The Energy Systems Explained

As a coach it can be frustrating to watch talented, intelligent athletes make the same training mistakes over and over again, and the most common mistakes are always training at the same pace and over-racing. If blind trust were common among athletes, coaching would be easy (remind me to talk to Bill Belechick about this), but since it's not common, I've written an explanation as to why I ask you to hold back the pace or not to race 2 weekends in a row in January. ☺

The most common training approach taken by untrained triathletes is to either try to follow the program developed specifically for their favorite professional, or to have a haphazard approach and train as their friends train. The problem with the first approach is that few if any of us have the talent, time and resources to devote to training that a professional does. Their programs are generally developed specifically for them from extensive laboratory and field testing. The training intensity and volume of the professional athletes takes years to develop and assumes a high level of durability.

The second approach - haphazard (usually hard and sporadic) training will only allow you to reach approximately 70% of your genetic potential. Generally speaking, you will tend to either undertrain or overtrain. In addition, your training will be very narrow in focus and not prepare you for all the situations you will be exposed to in triathlon.

The objective then, is to avoid the mistakes which can prevent you from performing your best as a triathlete with your given set of genetic capabilities, and to make the most of your training time. The challenge is not to gain a certain placing, it is to maximize your genetic potential and achieve results beyond the norm for your particular set of talents.

The Energy Systems

Aerobic

The aerobic system is the foundation on which endurance training rests. The aerobic system is the system that is continually replenishing the energy we use at all levels of activity - from sleeping to vigorous activity. The degree that this system is being called upon to produce energy is the critical issue. Generally speaking, as the duration of effort increases, the intensity must decrease and more energy must be provided during the task using aerobic metabolism.

Training the aerobic system has two important intensity levels. Aerobic conditioning and Max VO_2 training. The bulk of your training in all phases will be for aerobic conditioning. This is low intensity training that will accomplish various physiological adaptations crucial for performance improvement. These adaptations are;

- Improved respiratory function (oxygen delivery system)
- Improved cardiac function (blood pumping system)
- Improved thermoregulatory system (helps keep you cool)
- Improved neuromuscular function (efficiency and coordination)
- Improved fat burning capabilities (calories from fat spares carbohydrate)
- Increased number of mitochondria (energy producing structures)
- Increased liver and muscle carbohydrate stores.

Max VO_2 training will occur in the Race Phase and be accomplished by hard efforts above the Anaerobic Threshold. Exercise at this level increases the amount of oxygen you can consume during all out efforts. The greater the amount of oxygen consumed, the greater work potential. Aerobic workouts are performed below the anaerobic threshold (determined by testing), and the purpose for this type of training is to get the athlete accustomed to exercising for extended periods of time (more than 75 mins).

As a general rule, the longest of these workouts should be no more than 15 to 20 percent longer than the distance the athlete intends to compete at.

Anaerobic

Anaerobic metabolism occurs when the level of muscular activity causes the demand for oxygen to exceed the body's ability provide it. In the absence of oxygen, the body *will* produce energy but at a cost. The waste product of anaerobic metabolism is lactic acid. The more intense the exercise, the faster that lactic acid is accumulated in the muscles and blood. Anaerobic metabolism is responsible for the majority of energy production in all-out efforts lasting approximately 1 to 10 minutes. The point at which lactic acid begins to quickly accumulate in the blood is known as the Lactate Threshold.

A critical point needs to be made regarding the lactate threshold. The closer you can get your anaerobic threshold to your Max VO2, the faster you will become. **Simply having a high Max VO2 does not necessarily make you fast**. Being able to sustain efforts close to your Max VO2 is what will determine whether you are fast or not.

Lactic acid interferes with the muscles ability to contract. The burning sensation experienced with the accumulation of lactic acid is the result of a change in muscular acidity. The ability to tolerate and buffer the effects of this changing acidic environment is what anaerobic training is all about.

The anaerobic energy system is trained by two methods I use in training. The first is to produce large quantities of lactic acid by performing high intensity efforts for relatively short periods of time. The second method involves slightly less intense efforts that last longer. This improves the ability to tolerate lactic acid for longer periods of time. Both methods are important in developing maximum performance, but this type of training must be timed right and can't be used too often or you will have diminishing returns.

ATP-CP

ATP (adenosine triphosphate) and CP (creatine phosphate) are the substances used for cellular activity in all tissues, including muscle. This is the energy stored in muscles and available immediately for use by the muscles in contraction and relaxation. A limited amount of ATP can be stored in muscles. When the intensity of effort is maximal, this energy source is depleted in 20-30 seconds. After this time, intensity must decline or the effort must stop. ATP must be continually replenished during physical activity. In cycling and running, this energy system would come into play with climbing a short, steep hill or sprinting. Training this energy system requires very short bouts of all-out effort (10-15 sec) with long and probably complete recovery between efforts. Care must be taken not to stimulate the anaerobic energy system with its production of lactic acid. The objective of training this system is to deplete the ATP and CP stores thus stimulating a supracompensatory increase in ATP and CP stores. Additional neuromuscular conditioning causes this system to respond quicker. There is some controversy surrounding the training of this energy system. Whether or not it is an increase in the efficiency of this system or strictly a neuromuscular adaptation is unclear. Whatever the mechanism of change, the smart triathlete and marathoner will spend some time training for speed, even though those activities rely more on endurance than pure speed. Again*, the timing and application of this training is critical* and shouldn't be random.

Strength

Strength is the ability to generate force with your muscles. The ability to generate force via muscular activity is the essence behind any sport. In triathlon and in long distance running, you must be able to generate that force efficiently and consistently in order to compete. This does not necessarily mean that you can lift great amounts of weight. This does mean that you can exert force over and over again without undo fatigue during the course of a race.

Since strength is such an important aspect in reaching your potential, we need to determine the best means of improving strength. Most elite triathletes spend part of their base-building phase lifting weights, and to a small degree, maintain weight lifting during race season. It should be stressed, however, that weight lifting should never take the place of a scheduled swim, bike or run workout.

In order to gain strength, you must place a muscle under a progressive overload in order to improve strength. This same principle applies to improving muscular endurance. The resistance must be heavy enough to cause sufficient stimulation for muscular adaptation.

In regard to seasonal lifting, research is clear that strength gains obtained from lifting weights are quickly lost upon cessation of specific strength training. This effect appears

to be accelerated in the presence of endurance training. Therefore, your training program may include weight training in the winter, to be replaced by sport-specific resistance drills and body weight training (ie, yoga) in the race season. The workouts are designed to emphasize muscular endurance and strength.

TRAINING ZONES

Each workout uses one or more of the following zones. Staying within these zones will provide the control required to give proper short and long-term feedback on your training. When you've completed your maximum HR tests on bike and run, we will use YOUR personal heart rate zones as determined by the test.

Zone 1: Active Recovery/Easy: (.65 to .75 LT)

Purpose: This intensity is for recovery workouts after high intensity workouts. Active recovery is always better than inactivity. Light activity bathes your muscles in oxygen and carbohydrate rich blood while removing metabolic waste products from muscle. Training in this range will makes recovery faster and more effective.

Zone 2: Endurance: (.75 to .85 x LT)

Purpose: This zone will provide you with basic aerobic conditioning. This is the place where you lay down your base from which all other training will build off from. You must have a solid base of aerobic conditioning to prepare your body for the higher intensity efforts in later phases. As mentioned earlier in this article, this pace serves to increase the number of capillaries in your working muscles, train your muscles to utilize fats for energy production, improve your oxygen utilization systems and in general, develop a feel for what it is like to be training for an extended period of time. In this program, a great amount of training time is devoted to this zone. You will need to utilize your heart rate monitor to ensure you stay within your heart rate limits. Make sure you do not go above your zone when riding and running up hills, or trying to keep up with friends.

Zone 3: Tempo: (.85 to .90 x LT)

Purpose: Zone 3 is intensity will cause general aerobic conditioning as Endurance does, however, Zone 3 will deplete your glycogen stores and lead to fatigue much faster than Endurance. This will cause your body to restore lost reserves and therefore provides a specific training effect. The problem, however, is that many athletes spend too much time in this zone. Some even spend most of their time here. This leads to a significant deficiency in their training. If performed with additional high intensity efforts (such as intervals) and no recovery, overtraining can quickly develop. If all your workouts are performed in this zone, conditioning will lack the ability to sustain a competitive pace during racing or hard riding. Therefore, little time is spent in this zone in this program.

Zone 4: Intervals: (.95 x LT to Vo2Max)

Purpose: This zone provides the stimulation to allow you to raise your Lactate Threshold (10 minutes and over, below or right at lactate threshold), tolerate exercising in the presence of lactic acid (shorter intervals with little recovery), and raise your VO2Max (short, 2-5 minute intervals at or slightly below VO2Max). These are hard efforts that, if done correctly, will make you fast -- at a cost. The metabolic cost of exercising at this intensity is great and your body cannot tolerate an excessive amount of this type of effort. If too much time is spent riding in this zone, it will quickly lead to overreaching, overtraining and burnout. Proper training at this intensity will allow you to sustain a higher pace during a race or chase down the athlete in front of you. You will be operating at a higher percentage of your maximum ability for a longer period of time. Zone 4 efforts typically last from 90 seconds to 15 minutes depending on the intensity. You can manipulate each of the four elements (reps, time, intensity HR, recovery HR) for the desired effect.

Zone 5: Max Sprinting Effort (doesn't equate to a heart rate)

Purpose: This zone does not equate specifically to any heart rate range. It is for very short duration (10 - 30 second) efforts at absolute maximum intensity (120% of VO2Max utilizing your ATP-PC system) and comes late in your training program. Your body only stores enough energy in the muscles themselves to sustain this type of effort for about 30 seconds. After 30 seconds you must slow down if you have performed the sprint properly. Hard efforts such as these will be performed primarily when peaking and getting into racing form. Some Sprint efforts will be performed year-round, however, in order to maintain neuromuscular condition and keep riders accustomed to hard efforts. Zone 5 efforts demand that maximum recovery (at least LT -80, or at least 3-5 minutes between reps) follow each rep in order for your body to replace the spent glycogen within your muscles. Warm-ups and cool-downs before and after these sprints are essential to perform at maximum ability and avoid injury.

Practical Application of Zones

Endurance Training

Endurance runs and rides are generally performed for a minimum of 1 hour in order to have the desired effect. At this intensity, increase in volume is the only way to achieve training effects so they must be performed in some systematically built up manner. In the BASE and BUILD periods, these workouts can be done in the top half of the Endurance heart rate zone. In the RACE period, however, they are really a maintenance and recovery function, and as such should be done in the Recovery/Easy Distance heart rate zone, or lower Endurance Zone. Athletes may find this training somewhat boring, yet the accumulation of these long workouts will produce some of the most significant

physiological effects. Your metabolism and body fat can be transformed through the systematic use of these long, easy workouts.

Tempo Workouts

Tempo training is where most athletes spend too much time. This training will produce cardiovascular adaptations but at a greater cost than Endurance workouts. Tempo work depletes muscle glycogen and carbohydrate stores where Endurance work provides the opportunity for these sources to recover. Too much riding in Tempo Zone will make you stale and if done the day after Interval or Speed workouts, will not provide your body with the rest and recovery it needs to improve. That is why there is not a lot of time allocated to Tempo. Its best purpose is as warm-up prior to intervals or other intense workouts.

Intervals/Speed

Speed work is designed to expose your muscles to the type of hard sustained effort you experience in racing. It is very difficult to duplicate race pace efforts outside of competition, however, some group workouts can reach race pace as we are all aware. Due to the inconsistent nature of training outdoors, it is necessary to perform some of your speed work on the track or treadmill. This will allow you to attain a consistent effort and more effective training. Time trials and individual sport races are excellent means of performing speed work while also giving you feedback on conditioning progress. Use of your heart rate monitor will be critical when speed work is performed on the road and helpful when done on the treadmill. It is very important to train on different trails and courses that demand different running and bike handling skills and cardiovascular capabilities. This will give you the variety in terrain to help you become a well rounded athlete.

Intervals

There are three types of intervals that will be performed in this program. The first is Lactate Threshold Stimulation, the second is VO2 Max Stimulation and the third is ATP_PC Stimulation. The latter is essentially Sprinting and will be covered in the Sprinting Section.

Lactate Threshold Stimulation (Long) intervals will be performed during the late Base through the Race stage. These are the intervals that help raise your lactate threshold. Consequently they are performed slightly (1-5 beats) below or at Lactate Threshold.

VO2 Max Stimulation (Short) intervals are performed during the Late Build and Race stages of this program. These intervals help increase your VO2 Max while also conditioning your muscles to tolerate contracting in the presence of lactic acid. Consequently these intervals are very stressful.

All intervals can be performed on the treadmill or trainer when necessary, or outdoors on the track. You pick the venue based on how you feel and your weekly schedule.

Tips:

Never try to perform intervals unless you have the energy to perform them properly. If you are tired or haven't recovered yet, skip the workout or schedule it later in the week. Trying to perform high intensity workouts when tired will not benefit you and can cause overreaching.

The goal is to adhere strictly to heart rate goals on every interval, and to them as written in the schedule. If you fall off the pace and cannot maintain speed at the prescribed heart rate --STOP. Going beyond that will hurt your body. You need to stress your body for training effect, but if you overstress yourself, you will lower the improvement curve.

When performing your hill repeats, choose a hill of appropriate length for your prescribed intervals and, if possible, includes some sections that may be too steep for you at this time. This will help you develop both your anaerobic system and your riding technique. It is important to concentrate on maintaining proper technique while performing these intervals or climbing any hill. When you are at the limit of your strength and your thighs are burning, concentrate on pedaling in circles on the bike, or shortening the stride on the run. In addition, keep your upper body still. Don't waste energy.

Always do a warm-up (15 - 30 minutes of Zone 1 or Easy Distance. You should perform 2 or 3 accelerations to raise your heart rate to within 5 beats of your interval target heart rate followed by complete recovery. Cool down should be in Zone 1 or Easy Distance for at least 20 min.

Sprint Training

Speed relates to your muscular ability to spin the cranks (cadence), or have a fast turnover in running and swimming. Leg and arm speed is very important at the start of a race. Getting maximum leg turnover combines with strength to give you rocket speed out of the blocks. Speed is determined mainly by the ratio of fast twitch muscle fibers in the main movers (gluteus, quads, hamstrings). Sprinting capability is a combination of the neuromuscular and ATP-PC chemical system in your muscles. Sprinting is therefore best trained by doing repeated, maximal (that means absolute, total) efforts of 10 to 30 seconds followed by total recovery (at least three minutes of extremely light or no activity).

Weight Training

All athletes should build their strength through simple weight training. Research has found that weight training can increase your time to fatigue by allowing your muscles to operate at a lower percentage of their maximum while exercising. Research has also shown that strength training can enhance endurance performance independently of increases in VO_{2max} and that this improvement is related to increases in muscular strength. It has also been demonstrated that this improved endurance performance is related to an elevated LT.

Selection of exercises is very important. Exercises should be as sport specific or "functional" as possible. This means doing squats or leg press exercises instead of leg extension exercises. Bench press instead of preacher curls. Generally speaking the exercises you do should be multiple muscle movements as opposed to isolation type lifts. Free weights are also superior to machines in that free weights help train your muscular balance and coordination.