Training for Lactate Production and Tolerance on the Track

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The ability to produce a lot of power very quickly is one of the defining attributes of track riders. For example, a world class track rider can produce peak power outputs of up to 1,600 watts. Instantaneous power in a single pedal stroke has been measured as high as 3,100 watts. By comparison, 300–350 watts is the average sustained power output in an endurance situation and a "comfortable" power output is around 100–200 watts. In order for metabolic systems to produce the energy quickly enough to meet the demands of the high power outputs required on the track, anaerobic systems must be relied on. Aerobic energy production is simply too slow to meet the rapid demand for energy. The downside is that anaerobic capacities are limited, even in the best of riders. All too soon, the immediate energy stores are used up (within 5 seconds) and the effects of rapid lactic acid accumulation are felt (at 30–90 seconds). At this point the ability to do work becomes compromised.

> *mM/L or millimoles of lactate per liter of blood is the unit of measure for blood lactate.*

The highest blood lactate values have been measured following the kilo event, where levels of 15–18 mmol/L have been documented. Lactate levels following the sprint events (around an 11–second effort) can also be high, up to 13 mmol/L, in spite of the fact that the event is so short. By comparison, resting blood lactate levels are around 1–1.5 mmol/L and lactate levels during endurance rides typically will not get much above 3–5 mmol/L.

For the shorter track events (10 to 60 seconds) the athlete must be able to generate lactate very quickly; however, the durations of these efforts are not long enough where the effects of the lactic acid need to be dealt with, ie., the rider can get away with high lactate levels without compromising the effort. The longer events, on the other hand, like the 4,000m pursuit, require the rider to not only produce lactic acid but also to deal with the high blood lactate levels associated with sustained high power outputs. Training for this is known as *lactate production* and *lactate tolerance* training, respectively.

The Physiology of Lactate Production

Pyruvic acid is the molecule that is produced as a result of the breakdown of glycogen/glucose. It can be converted to either lactic acid in the cytoplasm (anaerobic glycolysis) of the muscle cell or enter the mitochondria. In the mitochondria it is used to produce ATP by way of aerobic mechanisms (aerobic glycolysis).

Pyruvic acid is produced in the cytoplasm of the muscle cell as a result of the breakdown of glucose or glycogen; this process is known as anaerobic metabolism. Pyruvic acid can then be converted to lactic acid (which is quickly converted to lactate), or enter the mitochondria to be used for aerobic energy production. When energy demands are very rapid, as during sprint or kilo events, the rate of glycolysis increases and more and more pyruvic acid is converted to lactic acid and lactate starts to accumulate. This is reflected by rapid increases in blood lactate levels.

Training for Lactate Production

Enzymes are biological catalysts which speed up reactions. Certain key enzymes within the muscle cell control the rates of energy producing pathways. By increasing the concentrations of these enzymes, the capacity for these pathways to produce ATP is increased. Thus, the ability to do aerobic or anaerobic work can be altered depending on which enzyme concentrations are changed by training.

Training that stimulates anaerobic glycolysis will induce increases in certain key enzymes involved in glycolysis, allowing for greater utilization of this pathway and thus a higher capacity for anaerobic work. When training lactate production, this pathway must be repeatedly stimulated by maximal types of efforts. These consist of short, all-out efforts of between 30–90 seconds. The rest in between must be sufficient to allow lactate levels to be reduced in order to allow for a maximal effort on the next repeat; performance for each repeat should not decline. Thus, the rest is long (2–8 times the length of the interval) and active (active recovery by cycling slowly allows for a more speedy removal of lactate). Repeats of the effort should be stopped when performance begins to decline in spite of the usual rest interval. The idea behind this training is to stimulate anaerobic glycolysis without inducing sustained high levels of lactate throughout the set.

Training for Lactate Tolerance

The primary difference between this and lactate production training, is that the rest is inactive and/or shorter (1–2 times the interval). In addition the interval may be longer (1–3 minutes). The idea is to induce sustained high levels of lactate throughout the set in an effort to stimulate adaptations which increases its rate of clearance. Performance levels will be difficult to maintain as lactate levels will continue to be high at the start of the next repeat. Typically this type of training is difficult and should not be performed more than 1–2 times per week.

Although both types of training are similar (both stimulate glycolysis and both induce lactate production), the desired outcomes are slightly different. The former is to maximally stimulate glycolysis with each repeat (ie., maintain performance or power output), although lactate levels are not necessarily that high by the end of the set. The latter is to induce high lactate levels at the end of the repeat or set, in spite of the fact that power outputs or performance declines (ie, glycolysis may not be maximally stimulated).

Aerobic Training

Track cyclists, however, deal with a double edged sword, for even in the shorter events, like the kilo, contributions to the overall energy production are made by aerobic systems as well. In the 4,000m pursuit for example, aerobic contributions have been estimated to be as high as 60%. Thus, the right combination of anaerobic and aerobic training must be done in order to maximize performance in these events. In the laboratory, elite track riders compare favorably with elite road riders when it comes to measurements of aerobic capacity (VO_2max) and watts at lactate threshold. Endurance levels of the track riders, however, are substantially less. By doing lactate threshold and VO_2max training, capillary supply to the muscles being used increases, the size and number of the mitochondria within the muscle increases and key enzymes within the aerobic metabolic systems also increase. All of these adaptations serve to improve reliance on aerobic energy mechanisms for a given workload. For example, prior to training, a four minute effort may be 50% aerobic and 50% anaerobic. After training, the same effort may now be 60% aerobic and 40% anaerobic. Because of this greater reliance on aerobic systems, lactate levels will be lower following the same effort. The rider can now ride at a higher speed before achieving the same lactate level.

VO_2max training involves doing endurance rides as well as high intensity (90% of max) intervals of 4–6 minutes with 1–2 minutes of rest in between. These efforts are very hard and it is difficult to do more than 4 or 6 repeats in a training session. Heart rates should be near maximal at the end of each effort. This type of training should be performed early on in the training season, as once VO_2max has increased, it can be maintained with as much as a 60% drop–off in training.

Lactate threshold training involves doing repeats of longer intervals (up to 20 minutes), although shorter ones may also be done with very little rest in between (ie., 30 seconds) at a maximal steady state. Heart rate monitoring is useful during these kinds of efforts (HR should be held at 70–80% of max), however, if a heart rate monitor is not available, the perceived effort should be "somewhat hard" (or slightly uncomfortable). The pace should be the fastest pace that can be held for the duration of the interval or set, similar to break-a-way or time trial types of efforts.

Research has shown that performance is compromised in a system following hard training that utilizes that system. For example, when training involves anaerobic systems, performance that utilizes this system will be compromised for up to 48 hours later. However, performance that involves the aerobic system will be less compromised. Thus, the concept of cycling the various energy systems throughout a training week has a strong physiological rational. In addition, research has shown that the total volume of work is greater when variety in training is used. The difficulty lies in knowing how much of a stimulus to apply to a particular system without compromising adaptations and performance in another. This of course will depend on the strengths and weaknesses of the rider (ie., what the limiting factor is).

In conclusion, performance on the velodrome involves the ability to generate and to tolerate high levels of lactic acid. Development of the aerobic system is also critical in order to increase the aerobic contribution for a given workload and/or to be able to work at a higher workload for a given lactate level. Thus, training needs to be varied in order to optimize both aerobic and anaerobic capacities. ®

Some Practical Conditioning Considerations

contributed by Tim Quigley,
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Training for Lactate Production

Gear: At or just below race gear, depending on conditions

Distance: 500 meters with a flying or rolling start or 1 kilometer with rolling start.

Rest Interval: A good rule of thumb is to allow five minutes more than the time needed for your heart rate to return to the pre-effort level. But remember, with this type of workout you want a maximum effort each time, therefore, too much rest is better than not enough rest. Also, make sure you keep rolling slowly to help clear the lactic acid from your legs.

Number of efforts: A good rule of thumb is to stop the workout when your speed or time drops significantly on two consecutive efforts.

Notes: Efforts should be done at or near maximum possible speed so as to maximally stimulate lactate production.

Training for Lactate Tolerance

Gear: Below race gear by 1 or 2 front chain-ring teeth or one rear cog tooth. You will need a relatively small gear to avoid the "bogging down feeling" that you would get with a large gear.

Distance: 500 meters to two kilometers from a rolling or flying start.

Rest Interval: For the short efforts, rest should be about twice the length of the effort. For example: If the 500m efforts are completed in about 35 seconds, rest should be 60–75 seconds long. As the length of the efforts increases, relative length of rest should decrease. If the two kilometer effort is completed in 2 minutes 45 seconds, the rest should be 3 minutes or less.

Number of efforts: Workouts of this nature are very demanding both physically and mentally. With that in mind, it is best to be conservative with the duration of this type of workout. Start with 2 sets of 6–8 efforts for the shorter (500m) efforts and one straight set of 4–6 for the longer (2 kilometer) efforts.

Notes: Be conservative. It is my experience that athletes often go too far when first trying this workout. Many times it may seem like you can do another set or two when in fact you have already done enough. Remember, you want to be able to train the next day as well. ⓞ

More Information Please!

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