Have You Ever Wondered Why?

We all hope (and sometimes pray) that the physical demands we place on our bodies during training will make us faster cyclists. Traditional training has always included long hours in the saddle with countless miles on the open road. And usually, after much sweat and tears (and a few saddle sores and sunburn) we ride faster. Have you ever wondered why? What happens inside our bodies that allows us to keep pushing the envelope? How can we complete that race at the end of the season that would have killed us only a few months before? The human body is a remarkable combination of interacting systems that allow for great amounts of training adaptation.

Training adaptation is a good thing as long as we don’t carry it too far. The million dollar question always comes back to “How much training, how hard and for how long?” In addition, you need to know how different types of training affect different aspects of the sport. The demands of cycling are unique in that each athlete must have the ability to sprint well, maintain power for prolonged periods of time and be able to recover quickly. Sounds easy, right? Finding the perfect balance between stressing a rider’s body and allowing for proper recovery is crucial. Each rider is different and everyone adapts to training in individual ways. However, there are similar adaptations that take place in all of our bodies.

A Brief Lesson In Physiology

Here is a brief overview of the body’s different energy systems. Understanding the different systems helps make the training principles and adaptations more logical.

Energy is required for every muscle contraction in the human body. This energy comes from the breakdown of the food we eat: carbohydrates, fat and protein. The food is broken down into energy (ATP) through three different, but interactive, energy systems. Based on how fast the ATP needs to be produced, our muscles are able to decide what type of fuel to burn for energy and how efficiently to consume these fuels.

The primary method of energy production during endurance activities is aerobic metabolism. This refers to the process of breaking down fuels in the presence of oxygen. When you are riding at relatively low intensities that last an hour or more, most of the required energy can be obtained from the breakdown of fats and some carbohydrates. Energy released from fats takes a long time to get through a long metabolic pathway and liberates little ATP. Therefore, as your exercise becomes more intense, your body relies more on the anaerobic breakdown of carbohydrates for fuel. The anaerobic pathway, known as glycolysis, can produce energy faster, but since oxygen is not used, lactic acid is a by-product. Unfortunately, this system of energy production is relatively inefficient and the maximal duration of exercise may be limited to only a few minutes of activity. In an all-out effort lasting 1 to 2 minutes, muscle lactic acid rises to levels that cause fatigue.

The good news is that all of the systems used to produce energy can be trained to produce more energy! However, the nature of the exercise stimulus determines the type of training adaptation. For example, if you only ride long, slow miles, you cannot train your body to sprint faster. You will, however, train your body to better utilize fuel for long, slow rides (more about this later).

Training Adaptations

Since physiological adaptations to training are specific to the type of training done, changes are specific to the intensity of the exercise performed during training. Aerobic or endurance training adaptations are the result of improvements in circulation to the muscle and in the muscle itself. Changes within the muscle can range from an improvement in blood flow to changes in how the
Aerobic Training

Exercise scientists have been fascinated with the effects of endurance training for decades. Regular strenuous exercise has been proven to lead to an increase in the capacity of the muscle for aerobic metabolism. Some of the many biochemical and physiological adaptations that take place in the muscle will be examined here.

One of the most important changes that occurs with endurance training is an increase in the number of capillaries surrounding each muscle fiber. The increase in capillarization allows for a faster exchange of oxygen and fuel between the blood and the working muscles. Think of your main arteries as highways with large trucks hauling oxygen and food to your muscles. Capillaries act like off-ramps; the more off-ramps you have, the more easily the trucks can get the oxygen and food to the working muscle. A high muscle capillary density has been thought to increase the amount of blood to the muscle by decreasing the distance that the blood must diffuse to get from the artery to the muscle. By allowing more trucks to get through at a shorter distance, more fuel is available for energy production.

Having more nutrients delivered to the muscle cell is good only if those nutrients can be turned into usable energy (ATP). Luckily, endurance training has also been shown to increase the number of mitochondria in the muscle cells. Mitochondria are most commonly known as the “powerhouses” of the cell; without them cells would be unable to liberate energy from nutrients and oxygen. The ability to use oxygen and to produce ATP aerobically depends on the number, size and efficiency of the mitochondria. The relatively low mitochondrial activity found in sedentary individuals means each mitochondria must work at high rates to meet the ATP requirements for exercise. Endurance training works to increase the number of mitochondria and aerobic enzyme activity, which will improve the capacity of the muscle fibers to produce ATP. In addition, the average size of the mitochondria has been shown to increase by about 35%. As a result, each mitochondria does not have to work as hard to respire as much energy.

Endurance training places repeated demands on the muscles’ supply of carbohydrate and fat required for fuel. One of the most important adaptations to endurance exercise training is the enhanced capacity of muscle to utilized long-chain fatty acids for fuel. This adaptation is accompanied by an increase in the proportion of energy derived from fat and a decrease in carbohydrate use. One research study showed the energy derived from fat during 2 hours of moderate cycling rose from approximately 40% before training to 60% after 3 months of training. Subsequent studies showed that after endurance training, carbohydrate oxidation was reduced by 30% during moderate exercise.

So what does all this mean? Endurance training can lead to an increase in the use of our unlimited supply of fat for fuel, and to a decreased dependence on our limited carbohydrate supply. In competitive cycling events that can last for several hours, these adaptations can help to prevent early depletion of glycogen and hopefully work to improve performance.

Anaerobic Training

When the demands of exercise become too much for the aerobic system, the muscle cell must turn to anaerobic metabolism for faster production of ATP. Lactic acid is a chemical by-product of anaerobic ATP production. During low-intensity exercise, the lactate is cleared from the muscle cell as quickly as it is produced. During short-term, high-intensity sprint exercise, lactic acid is produced faster than it can be cleared so that it eventually accumulates within the muscle fiber. When lactic acid accumulates in the muscle fiber, the pH of the fiber is altered and fatigue sets in.

During and after sprint exercise, the pH of the muscle fiber drops. Such a disturbance in the pH balance of the muscle impairs its capacity to generate ATP. There are certain chemical “buffers” in the muscle which temporarily work to neutralize the lactic acid. An increase in the muscle buffering capacity delays the onset of fatigue during anaerobic exercise. Research has shown that buffer capacity increased 12 to 50% as a result of eight weeks of sprint training, but was not changed with aerobic training.

Lactate accumulates within the muscle, in part, because it does not freely diffuse across the cell membranes. If no work is done, the rider sits between sprints, the lactic acid can take up to 1 or 2 hours to completely diffuse. During low intensity, active recovery, lactate is able to flow through the active muscle, and increase the rate of lactate diffused out of the muscle. Although an increase in muscle capillarization is a direct response to endurance training, it is critical in helping to remove lactate from the muscle after anaerobic exercise.

Train, train, train—by exploring the different ways that the human body adapts to exercise, you hopefully have realized that variety is the key. Even if you are a sprint athlete, your body needs the adaptations obtained during endurance training to better help you cope with the stresses of sprint workouts. It works the other way, too. If you are an endurance cyclist, you still need the adaptations that take place with sprint training. There is just no way around a balanced training plan!