Parrillo Performance Nutrition Bulletin # 6

Liver: Natural Iron

by John Parrillo

Liver has been a mainstay supplement for bodybuilders and power athletes for years — and for good reason. Recently, endurance athletes have also realized the incredible nutritional value of liver. Liver provides heme iron, high quality protein, and B vitamins, thereby meeting several of the increased nutritional needs of athletes in a single blow. Heme iron is responsible for hemoglobin's ability to carry oxygen in red blood cells. Heme iron is the best absorbed — the most bio-available — of all iron sources (2,6). And liver is nature's best source of heme iron (2).

Your body generates energy by breaking down foods and transporting the food molecules to all the cells of the body. Inside the cells, the foods are burned in a chemical reaction called "oxidation," which simply means reaction with oxygen. (This is very similar to what happens to food when it burns in a fire.) For foods to be converted to energy, the cells have to get plenty of oxygen. This constant need for energy is so critical that if tissues are deprived of oxygen for more than a few minutes they will die.

As you know, red blood cells are responsible for transporting oxygen to all the tissues of the body. They do this by binding oxygen to hemoglobin, the red pigment in the blood. Hemoglobin is a protein that includes a special chemical structure known as heme—a complex of porphyrin and iron. And it's the iron which binds oxygen in the lungs and subsequently releases it in the muscles and other peripheral tissues. Muscles contain myoglobin, an oxygen-carrying protein that works inside cells. Like hemoglobin, myoglobin also requires iron to bind oxygen. Without the iron, the whole oxygen transport system won't work. Not only that, but iron is also required by the enzymes in the electron transport chain—the series of reactions in which oxygen is consumed in the cells. So iron is required not only for transporting oxygen to the tissues but also for its use inside cells. Because of its critical role in oxygen utilization, iron has earned its reputation for occupying a central position in energy metabolism.

> Iron defeciency is widely recognized as the most common nutritional deficiency in the world

Iron deficiency is widely recognized as the most common nutritional deficiency in the world (2, 3). As many as 22% of American women are iron deficient, and the number is as high as two-thirds in developing countries (1, 2). The daily iron requirement for women is 18 mg per day, while on average they obtain only 10-12 mg per day (1). Men have lower daily iron requirements, so are somewhat less prone to suffer from deficiency. Among athletes, about 10% of males are iron deficient, compared to 22-25% of females (1). Many times a feeling of fatigue or low energy is the result of an unrecognized iron deficiency (2, 3).

Dietary iron sources are usually divided into two general categories: heme iron and nonheme iron (2). Heme iron is iron which is already bound to heme—the red pigment in hemoglobin. Good sources of heme iron are red meat and liver. White meat chicken and turkey breast also contain heme iron, but in lower amounts (2). The form of iron found in plants is not incorporated into heme and is therefore called nonheme iron. Iron from red meat and liver, in the form of heme iron, is much easier for your body to absorb (6).

Iron deficiency is associated with vegetarian diets (1). Some vegetables, such as beans, corn, and spinach, contain a significant amount of iron. Unfortunately, iron from vegetable sources is poorly absorbed (1). Only 1.4% of iron from spinach is absorbed. Seven percent of iron from soybeans is absorbed, making it one of the best vegetable sources of iron.

Red meat provides much higher amounts of iron per serving than vegetable sources (2). Additionally, liver is an even better source of iron than red meat. Furthermore, the iron from red meat and liver—heme iron—is much easier for your body to absorb (2, 6). About 15-20% of iron from red meat and liver is absorbed (2). The higher iron content of these foods, along with the greater bioavailability of heme iron, makes red meat and especially liver much better dietary iron sources.

Another factor may also be involved in explaining the association of iron deficiency with vegetarian diets. The efficiency of iron absorption depends on protein intake (5). Meat proteins improve the absorption of heme and nonheme iron (5). Furthermore, the presence of heme iron also improves the absorption of nonheme iron (4). Athletes who do not eat red meat or liver have an increased risk of developing anemia (6).

Anemic children and adults are often thought of as backward or apathetic (2). Recently it has been realized that subclinical iron deficiency, less severe than anemia, can result in poor performance on a variety of behavioral and cognitive tests (2). This effect is reversible and responds to iron supplementation, depending on the severity of the deficiency. Some test scores of children improved after a single iron injection, while in other experiments 11 or 12 weeks of iron therapy resulted in improvement. Several studies have found a positive correlation between IQ and iron level: the higher the iron level, the higher the IQ (2). Bear in mind, however, these studies are concerned with deficient children, and increasing iron levels in children with already sufficient amounts would not be expected to confer any advantage.

It is well established that iron deficiency decreases work output and athletic performance (3, 6). This is primarily due to reduced oxygen carrying capacity of the blood, but reduced aerobic capacity of the muscle (due to tissue level iron depletion) is involved as well (3). Iron supplementation has been shown to be effective at increasing productivity of iron deficient workers. Plantation workers and rubber tappers in Central America (2) and tea pickers in Sri Lanka (3) who were iron deficient displayed decreased performance and work output. Following iron supplementation, productivity improved (2, 3). Also, iron deficient children and adults are much more likely to suffer from infectious diseases than those receiving iron supplementation (2). White blood cells need plenty of oxygen to kill invading bacteria. And having a good, strong immune response is critical to maintaining optimum health.

“Sports anemia” is induced by exercise training and endurance athletes are especially at risk (1, 3, 6). Many times, sports anemia is not associated with a true iron deficiency. Skeletal muscle fibers are damaged during intense exercise training, and this damage must be repaired during the recovery period following exercise. If dietary protein intake is inadequate, the body will draw on red blood cells, hemoglobin, and plasma proteins as a source of protein to repair the muscles (3). If protein intake is limited, repair of muscle tissue may soak up all of the incoming protein and not leave enough left to rebuild new red blood cells at the normal rate. Increased protein intake may be effective in treating sports-induced anemia (1). Often times, an athlete experiences a decrease in red blood cell count and serum iron levels during the early phase of training (1). This could be due to the fact that aerobic training causes an increase in myoglobin (an oxygen carrying protein) and cytochrome content of muscle tissue and the protein and iron required for their formation could be obtained from destruction of red blood cells (1, 3). In other words, myoglobin may be increased at the expense of hemoglobin if protein intake is inadequate.

Athletes with low hemoglobin levels do not perform as well at endurance events. Interestingly, endurance athletes have the highest incidence of sports anemia and also have the highest protein requirements. There seems to be an iron cost associated with exercise (3) and there is no question that iron deficiency compromises athletic performance (6). Studies suggest that athletes have a higher than usual incidence of iron deficiency, and this is probably caused by iron depletion during exercise (3). Female athletes and endurance athletes are especially at risk of iron deficiency (1, 2, 3, 6). Iron deficiency anemia reduces maximal oxygen uptake, reduces work output, and increases the time required to recover between workouts (1). Encouragingly, iron supplements have been shown to be effective in reversing the effects of iron deficiency and in restoring hemoglobin levels (1, 2). Iron supplementation is effective in improving athletic performance and work output of deficient individuals (1, 3). It has been reported that iron supplementation alone will not correct true sports anemia, which is reasonable when considering it as a protein deficiency. However, since liver provides both high quality protein and heme iron it should be beneficial to athletes suffering sports anemia. Liver may also be effective in preventing the iron deficiency induced by exercise training.

Liver is the best source of heme iron (2). Heme iron is damaged by cooking, reducing the bioavailability of iron by as much as 50% (5). Desiccated liver supplements thus represent probably the most bioavailable iron source. Parrillo Performance Liver-Amino Tablets™ are made from de-fatted liver, which means you don’t get all the fat and cholesterol that comes along with liver and red meat. Plus we add predigested casein to further increase the protein content to 1.5 grams per tablet. This is why we feel Parrillo Performance Liver-Amino™ is one of the best supplements available for bodybuilders and endurance athletes: It provides heme iron, high quality protein, and B vitamins all in one.

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Parrillo Performance Nutrition Bulletin # 7

Protein: Superfood For Bodybuilders, Part I

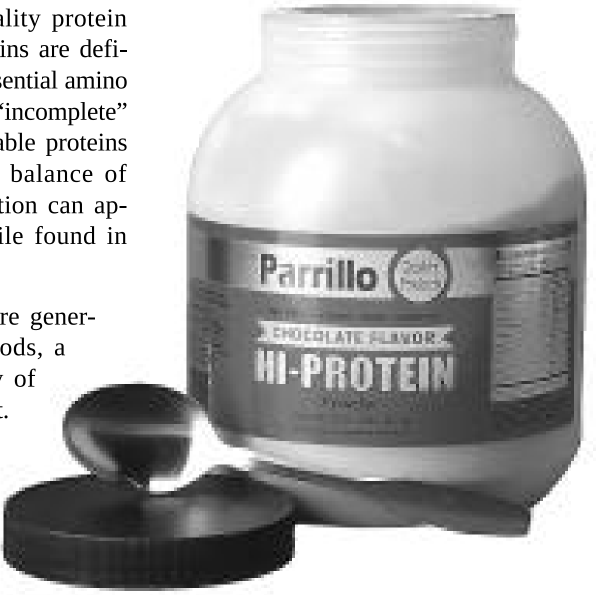
by John Parrillo

Proteins are found in all cells and tissues and are required for the structure and function of every part of the body. And of special interest to bodybuilders, muscles are made of protein.

Proteins are chain-like molecules, and the links of protein chains are called amino acids. About 20 different amino acids occur in human proteins. Twelve of these can be made within the body. The other eight are called “essential amino acids” because they cannot be made by the body; therefore, it is essential that they be obtained from the diet. The proteins you eat as food are not directly incorporated into your body tissues. Instead, the protein chains are digested to yield short fragments (peptides) and individual amino acids which are absorbed into the bloodstream. The individual amino acids then serve as building blocks your body uses to build its own proteins. If any one of the amino acids is deficient, your body can’t make new protein molecules. They all have to be there at the same time.

> Protein is required in the diet to maintain tissues and organs and to supply building blocks for growth.

Protein is required in the diet to maintain tissues and organs and to supply building blocks for growth. Proteins from animal sources such as meat, eggs, and milk, are called “complete” proteins because they supply all the essential amino acids. Animal proteins provide a balance of amino acids similar to that of human tissues. Plant proteins have a profile of amino acids different from human proteins. For this reason animal proteins are considered to be higher quality protein foods. Most vegetable proteins are deficient in one or more of the essential amino acids and are therefore called “incomplete” proteins. However, if vegetable proteins are combined properly, the balance of amino acids in the combination can approach the amino acid profile found in animal proteins.



While animal proteins are generally high quality protein foods, a problem arises in that many of them also contain a lot of fat. You must be selective when using animal proteins to avoid the fat that comes along with them. Good lean protein sources include skinless turkey breast, skinless chicken breast, fish, and egg whites. Occasional red meat is fine, as long as you consume the leanest cuts. Always trim all visible fat.

There has been a lot of debate about the protein requirements of athletes. Historically, nutritionists assert that athletes do not require any more protein than sedentary people. Athletes, however, believe they need more. There is some reason behind both points of view. On one hand, it is well known that weight lifting causes damage to muscle tissue (1). So it makes sense that someone who lifts weights would have to eat more protein than a sedentary person because his body has to repair that damage. Furthermore, if you want to increase the amount of muscle mass on your body, it seems obvious that you would have to eat some extra protein to support this growth. On the other hand, nutritionists point out that this increase need for protein is offset by increased efficiency of protein utilization in the trained athlete (1). If your body utilizes its protein food more efficiently, then it may not need any extra after all. Furthermore, eating excess protein does not in itself make you more muscular. If it did, we would just eat more protein food and get more muscular. Unfortunitely, it’s not that easy.

The National Research Council sets the recommended daily allowance (RDA) for protein intake at 0.8 grams protein per kg body weight per day (g/kg/day). This works out to be 0.36 grams per pound body weight each day (g/pound/day), which is 56 grams per day for a typical male and about 72 grams per day for a 200 pound bodybuilder. This value for the RDA was determined to be the amount required by most of the average population—not for athletes or other very active people. Recently, a new way of measuring the protein status of the body has been developed—the metabolic tracer technique. Using this method, protein requirements are seen to be 23-178% greater than estimated by the nitrogen balance technique (2), a conventional method of measurement.

Much modern research indicates that

the protein needs of athletes range from 1-2g/kg/day (0.45-0.9g/pound/day)—about twice the RDA (3). Other studies suggest that some hard training strength athletes require in excess of 2g/kg/day (0.9 g/pound/day) to maintain nitrogen balance (4) and that as much as 3.5g/kg/day (1.6g/pound/day) may be beneficial in maximizing gains in strength and mass (5). Apparently, the increase in efficiency of protein utilization which has been reported to occur during adaptation to exercise may not always be enough to offset the increase protein demand. In other words, the RDA for protein may not always be enough even if it is utilized with 100% efficiency. The RDA protein recommendation may be enough for sedentary people but endurance athletes and very muscular athletes need more.

Use Parrillo Performance Hi-Protein Powder™ for increased protein needs.

See bulletin #8 for more on protein.

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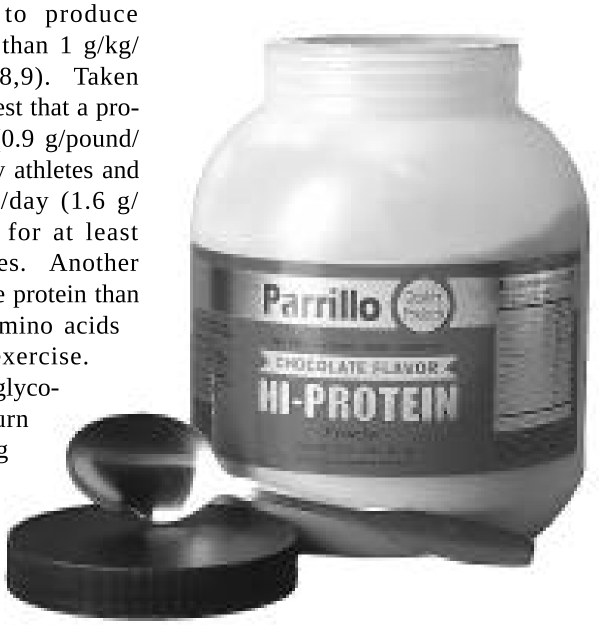
Protein: Superfood For Bodybuilders, Part II

by John Parrillo

Strength training is a powerful anabolic stimulus and, if performed properly, results in increased lean body mass (2). Specifically, the amount of myofibrillar protein, composed of actin and myosin, is increased. Muscular tissue is made of protein which is synthesized from amino acids. The amino acids are derived from the digestion of protein foods. Therefore, eating more protein foods provides more building blocks for the synthesis of new muscular tissue (2, 6). After all, during intense weight lifting, the muscle fibers are damaged (this is why you're sore after a workout), and they must be repaired(1). Muscular growth occurs by over-compensation during the repair process. The harder you weight train the more damage you do to your muscles (which stimulates growth), and the more protein you need to repair that damage. While strength athletes have known this for years, many nutritionists assert that excess protein will be stored as fat or glycogen. To reconcile these views, we should realize that most studies which fail to demonstrate that exercise increases protein requirements use subjects who are not training intensely enough to stimulate increases in lean body mass.

To extract several examples from the scientific literature: In a group of 10 weight lifters exercising intensely and consuming 2 g/kg/day (0.9g/pound/day) protein, 4 were in negative nitrogen balance (4). In another study, a protein intake of 2.8 g/kg/day (1.3 g/pound/day) was found to result in higher nitrogen balance and greater muscular gains than an intake of 1.4 g/kg/day (0.64 g/pound/day) (7). When weight lifters increased their protein intake from 2.2 to 3.5 g/kg/day (1.0 to 1.6 g/pound/day) they increased in strength and lean mass (5). A protein intake of 2.6 g/kg/day (1.2 g/pound/day) was found to produce greater nitrogen retention than 1 g/kg/day (0.45 g/pound/day) (8,9). Taken together, these results suggest that a protein intake of 2 g/kg/day (0.9 g/pound/day) is inadequate for many athletes and that as much as 3.5 g/kg/day (1.6 g/pound/day) works better for at least some hard training athletes. Another reason athletes require more protein than sedentary people is that amino acids are used as fuel during exercise. After the body uses up its glycogen stores, it begins to burn amino acids (the building blocks of protein) and fat for energy. In the liver, amino acids with three or more carbon atoms can be converted into glucose via a process called "gluconeogenesis." The branched chain amino acids (BCAAs) leucine, isoleucine, and valine can be burned for energy directly in the muscle.



This becomes significant during high intensity endurance exercise. Under conditions of prolonged endurance exercise (a 10-mile run, for example), the oxidation of amino acids can approach recomended daily protein requirements, and dietary amino acid needs could be elevated substantially (2, 10). In contrast, studies involving low intensity exercise actually indicate decreased protein need as the athlete adapts to the training regimen.

Oftentimes, an athlete experiences a decrease in red blood cell count and serum iron levels during the early phase of training (6). This condition, known as sports anemia, could be due to the fact that aerobic training causes an increase in myoglobin (an oxygen carrying protein) and cytochrome content of muscle tissue, and the protein and iron required for their formation could be obtained from destruction of red blood cells (6, 17). In other words, myoglobin may be increased at the expense of hemoglobin if protein intake is inadequate. Furthermore, skeletal muscle fibers are damaged during intense exercise training, and this damage must be repaired during the recovery period following exercise. If dietary protein intake is inadequate, the body will draw on red blood cells, hemoglobin, and plasma proteins as a source of protein to repair the muscles (17).

Increased nitrogen excretion (in urine and sweat) is commonly observed after exercise, suggesting that protein is being used as an energy substrate to fuel activity (1). Nearly all studies which include nitrogen loss through sweating find subjects to be in negative nitrogen balance during endurance activities. During prolonged exercise blood glucose levels drop, eliciting a release of glucagon from the pancreas. This hormone mobilizes amino acids from muscle tissue to serve as substrates for glucose synthesis in the liver. Dohm and coworkers (10) found an increase in urinary urea excretion (waste products from protein catabolism) during the day following a 10 to 12 mile run by male runners. This result indicates an increase in protein catabolism induced by endurance exercise. The amount of protein metabolized was calculated to be 57 grams, enough to supply 18% of the energy expended during the run. The authors suggested that protein was catabolized, possibly from skeletal muscle, to provide precursors for glucose synthesis in the liver.

In summary, the short term studies indicate that endurance exercise is catabolic in nature, leading to an acute increase in protein catabolism. Some long term studies suggest an adaptive response to endurance training whereby the proteins are utilized more efficiently (1). Other experts suggest that protein requirements of trained athletes remain elevated after adaptation (11, 12, 13). For example, 57 grams of protein— equivalent to the RDA for a 158 pound man - may be catabolized as fuel during a 10-12 mile run (10). Apparently, the increased efficiency of protein utilization which occurs as an adaptive response to endurance training is not sufficient to accommodate the demands of intense or prolonged endurance exercise.

Of course, these arguments should not discourage strength athletes from engaging in aerobic exercise. Aerobic exercise is required to condition the cardiovascular system and maintain overall health and is very effective at burning fat. Athletes interested in increasing muscular mass should still participate in aerobic exercise but eat enough additional protein and calories to compensate for the energy expense.

Lemon (2) states, "Although the current recommended dietary allowance does not recognize that protein/amino acid needs are higher in strength athletes, there is a substantial amount of experimental support to the contrary...If high protein/amino acid diets are advantageous, it may be due to increased amino acid availability and the enhanced anabolic stimulus of heavy resistance exercise." The athlete should bear in mind the importance of adequate energy intake. For growth to occur, adequate protein and calories must be consumed to maintain the body as well as provide enough building blocks for new muscular tissue.

Since protein needs vary depending on exercise type, intensity, frequency, duration, environment, and level of conditioning of the athlete (14), it is impossible to make exact recommendations for an individual athlete. It is possible, however, to extract some minimum guidelines from the literature. The general trend, (among intensely training athletes) seems to be increasing protein intake increases nitrogen balance and muscular gains, at least to a level of 3.5 g/kg/day (1.6 g/pound/day). Encouragingly, protein supplements also seem to be effective in improving gains in muscle mass over that resulting from training alone (15).

Athletes interested in increasing muscular mass should still participate in aerobic exercise but eat enough additional protein and calories tocompensate for the energy expense.

The published studies generally use subjects engaged in either strength training or endurance exercise, but not both. Many professional bodybuilders perform two hours of intense weight lifting plus two hours of aerobic conditioning per day (or even more), while at the same time consuming a calorie restricted diet. Rather than being exceptional, we deal with many athletes following such a regimen as they prepare for competition. These athletes undoubtedly have exceptional protein requirements. On ***The Parrillo Perfromance Nutrition Program***, we recommend that bodybuilders consume 1.5 grams of protein a day per pound of body weight. One gram per pound of body weight should come from lean proteins, with the remaining .5 gram per pound of body weight coming from starchy and fibrous carbs. We've seen bodybuilders greatly improve their physiques by following these guidelines.

If you don't consume enough protein, your rate of muscular growth will be retarded. To help you meet your protein needs, we have developed Hi-Protein Powder. Each scoop provides 20 grams of ultra quality protein.

People consuming a high protein diet should be sure to drink plenty of water and to get enough calcium. Protein metabolism generates ammonia, which is converted to urea and excreted in the urine and sweat. Drinking plenty of water aids the kidneys in removing this nitrogenous waste and dilutes calcium salts which could form precipitates (kidney stones). Notably, there is no evidence suggesting that strength athletes consuming a high protein diet have an increased incidence of kidney disease. The data suggesting that a high protein diet contributes to the progressive nature of kidney disease come from people with pre-existing kidney problems (2). Many studies have demonstrated a positive correlation between protein intake and calcium excretion (16). Results are equivocal regarding protein intake and calcium absorption. Some studies show that protein improves calcium absorption while others show the opposite. Calcium balance can be maintained during high protein diets by assuring adequate calcium and phosphorus intake (at least the RDA, 800-1200 mg/day). Each of our Mineral-Electrolyte tablets provide 250 mg calcium and 250 mg phosphorus.

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Parrillo Performance Nutrition Bulletin # 9

Carbohydrates: Ultimate Food Fuel, Part I

by John Parrillo

Carbohydrates are grouped into two general classes: complex carbohydrates and simple sugars. Complex carbohydrates are nothing more than simple sugars linked together into long chains. Your body digests the complex carbs into simple sugars and releases them into the bloodstream as glucose. In the end, then, all carbohydrates are converted into glucose before they are used. Based on this, you might think it wouldn”t make any difference whether you get your carbs from starch or simple sugars—but it does.

Simple sugars are released into the bloodstream immediately, causing a rapid increase in blood sugar level and an insulin surge. Because simple sugars are released faster than the body can burn them for energy or store them as glycogen, insulin causes the access to be converted to fat.

Complex carbs, on the other hand, must be digested, a process that slows down their rate of release into the bloodstream, resulting in a more moderate insulin release and a more uniform energy level. Also, since they don’t cause as big an insulin release, complex carbs are not as prone to be converted to fat. One hundred grams of sugar will have a different effect on your body than one hundred grams of starch, even though both supply 100 grams of carbohydrate.

The Parrillo Performance Nutrition Program further subdivides complex carbs into two classes: starchy carbs and fibrous carbs. Good sources of starchy carbohydrates are potatoes, rice, beans, oatmeal, and whole grains, and good sources of fibrous carbs include broccoli, lettuce, spinach, green beans, asparagus, and other fresh vegetables. On ***The Parrillo Performance Nutrition Program***, you eat at least one to two servings of starchy carbs and one to two servings of fibrous carbs at each meal, along with a lean protein source.

High fiber foods such as fibrous carbs contain cellulose, a plant carbohydrate that humans cannot digest. Cellulose, provides bulk which helps with elimination and is good for your intestines. Also, fiber and protein slow the digestion of starchy carbs, resulting in a more gradual release of glucose into the bloodstream and more sustained energy levels. This way, insulin release is more moderate, rather than the sharp spike of insulin released in response to simple sugars. When you combine foods in the way recommended by our nutrition program, you have more energy and less fat storage. Plus, you can eat all the vegetables and salad greens you want and still stay lean.

> Because simple sugars are released faster than the body can burn them for energy or store them as glycogen, insulin causes the excess to be converted to fat.

Be sure to avoid simple sugars. These include not only processed sugar but also foods like honey, milk, and fruit. Milk contains lactose, or milk sugar. Fruit contains a simple sugar known as fructose, which is easily converted to fat in the liver (1). Although fresh fruit and low fat dairy products are healthy, nutritious foods, they contain a lot of natural sugars which are easily converted into body fat. If you’re striving for ultimate leanness and a high energy level, avoid the consumption of sugary foods, including fruit and dairy products.

Animals have a very limited ability to store carbohydrate and instead rely on fat as the storage form of energy. Fat is a more efficient way to store energy because it contains nine calories per gram, as compared to four calories per gram in carbohydrate, and because it does not require water for storage, as does carbohydrate. Since animals are mobile, they store energy as fat. That way, they can store more energy in less space and with less weight.

Only about 600 grams of glycogen (the body’s storage form of carbohydrate) can be stored by the human, although this probably varies according to the individual’s training state, diet, and amount of muscle mass. Glycogen is stored mostly in the muscles where it will be used, and also to a small extent in the liver. Muscle glycogen is not released into the bloodstream and is only used by the muscle in which it's stored.

After muscle glycogen stores become depleted, liver glycogen is broken into glucose units and released into the bloodstream for use by working muscles throughout the body and by the central nurvous system. Because the human body cannot store much carbohydrate, it is very important, especially for athletes, to regularly consume a diet high in complex carbohydrates to fuel the body.

Many experiments indicate that carbohydrate is the body's preferred fuel during exercise. More than 99 percent of the carbohydrate is used in the body to form adenosine triphosphate, or ATP (2). ATP is the fuel source used directly by the muscles to power contractions. ATP is not stored by the body so it must be constantly produced from the aerobic metabolism of carbohydrates, fatty acids, and amino acids (aerobic means "with oxygen").

Carbohydrate is unique in that it can also be metabolized anaerobically (without oxygen). The anaerobic production of ATP from carbohydrate is called glycolysis. Glycolysis makes a big contribution to the energy expended during very intense exercise of short duration, such as weight lifting. Lifting weights requires so much energy so fast that aerobic metabolism can't keep up with the demand. By the time oxygen can get from the lungs to the muscles and inside the cells, your set is already over.

Although glycolysis is relatively inefficient, it offers the advantage of generating energy instantly upon demand. One disadvantage of anaerobic metabolism is that it produces lactic acid as a waste product. Lactic acid accumulates inthe muscles and the blood and is responsible for the burning sensation at the end of the set. The accumulation of lactic acid shuts down energy production and forces you to stop and rest. Most of the lactic acid makes its way from the muscles into the bloodstream. The liver is able to convert the lactic acid back into glucose so it can be used as fuel again. The conversion of lactic acid back into glucose requires oxygen, and this is why you continue to breathe hard for a few minutes while you're recovering after a set. This pay-back from anaerobic metabolism is called "oxygen dept."

In conclusion, your body likes to burn carbs for energy and to store energy as fat. Generally speaking, the more carbs you eat, the more carbs your body will burn for energy, and the more fat you eat, the more fat you'll store. This is why athletes—and especially bodybuilders—should eat a diet high in complex carbohydrates and low in fat, In fact, anyone interested in having a lean, high-energy body should consume a high-carbohydrate, low-fat diet. We also recommend carbohydrate supplementation with Pro-Carb™, which is formulated with maltodextrin, a slow-releasing carbohydrate. Not only is it high in carbohydrates, but a Pro-Carb™ drink also supplies water which is needed for glycogen storage. To order Pro-Carb™, call our toll-free number at 1-800-344-3404.

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Carbohydrates: Ultimate Food Fuel, Part II

by John Parrillo

High intensity exercise of short duration, such as weight lifting, relies on the anaerobic pathway for adenosine triphosphate (ATP is the fuel source used directly by the muscles to power muscular contractions.) Under these conditions, only glucose can be used as fuel (1). Exercise of low to moderate intensity (up to 60 percent of aerobic capacity) can be fueled almost entirely aerobically (1). This means that carbohydrate, fat, and amino acids can all be used as fuel for low intensity exercise.

Hormones are released into the bloodstream during exercise, and these promote fat mobilization and the use of fat for energy. At low to moderate intensity exercise, fat and carbohydrate each supply about half of the energy (1).

Fat cannot be metabolized rapidly enough to meet the energy requirements of intense exercise (above 70 percent aerobic capacity). Furthermore, it takes more oxygen to burn fat than to burn carbohydrate (1,2). This makes carbohydrate a better fuel choice for intense effort, when oxygen supply is limited. For a given amount of oxygen, more energy can be obtained from carbohydrate than from fat. Muscle glycogen is the fuel source used for most forms of exercise, especially weight training. It takes 30 to 60 minutes of exercise for fatty acids to be available to the muscles to use as fuel (1). Up until this time, glucose derived from muscle glycogen is the primary fuel.

This is why it's best to do your aerobics when you're glycogen depleted, and the hormones released during exercise have had time to mobilize fatty acids. An excellent time for aerobics is in the morning before breakfast, because you're glycogen depleted then. And, the longer you spend exercising, the more fat will be used as the fuel source.

Exercise training, especially endurance exercise, increases aerobic capacity. As the heart, lungs, and blood system get bigger and stronger, they can deliver more oxygen to the tissues. This allows relatively more fat to be used at a given level of exercise intensity. The anaerobic threshold is the intensity of effort at which lactic acid begins to accumulate and is usually expressed as a percentage of aerobic capacity (1). Lactic acid is produced from anaerobic metabolism of glucose, so the anaerobic threshold is a measure of how well your body is trained for aerobic energy production. Trained athletes start to accumulate lactic acid at about 70 percent of aerobic capacity, while untrained individuals begin to accumulate lactic acid in their blood at about 50 percent aerobic capacity.

Furthermore, if aerobically trained and untrained individuals exercise at the relative intensity (the same % VO2max), the untrained individual will accumulate more lactic acid in the muscles and blood than the trained individual (3). The difference would be even greater if exercise was performed at the same absolute oxygen requirement. This is explained in part by decreased clearance of lactic acid through the liver by untrained individuals (3) and also by more efficient aerobic metabolism of carbohydrates and fat in the trained athlete (4).

In addition to increasing muscle glycogen storage, endurance training also increases the muscles' ability to use fat as an energy source. This increased ability to burn fat spares glycogen stores, thus further increasing endurance (4). Endurance training increases the size and number of mitochondria in the muscles and activates enzymes involved in the Krebs cycle and oxidative phosphorylation - the central energy producing pathways of the body (1,3). This is one reason why bodybuilders should engage in aerobic exercise: It increases the ability to burn fat for energy. This not only helps you stay lean but also spares glycogen so you can train harder and longer.

Muscle glycogen reserves become progressively lower during exercise. During long bouts of exercise, glycogen reserves may drop to critically low levels - to the point of glycogen depletion (1). The athlete then feels exhausted and must stop exercising or dramatically reduce the intensity. The point of muscular fatigue coincides with glycogen depletion (5). This is separate from momentary muscular failure at the end of a set which is due to lactic acid accumulation. Glycogen reserves can also be depleted gradually over a period of days if carbohydrate intake does not match that utilized during exercise. This feeling of fatigue from failure of adequately replenish glycogen reserves is often interpreted as overtraining. In some cases, overtraining may be alleviated by increased carbohydrate consumption. Not getting a good pump in the gym is a clue that you're probably glycogen deficient.

The amount of carbohydrates you take in affects your training intensity. A group of athletes consuming 300 to 350 grams of carbohydrate per day was seen to become progressively more glycogen depleted during successive days of training (6). After several days, these athletes were unable to continue with heavy training. In contrast, a diet providing 500 to 600 grams carbohydrate per day was seen to result in complete repletion of glycogen reserves, and athletes on this diet were able to maintain a heavy training schedule.

Of course, these numbers are not prescriptive. An individual athlete's carbohydrate requirement depends on his energy needs, which in turn depend on the type, intensity, duration, and frequency of exercise. Endurance athletes require the most energy and the most carbohydrates. The longer and harder you train, the more carbohydrate calories you need.

Some athletes train so heavily that they have trouble consuming enough high carbohydrate foods to fuel their activities and replenish glycogen stores (1). Also, consuming a huge volume of food can cause gastrointestinal distress, bloating, or discomfort, and is not conducive to optimal exercise performance.

Carbohydrate drinks are very useful in this situation, as well as for athletes trying to further increase caloric intake. Carbohydrate beverages are also useful during training and athletic competitions to help maintain energy. The best carb drinks contain slow-release glucose polymers (dextrins) rather than simple sugars such as glucose, sucrose, or fructose. This is the formula contained in our Pro-Carb™ powder drink mix made from maltodextrin, a slow-releasing carbohydrate. To order Pro-Carb™, simply call our toll-free orderline at 1-800-344-3404.

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Carbohydrates: Ultimate Food Fuel, Part III

by John Parrillo

The technique of glycogen supercompensation (glycogen loading) allows an athlete to nearly double the level of stored muscle glycogen (1). The greater the pre-exercise glycogen content, the greater the endurance potentionial (1). The maximum amount of carbohydrate which can be stored by the body is reported to be 600 grams (1), although this probably varies according to the individual's amount of muscle mass. Presumably, more muscular athletes have the ability to store more glycogen and thus would be expected to have more endurance.

In 1967, a classic study was performed to examine the effects of carbohydrate intake on glycogen levels and endurance (2). Endurance was measured by exercise time to exhaustion at VO2max (75% maximal aerobic capacity). A direct relationship was found between carbohydrate content of the diet and endurance time. A low carbohydrate diet (5% of calories) provided muscle glycogen stores of 38 mmol/kg, which sustained one hour of exercise. A moderate carbohydrate diet (50% of calories) resulted in glycogen levels of 106 mmol/kg, which sustained 115 minutes of exercise. The high carbohydrate diet (82% of calories) resulted in glycogen stores of 204 mmol/kg, which supported 170 minutes of high intensity exercise. This experiment provides solid evidence that a high carbohydrate diet is beneficial for endurance performance.

Taking it a step further, it was found that glycogen stores could be even further increased by a supercompensation technique. For three days, the athlete trains as usual but consumes a low-carbohydrate diet that completely depletes the glycogen reserves. Then, for the next three days, the athlete rests and consumes a high-carbohydrate diet. During this recovery period, the body overcompensates and stores more glycogen than normal. When used before competition, this technique helps extend endurance limits.

A more moderate approach has also been developed which seems to work just as well (3). In this protocol, the athlete consumes a 50% carbohydrate diet for three days, while training hard. For the next two days, carbohydrate intake is increased to 70% of calories, and exercise time is decreased to 20 minutes. On the last day before competition, the athlete rests and consumes a high-carbohydrate diet. This experiment demonstrated that it's not necessaryto totally deplete glycogen reserves for supercompensation to occur.

Bodybuilders should probably not strive to totally deplete their glycogen reserves because at that point it's very easy to lose muscle. As a general guideline, we suggest while de-carbing that you adjust your carbohydrate intake so that you lose your pump about three-fourths of the way through the workout. For most bodybuilders, this turns out to be between 100 and 300 grams of carbs per day - an amount sufficient to stimulate glycogen supercompensation without causing a loss of lean body mass. Also, supplementation with branched chain amino acids (Parrillo Performance Muscle Amino Formula™) may help prevent any skeletal muscle protein catabolism.

If you supply your body with a given amount of carbohydrate as either complex carbs or simple sugars, both will help replenish glycogen stores, but more of the simple sugars will be converted to fat.

Bodybuilders who want to use glycogen supercompensation to pump up their muscles during competition should be aware that endurance training is the ultimate stimulus for increased muscle glycogen synthesis. (1). Endurance training increases the activity of glycogen synthase, the enzyme responsible for glycogen storage (1). Furthermore, the effect is specific for the muscles used. Glycogen depletion and subsequent supercompensation is localized to the muscles which are exercised (4). For example, endurance training legs will promote glycogen loading in legs but not in arms. The endurance athlete practicing glycogen loading should glycogen-deplete using the same form of exercise as he will perform in competition. The bodybuilder getting ready for a show should train all major muscle groups to the point of glycogen depletion for a few days before carb loading. A good way to gauge this is to train to fatigue using high rep sets until you lose your pump. Then, for the last two or three days before the show, taper down your activity and increase your carbohydrate intake. Details are described in the ***The Parrillo Performance Nutrition Program***.

Starchy carbohydrates (complex carbs) such as brown rice, potatoes, yams and grains seem to be more effective in replenishing glycogen stores than simples sugars (5). In one study, after a 48-hour recovery period following glycogen-depleting exercise, starch resulted in greater muscle glycogen synthesis than did glucose. Other studies, however, have failed to reproduce this observation.

It seems reasonable to expect that complex carbs would do a better job of replenishing glycogen stores because they are released into the bloodstream more slowly. This slow release maintains elevation of insulin, and insulin in turn stimulates glycogen synthase (4).

Simple sugars are released more rapidly, potentially overwhelming the glycogen synthesis pathways. Furthermore, the increased insulin release resulting from simple sugars causes some of the sugar to be stored as fat. If you supply your body with a given amount of carbohydrate as either complex carbs or simple sugars, both will help replenish glycogen stores, but more of the simple sugar will be converted to fat. For this reason, our program recommends that bodybuilders use complex carbs to minimize any “spill over” of carbs into fat stores.

One study has been performed to investigate the effectiveness of a maltodextrin beverage for glycogen supercompensation (6). Muscle glycogen was measured by biopsy and endurance was measured by run time to exhaustion at 75% VO2max. Subjects glycogen-depleted by consuming a 20% carbohydrate diet for three days while continuing to train. During the next three days, the subjects ran less and consumed a 90% carbohydrate diet to replenish glycogen stores. During the glycogen loading phase, one group received carbs from rice and pasta and another group received a maltodextrin beverage. The 90% rice-pasta diet resulted in lower muscle glycogen levels than did the 90% maltodextrin diet. Total endurance times for the two groups following the 90% carbohydrate diets were essentially identical. The authors suggest that the greater glycogen loading in the group receiving the maltodextrin supplement may be a result of better absorption and assimilation of carbohydrate calories in liquid form. Also, subjects in the maltodextrin group reported less gastrointestinal discomfort.

Carbohydrate feeding during exercise events lasting longer than 90 minutes may increase endurance by providing glucose to muscles after their glycogen stores have been diminished (1). Parrillo Performance Pro-Carb™ is ideal for this, since it provides glucose as maltodextrin—a slow release glucose polymer. Maltodextrin beverages like Pro-Carb™ have been demonstrated to increase blood glucose levels during exercise and to increase exercise time to exhaustion (7, 8). Dehydration and glycogen depletion can both compromise athletic performance, so Pro-Carb™ drinks are perfect for endurance athletes and hard training bodybuilders.

After the muscles deplete their glycogen stores they begin to use more blood glucose for energy. The liver has its own glycogen stores and can also synthesize glucose from amino acids in a process known as gluconeogenesis. While the glycogen stored in the liver can be mobilized and released into the bloodstream, glycogen stored in a muscle is used only by that muscle and cannot provide glucose for the blood (2). After liver glycogen is depleted, blood glucose drops and central nervous system symptoms of hypoglycemia (dizziness, nausea, fatigue) develop, in addition to local muscular failure (1). Carbohydrate supplementation during exercise increases endurance by helping to maintain blood glucose, which provides fuel for the muscles and the central nervous system (1). Experiments with cyclists have demonstrated that carbohydrate feeding during exercise can increase endurance by 30-60 minutes (1).

Replenishing depleted glycogen stores is essential to prevent fatigue associated with repeated days of heavy training (1, 4). Of course, adequate carbohydrate intake is required to maintain glycogen stores. In general, the amount of glycogen stored is proportional to carbohydrate consumption, at least up to 600 grams of carbs per day (4). Athletes who train every day generally need 500-600 grams of carbohydrate per day to maintain glycogen reserves (1). As mentioned, the body has the ability to store about 600 grams of carbohydrate, and carbs consumed in excess of this will probably not result in proportionately greater glycogen storage (4). Of course, individual requirements vary, depending on lean body mass, basal metabolic rate and activity level.

It is important to consume carbohydrate immediately after exercise in order to maximize glycogen storage (1, 9). When consuming carbohydrates after exercise, muscle glycogen stores are replenished first (4). Next, liver glycogen is replaced. After muscle and liver glycogen stores are full, additional carbohydrates will be stored as fat (4).

It has been shown that glycogen supercompensation increases endurance time of runners and cyclists (4). Athletes finish best times when they begin with full glycogen stores (4). Glycogen loading does not improve speed at the beginning of a race but rather allows the athlete to maintain the same pace longer before slowing down (1, 4). In other words, it improves endurance but not speed.

As most athletes aren’t hungry right after training, this is the ideal time for a Pro-Carb™ drink. The Pro-Carb™ Formula is perfect for endurance athletes and bodybuilders who constantly push themselves to the glycogen depletion limit during extended training. Drinking Pro-Carb™, containing maltodextrin, is a great way to get your body the carbohydrates it needs to replenish its glycogen stores following extended periods of training. Pro-Carb™ can also be taken during workouts to supply the added carbohydrates needed to maintain a high energy level during intense workouts.

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