chigo, the problem of iron deficiency is confusing since recent articles by Drs. Goldstein and Lofler suggest that lower iron might actually benefit athletes and that rigorous exercise results in substantial blood loss through the gastrointestinal tract and sweat. Many women athletes in particular have low iron levels. If low iron were beneficial, blood donation may help certain athletes, although most of these benefits will be transitory. The overwhelming amount of data suggests that long-term iron deficiency will result in very significant cognitive problems, coldness, fatigue, and depression. Many athletes have sub par performance due to even borderline iron deficiency. In addition, excess iron can lead to fatigue (Dallongeville, et al, 1989; Rowland, et al, 1989; O'Tolle, et al, 1989; Clarnette, et al, 1990).

Importance of Potassium

It is important not to neglect potassium. Some studies suggest that highly trained women compensate for increased utilization of potassium by having a higher intake of potassium. This increase in potassium may be beneficial. It is very easy to give 10 milliequivalents of Klotrix every other day in athletes without noticing any toxicity problem whatsoever in terms of elevation of the potassium. Furthermore, this supplementation will probably guarantee greater reserves during high performance stress.

Role of Sodium

No review of sports nutrition is complete without mention of sodium. Low sodium levels can result in altered mentation, seizures, and pulmonary edema. Water intake can be a problem without adequate sodium and electrolytes. Water should be thought of as a nutrient, and water high in trace minerals should be ingested. By increasing potassium, this may increase sodium loss. Careful electrolyte balance must be maintained in athletes. The problem is quite similar to very ill patients where proper electrolyte balance can make the difference between life and death.

Nutritional Supplements That Benefit Athletes: Amino Acids

Branch chain amino acids are not the only amino acids that can benefit athletic performance. Tyrosine, one of the amino acids that builds adrenalin, also has other benefits according to U.S. Army Research Institute of Environmental Medicine in Nadic, Massachusetts. In this study, 23 men aged 18 to 26 were exposed to altitude changes. The subjects who received 600 milligrams each of tyrosine were better able to tolerate 40 minutes of exposure to

mountainous terrain. Tyrosine significantly reduced the adverse effects produced by exposure to cold, decreased oxygen, headache, coldness, distress, fatigue, muscular discomfort, and sleepiness in simulated mountain climbing stresses. Many similar studies have also repeated the use of tyrosine with benefit in military stress conditions. Recent research has linked stress-caused impairments of performance with depletion of brain stores of the neurotransmitter norepinephrine, which functions in neural tracts responding to stress. The amino acid tyrosine is the dietary precursor for norepinephrine, and supplementation with tyrosine has been demonstrated in the laboratory to alleviate declines in both neural norepinephrine and performance during stress. Thus, tyrosine supplementation might help to prevent and treat stress casualties in sports or combat.

In acutely stressful situations, one may benefit from tyrosine ingestion along with branched chain amino acids. Branched chain amino acids like steroids may reduce tyrosine and tryptophane absorption. Taking methionine with tyrosine may result in increased absorption of tyrosine, according to Braverman, 1987. In general, tyrosine and methionine supplements are best taken during the morning and afternoon, while branched chain amino acids are best taken before dinner, bedtime, or a workout (Banderet, et al, 1989; Salter, 1989).

Segura and Ventura (1988) suggest that L-tryptophan supplementation may benefit exercise performance. Twelve healthy sportsmen were subjected to a work load corresponding to 80% of their maximal oxygen uptake on two separate trials, after receiving a placebo and after receiving the same amount of L-tryptophan. The subjects ran on a treadmill until exhaustion. Total exercise time, perceived exertion rate, maximum heart rate, peak oxygen consumption, pulse recovery rate, and excess post-exercise oxygen consumption were determined during the two trials. The total exercise time was 49.4% greater after receiving L-tryptophan than after receiving the placebo. The longer exercise time as well as the total work load performed could be due to an increased pain tolerance as a result of L-tryptophan ingestion, which is best taken at night. (L-tryptophan will be back on the market as soon as proper protection from contamination of the product is assured.)

The performance of strenuous physical exercise is associated with discomfort and pain, the tolerance for that being modulated by the activity of the endogenous opioid systems. 5-hydroxytryptamine (5-HT) affects nociception through its effects on the enkephalin-endorphin system. Tryptophan and possibly cranial electrical stimulation (CES) may raise serotonin levels, increase pain tolerance, and thereby increase exercise tolerance. After all, no pain, no gain, or according to the suffering is the reward!

Growth Hormone

Increasing evidence suggests that growth hormone can restore muscle health very late in life, and increase muscle development early in life. Increases in growth hormone can probably occur from many amino acids (i.e., tryptophane, leucine, isoleucine, arginine, ornithine). These increases are greatest when the amino acids are given intravenously. Possibly amino acid loading prior to strenuous exercise (this has already proven benefits for trauma, the catabolic state most similar to severe exercise) may be beneficial. At this time it is unclear if oral amino acids can really elevate growth hormone and its mediators significantly. Growth hormone injections may be practical in the very near future, according to recent studies (Moretti, et al, 1982).

Possible Benefits of Choline

Studies on 17 healthy athletes who ran the Boston Marathon, as published October 2, 1986 in *The New England Journal of Medicine*, showed that this exercise was associated with a major fall (i.e., about 40%) in plasma choline levels; all of the subjects showed at least some reduction in the choline levels. A second study conducted on 16 additional subjects the following year confirmed this observation: mean plasma choline levels fell by 35%, and all but 2 of the subjects exhibited some reduction.

Plasma choline fulfills two major functions: all

of the cells in the body use it to produce constituents of their own membranes (like phosphatidyl choline and sphingomyelin); moreover, particular nerve cells, or neurons, all over the body use it to make acetylcholine, the chemical signal that they release to transmit instructions to the cells that they innervate. Among such "cholinergic neurons" are all of the nerves that determine whether muscles will contract.

Other studies, using pieces of muscle with their nerve intact, incubated in the presence of fluids containing varying amounts of choline and stimulated electrically, have clearly shown that when choline levels are reduced, the amounts of acetylcholine that the nerves release are reduced in parallel. Thus, it is not unlikely that a major reduction in plasma choline levels *in* the body would also diminish the ability of the nervous system to "instruct" muscles to contract, potentially affecting performance.

Plasma choline levels can be raised at will by taking purified phosphatidyl choline orally. In general, it takes 7-9 grams to approximately double plasma choline, and it can be anticipated that a like amount would be able to sustain plasma choline levels in the exercising athletes. Choline also has benefits in brain function which may help concentration and overall performance (Ghigo, et al, 1989; Safford, et al, 1989).

Management of Soft-Tissue Injuries with Nutritional Therapies

Management of soft-tissue injuries in sports has taken some interesting turns with the natural agent 5'-methylthioade-nosine, a naturally occurring nucleoside which has anti-inflammatory and analgesic activity. The usual approaches to sports soft-tissue injuries have used the concept of RICE (rest, *ice* application, compression bandage, and elevation) and the use of NSAID's, or nonsteroidal anti-inflammatory drugs (fish oil can often replace the use of these). The natural compound is a derivative of adenosine, which has also been used as an anti-arrhythmic and probably anti-convulsant, has some anti-inflammatory properties, and holds promise for natural treatment of sports injuries and may even be beneficial as a compound for massage in very high stress athletic competition. At this point the use of lotions or creams for the benefits of sports is not clear. It does seem though that contusions, sprains, tendinitis, epicondylitis, and strain may be treated by 5'-methylthioadenosine(Anselmi,etal, 1990).

Optimizing Athletic Performance

The Optimal Diet for Athletes

The proper diet for an athlete depends on what stage he or she is in in terms of performance. Numerous studies suggest the importance of an adequate calorie content for various athletes and that carbohydrate loading is essential to adequate endurance, especially right before sporting events. Frequently athletes eat a big macaroni or pasta meal before an important event. During periods where training is not as intense, increased protein intake may be necessary to build lean muscle. High protein diets are also adequate defenses against fluid retention. Long-term use of high protein diets probably will result in reduced endurance but increased muscle development (Bailor, et al, 1990; Bailor, et al, 1988).

Resistance weight training during caloric restriction enhances lean body weight maintenance. It also increases HDL and lowers LDL. If one wishes to improve lean body mass, there can be benefits of being on a high protein diet and doing resistance weight training. There is a time for a complex carbohydrate diet and a time for a high protein diet *in* athletics. Another possible diet in theory is the Princeton Plan which alternates high carbohydrate and high protein. On the high carbohydrate day, aerobics are used to burn body fat as fuel. The next day, resistance training utilizes the glycogen stored in the muscles and liver from the day before. You eat based on your exercise needs for the next day (Heleniak, et al, 1990; Ratz, et al, 1989).

Reaching Maximum Performance: The Use of Diet

Complex carbohydrate loading regimens have been reported in many studies to benefit high-intensity, strenuous exercise (i.e., marathons). Through exercise, glucagon

can be depleted by nearly 35 percent. Moderate intensity, long duration exercise and even short intensity exercise may be helped by complex carbohydrate loading. According to some studies, there are glucose polymers that will assist this carbohydrate loading and are available in drink form. Glucose polymers with nutrients given intravenously may result in even greater athletic performance benefits.

Maximum manipulation of performance in athletes will probably continue to improve with the use of peptides and other natural hormone-like substances. Loading athletes through superintravenous nutrition prior to marathons or sporting events would seem to be the most striking way of impacting athletic performance naturally. For example, intra-arterial infusion of PgE_2 (prostaglandin E_2) produces increased skeletal muscle protein degradation. PgE_1 increases growth hormone secretion and decreases insulin secretion, while insulin is antagonistic to growth hormone. Fish oil, vitamin E hormones, PGE_1, and other prostaglandins might be infused to impact muscle growth. Furthermore, intravenous arginine is probably the only way in which arginine can significantly increase peak performance by increasing growth hormone. Intravenous loading of nutrients (particularly amino acids, prostaglandins) a day prior to athletic performance, as well as carbohydrate loading, may produce outstanding effects in athletic performance (Pressler, et al, 1984).

Arriving at a Supplement Program

A review by Brouns (1989) suggests that numerous vitamins can benefit exercise performance when deficiency is established. It is clear that poor vitamin status is harmful and that any given individual might suffer from a mild deficiency at any given time. Rigorous athletic performance is marked by nutrient deficiencies if looked for. Although no recommendation for megadoses can be made solidly, it can be concluded that any nutrient deficiencies, induced by either low intakes or losses during performance (both are extremely common), can impair physical performance. The concept of low level of protective supplementation certainly seems prudent considering the numerous studies documenting nutrient losses. Testing of athletes in most cases should document some treatable deficiency or tendency (Singh, et al, 1990).

Ways of Improving Muscle Strength and Performance

General muscle weakness and atrophy is a common feature of hyperthyroidism. Proximal muscles seem to be much more affected than distal muscles. Neuromuscular abnormalities also occur in hypothyroidism in the contractile mechanism of the muscle. Hyperthyroid patients that are treated have an absolute increase in muscle strength, and this is probably also true of hypothyroidism patients. Through thyroid stress testing it may be determined that a small percentage of athletes may have borderline hypothyroidism and thereby benefit from thyroid supplements. Another technique to augment athletic performance might include the use of cytomel (or T3) (Celsing, et al, 1990).

Tests for Athletes: Nutritional Status

It would seem appropriate for all determined athletes to have regular body composition tests and complete trace element, fatty acid, amino acid, and vitamin diagnostic testing along with routine blood testing. Even neurotransmitter profiles might be evaluated. Correcting marginal nutritional imbalances would probably contribute a small but sometimes very significant amount to overall athletic performance. It might also be important to study brain mapping (brain electrical activity map or BEAM) and amino acids and neurotransmitters pre- and post-exercise since we know that running releases endorphins, increases neurotransmitters, etc. New brain scanning techniques such as positron emission tomography (PET) or single photo emission computerized tomography (SPECT) along with BEAM should document the biochemical nature of the runner's highs such as love, spirituality, etc. Exercise is a great natural antidepressant and is probably critical to good mental health. Below is an outline of potential, beneficial testing for athletes.

Recommended Nutritional Testing for High Performance Athletes

Routine blood tests (i.e., ESR, thyroid, etc.)
Essential fatty acids, plasma
Essential plasma amino acids
COQ10
Carnitine
Vitamin diagnostics profile
Complete trace metal screening in red blood cell

Other Low Yield Possible Tests for High Performance Athletes

Hair test for toxins
Immune testing
Endorphin and neurotransmitter levels
Brain mapping (to follow changes in the brain before and after strenuous exercise)
Trace elements *in* white blood cells
Allergy testing

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