Is Lactic Acid a Four Letter Word?

by Patti and Warren Finke, Team Oregon

Next to heredity, the most important aspect of human performance is the ability of the body to efficiently utilize its fuel resources. The effects of training on the major elements of the pulmonary and cardiovascular systems and on the profusion and structure of muscles, mitochondria, enzymes and other factors all control the types and efficiency of fuels utilized and the ultimate performance.

ENERGY SOURCES

The actual source of energy used by the muscles in running or any other kind of activity is ATP (Adenosine Tri Phosphate). It can be generated either aerobically or anaerobically (with or without oxygen). All running events use a combination of the two systems. Distance running, which we will define here as any event over 1 mile, primarily uses aerobic metabolism; but it is important to understand the contributions from anaerobic metabolism.

Anaerobic Energy Sources

Anaerobic energy sources are used at the start of exercise and when the intensity of exercise is greater than that which can be supported by the available oxygen supply using aerobic sources. The point where this occurs is called the "anaerobic threshold". It occurs at a pace near your 2 mile race pace or about 10% faster than your 10 K race pace (0.9 x 10K pace/mile). The anaerobic threshold is not an immediate transition from aerobic to anaerobic metabolism but is more like the point where the anaerobic contribution increases rapidly with intensity.

There are two sources of energy in the anaerobic system, the phosphate system and the lactate system. The phosphate system consists of small stores of high energy ATP and Creatine Phosphate (CP) in the muscle. The phosphate system is the primary system used in events taking 10 to 20 seconds(short sprints). When the store is exhausted, additional energy must be generated to replenish the phosphate pool or keep the muscles working. The stores can be regenerated and used over and over again.

The lactate system utilizes glycogen (sugar) stored locally in the muscles and remotely in the liver and the glucose present in the blood. The higher the energy requirement the more the local stores in the muscle are favored. Anaerobic glycolysis or the breakdown of the glucose quickly for intense exercise results in the formation of lactic acid. Lactic acid is often thought of as a "waste product". In the presence of oxygen, however, it is easily converted to ATP and becomes a fuel. There is also evidence to suggest that lactic acid can be shuttled back and forth to other muscle groups via the bloodstream. Lactic acid may not accumulate if the intensity of the exercise is low enough for it to be oxidized to make more ATP. When the rate of production exceeds the rate of removal, the lactic acid begins to accumulate, bloodstream pH level, (acidity), rises and the muscles do not function as well and begin to "burn". An example of the result of lactic acid accumulation is the "tying up" of the 800 meter runner the last 100 yards after starting too fast. Examples most of us have felt are the burning from too many sit ups (lactic acid in the abdominal muscles) or the quadriceps burning felt when bicycling or running up a steep hill.

Aerobic Energy Sources

At exercise intensities below the anaerobic threshold, energy conversion is primarily aerobic. The energy for aerobic metabolism comes from two sources glycogen (muscle and liver glycogen, blood glucose) and fat. Aerobic glycogen conversion is the most readily available source of energy and the primary energy source up to about 30 minutes of exercise. After 30 minutes, fat has been mobilized from fat stores and becomes a major contributor. There is always a combination of glycogen and fat usage with the relative contributions at any time determined by the intensity of exercise. More intense exercise will tend to burn more of the most readily available fuels, first muscle glycogen, then liver and blood glycogen and finally fat. As the intensity of the exercise decreases, a higher ratio of fat is used. At paces more than 30% slower than your 10K race pace (1.3 x 10K pace/mile), you should be utilizing the highest ratio of fat for fuel.

There is a finite storage of glycogen which can be increased somewhat through training. These stores will run out usually after 1 hour 45 minutes to 2 hours of hard running. On the other hand, there are nearly unlimited supplies of fat making it the fuel of choice for longer events. One pound of fat contains enough energy to run over 50 kilometers (31.2 mi). Fat, however, cannot be easily metabolized without the presence of muscle glycogen. Therefore if muscle glycogen levels are badly depleted, fat is available but cannot be utilized leading to a drastic drop in performance ("hitting the wall"). This is why it is important not to start too fast in long training runs or races and "waste" your muscle glycogen stores.

At lower intensities more glycogen from the liver and bloodstream can be utilized. This spares some of the important muscle glycogen stores so that efficient aerobic metabolism using fat can be maintained for a longer duration. In ultramarathon events liver glycogen depletion has been observed indicating that ingestion of sugar or sugared drinks may be necessary. There is evidence it will enhance performance in marathons.

In exercise lasting over 4 hours, protein may be broken down, first from muscle enzymes and then from muscle tissue itself, to make the necessary glycogen for fuel. This method of energy conversion is extremely inefficient and the body's last resort for survival.

ENERGY UTILIZATION

The ability to perform work with our muscles is dependent on our muscular composition and our muscular fitness level. There are two major types of skeletal muscles: slow red and fast contracting. Slow red muscle, because it has lots of blood vessels to carry the nutrients, lots of myoglobin to transport oxygen and lots of energy factories known as mitochondria, consumes oxygen well and generates ATP or energy with aerobic metabolism. Because of its aerobic ability and its resistance to fatigue, this is the primary muscle type of the long distance runner. Slow red muscles tend to be long and thin, note the slender legs of most marathoners.

Fast contracting muscle may be either white which uses the anaerobic phosphate or lactate energy systems or red which has the same characteristics as the slow red, but can use either anaerobic or aerobic metabolism to work. Note that fast white muscles usually are those that can hypertrophy or get big and are the primary muscles of body builders, sprinters and jumpers. People with a high percentage of fast white muscle fibers do not perform well in endurance events.

With a couple of exceptions which are mentioned below, we are born with a musclemake up consisting of a fixed ratio of both kinds of fibers and cannot change it. The most notable exception is that fast red muscle may be converted to use either aerobicor anaerobic metabolism through appropriate training. Some studies have shown that ultra distance runners who have broken down huge amounts of muscle tissue during strenuous events rebuild with slow red fibers. This would be considered a rather extreme way to alter muscle makeup, however.

Training Requirements for Events

Aerobic endurance training makes major changes in muscles. It increases size and the number of mitochondria, (ATP factories), as well as the amount of enzymes they produce. It also increases the amount of myoglobin and the number of blood vessels, which enhance the ability to get remote fuels to the muscles. These changes occur in red muscles not in white; they, therefore, generally increase aerobic metabolism and may actually decrease the ability for anaerobic metabolism. Remember that we always use a combination of both, but you must look at your major energy needs to see what kind of training is best for you.

Training programs for any event should utilize a base building period, during which stamina is increased before any rigorous specific training is done. The specific training is only half of the training regimen; the other half being easy recovery days during which actual adaptation takes place. Here are some specific training requirements for the energy systems for various events.

- **The Short Sprints:** Extremely high intensity, extremely short duration races. The short sprints use the phosphate system primarily and are done by those who inherited a large percentage of fast white fibers. If this is you, you already know that energy conversion is not your primary training Starting and other neuromuscular kinds of training are most important. You probably already know that marathoning would not be much fun for you and are probably not reading this article. Those of you who have some white fibers (can jump straight up over 6 inches) and can utilize your phosphate system have a great finishing kick you can use for the last 100 yards of any race.
- **The Two Mile:** Very high intensity, short duration race run at or very near anaerobic threshold. This race is about 50:50 anaerobic and aerobic energy usage using the lactate system and aerobic glycolysis burning primarily muscle glycogen and almost no fat. The convertible fiber should be trained to anaerobic with an attempt to push anaerobic threshold very high. The specific training would be intervals close to anaerobic threshold pace to train the lactate system and enhance the ability of the muscles to work at higher pH levels and fast continuous short runs to develop aerobicglycogen metabolism.
- **The 10K:** High intensity, medium duration race. This race is run mostly on aerobicglycogen and a small amount of fat with the convertible fibers trained to use glycogen aerobically. The lactate system is important in this distance race for hills, surges and starting the finishing kick with 1/4 mile to go. The specific training would be fast continuous running to develop aerobic glycogen metabolism and hill workouts, fartlek and some intervals for the lactate system. Anaerobic training should be minimized to insure that convertible muscle fibers are trained for endurance. A long aerobic run of up to 15 or 16 miles is important for the endurance to complete the race.
- **The Marathon:** Medium intensity, long duration race. This race is almost entirely on aerobic metabolism with a high percentage of fat utilization. The convertible fibers are trained for endurance. Marathon training concentrates on long slow runs with one long run a week which may approach or exceed race duration. This long run needs to belong enough (over 16 miles) and slow enough (close to 30% slower than 10K race pace) to decrease the dependence on muscle glycogen and enhance fat burning and the ability of the muscles to make the fat mobilizing and fat burning enzymes.

COMMON TRAINING ERRORS

Many runners do not understand the energy conversion systems and base their training on what others do or have told them to do rather than their own needs. Some common errors we have seen runners make are:

- **Fast Intervals:** Training anaerobically for aerobic races. Many runners who run intervals for 8K and 10K races run them too fast and train their convertible fibers to be anaerobic. Do not train more than 10% faster than your 10K race pace.
- **Trying to Trade Intensity for Volume:** We often see runners who think fast short runs are equivalent to long slow runs. This shows a basic misunderstanding of how the bodies energy systems are used and trained. In fact, a much wider range of energy systems are trained using long slow distance including those used in short road race events. It is especially important to realize this when training for the marathon. The key for marathoning is to learn use fat and spare glycogen at faster paces, The muscles learn to do this from long slow runs not from first depleting the glycogen and then trying to burn fat. Fast runs of 16 miles are a sure way to train your muscles to use up most of their glycogen with 10 miles still to go in the marathon.
- **Too Much Speed work:** The percentage of time you spend doing one kind of training should be consistent with the importance of the energy systems used in the race.
- **Pain and Gain:** Running short fast runs for weight control. It takes 30 minutes to mobilize fat which will be used only if the exercise intensity is low. Walk or run at apace 30% slower than your 10K pace to burn the most fat. You burn about 100 calories per mile no matter what the pace; but you want it to be 100 calories of fat not glycogen.