The Winning Mindset

Scott Christensen

Understanding Lactate Threshold Training: Part 1 of 3

Purpose:

The purpose of CTCs *The Winning Mindset* is to collect and present articles by accomplished athletes, coaches, and business leaders in an effort to provide our readers with valuable insight into successful training, racing, business, and the characteristics of a high-performance mindset.

Subject:

Coach Christensen was asked to prepare a 3-part series on understanding **Lactate Threshold** and how to train and improve it. The first article, presented here, is Scott providing an introductory lesson aimed at a reasonably educated, **first year junior high distance coach** with a trio of committed athletes on her squad. Readers are encouraged to break down each paragraph, take notes, and explore the concepts further.

The second article in this series will expand the discussion to the high school level with a few more accomplished athletes.

Scott Christensen has produced volumes of excellent training presentations that are available for purchase at **CompleteTrackandField.com**.

Coach Christensen's Response:

The human body uses a complex system of biochemical reactions to sustain life. Many of these are called acid-base reactions because they involve positive ions, called acids, reacting with negative ions, called bases. Equilibrium occurs when the positive ions equal out the negative ions, in the end, thus maintaining homeostatic neutrality. Energy system fueled (food converted to muscle friendly fuel) exercise disturbs this neutrality depending on exercise intensity; usually causing the fluids of the body to become slightly more positively charged or acidic. The increased acidity causes problems with enzyme activity in cells and slows life-sustaining reactions. This is one type of exercise fatigue and could lead to exhaustion. Recovery from exercise brings the body fluids back to neutrality and the enzymes return to normal function.

Enzymes are macromolecular biological catalysts found in living organisms. Enzymes control the starting, stopping, and rate of biochemical reactions as directed by process-specific genes in the genome. There are known to be over 5000 enzymes in humans, controlling all life-sustaining biological reactions including hundreds of enzymes necessary for processes of the energy and muscular systems. Specific athletic training has been shown to increase the quantity and quality of enzymes that are a part of these systems.

Competitive running events between 800 meters and 10,000 meters have a varied and significant mix of both aerobic and anaerobic energy system contribution at race pace. The most equal mix occurs in the middle distance events of the 800 and 1600 meters. The aerobic system produces no acid byproducts in its energy conversion cycle, but the anaerobic energy system does produce acid in the form of hydrogen ions in converting energy, and sometimes the quantity is quite significant. In order for a distance runner to be successful, they will have to tolerate both a small amount of acid concentration over a moderate distance at moderate intensity in the early stages of the race and a large acid concentration over a short distance at high intensity at the end. Scientists in the lab, and coaches on the track, have found it to be most accurate to measure the strength of the acidic hydrogen ion concentration by measuring the more stable basic portion of the lactic acid molecule, called lactate (lactate is a much larger molecule, so it is easier for an instrument to detect and measure). There is a direct relationship between the two ions, thus inferring that measuring a high amount of lactate ions ($^-$) in the blood correlates to a high amount of hydrogen ions ($^+$) present.

For humans at rest, normal lactate concentrations are very low in the blood and interstitial fluids. Its neutrality counterpart, hydrogen ion concentration, is very low at rest as well. The lactate level in blood at rest is commonly measured at just under 1.0 mmol/L. Walking bumps it up to about 1.5 mmol/L. Jogging does not raise lactate much, only to about 1.75-2.25 mmol/L of blood in trained runners, but higher in untrained runners. Eventually, running gets fast enough that the lactate ion (and correlated hydrogen ion) concentration becomes high enough that it starts to affect biochemical reactions in the body; chiefly, cellular enzyme actions are compromised. In most untrained or trained runners, this point occurs at about 2.5-3.0 mmol/L. The physiological term for this point is called the *lactate threshold* (LT) of a runner. It is the point where normal body biochemical processes cannot clear or buffer lactate/hydrogen from the blood fast enough, so hydrogen ions begin to accumulate and disrupt enzyme action and corrode tissue membranes. This is the beginnings of fatigue in a runner. As heart rate gets faster and faster, the accumulation rate of lactate/hydrogen ions increases exponentially in all skill levels of runners (figure 1) from the LT inflection point.

A moderately to highly trained distance runner can run for 50-70 minutes at their individual lactate threshold pace before fatigue causes them to stop. A good coaching reference would be that this is about a 15 kilometer race run to exhaustion.

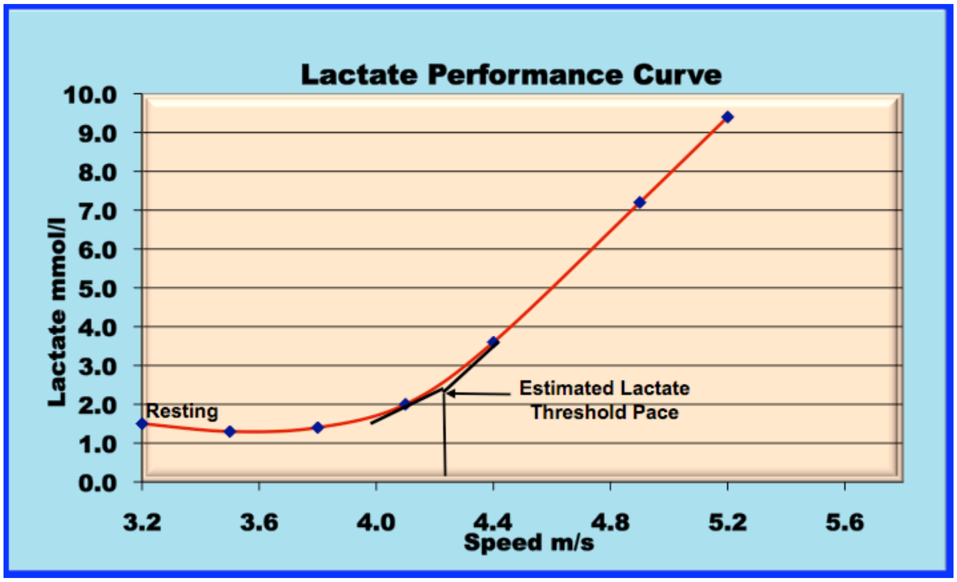

Figure 1. For most trained and untrained runners, the lactate threshold occurs at 2.5-3.0 mmol/L. That is about 15 kilometer race pace.

It makes sense that a distance runner gets more and more fit as the season progresses. Theoretically, that means the athletes 15 kilometer time should improve as a result. A runner gets faster through training. However, by definition, the 15k race is still run at the athlete's LT pace. That can mean only two things; that both the runners' lactate tolerance and running economy have improved. Like an untrained or moderately trained runner, a highly trained runner remains in the 2.5-3.0 mmol/L range for their LT, the pace has just gotten faster at that point. However, some highly trained runners can be >5.0 mmol/L of lactate in a liter of blood at LT, which in most people would cause tremendous fatigue in a distance race. That correlates to a lot of hydrogen ions accumulating over a 15k distance. Only a small number of people could handle that significant hydrogen ion load, thus the label of *elite* distance runner at those sorts of high LT values.

Distance training that is stressful at times does improve LT pace values in most people. It allows a runner to go faster at 15k pace because they can tolerate a higher hydrogen/lactate load from where they began. The physiological term for this improvement from baseline fitness is called the *high lactate response curve* (HLRC). On a graph, it would be shown to be a shift to the right and slightly down from the original pace curve (figure 2). This is a very valuable training key and is what coaches need to aim for in training athletes. After a period of LT training, runners will accumulate less lactate/hydrogen ions at the same speeds as they did before, and accumulate the same lactate/hydrogen ions at faster speeds than they did before. They are faster with the same level of fatigue.

Simply running miles upon miles at low intensity will improve distance runners' fitness, especially in the beginning. However, there gets to be a time where the effects of doing mileage only diminish in fitness development. Intensity needs to pick up. The logical next step in distance training is to prescribe workouts done just a "little faster" than garden variety, comfortable mileage work. That little faster point is work done at LT pace. Recall that LT pace is 15k race pace. However, if one was to go out and race an exhaustive 15k effort, it would take many days to recover from. The pace is good, but the distance is just too far. If the runner cuts the distance in half, but still runs at 15k pace, then the recovery period can be reduced to 24-48 hours. This is the idea behind the *tempo run*. Physiologists define the tempo run as 25-35 minutes of individual LT pace running. The distance of the run is about 4.5 miles or half a 15k. Note that this does not mean a 25-35 minute race to exhaustion. There is still a lot left in the energy tank, in fact, they should immediately be able to do it again, but of course, they won't. The important coaching point is to get the pace for each runner as close to their individual LT pace as possible. Too fast, and recovery drags on all week. Too slow, and the session becomes nothing more than a basic mileage session.

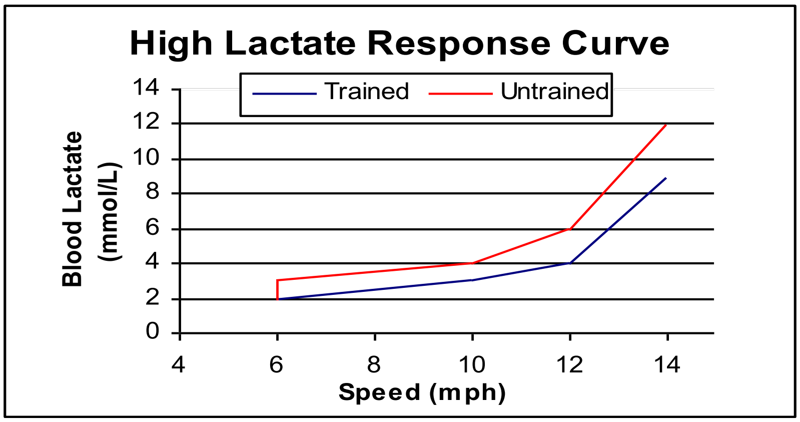

Figure 2. A trained runner accumulates less lactate at all sub-maximal speeds compared to the untrained runner, thus shifting the lactate threshold to the right (faster) side of the graph.

The pace is the key to effective LT workouts. As examples, let's look at a trio of relatively young and inexperienced runners that do not have many prior data points to reference from.

1. Kyle has been training for about a month and is up to about 25 miles per week. His coach decides to add a 4.5 mile tempo run at his LT pace today. Kyle ran 5:20 for 1600 meters in a track meet two days ago. Without any further testing, exercise physiologists have developed many charts and tables to establish what Kyle's LT pace is and it should be about 6:50 per mile for today's tempo run. His total time for the route should be 30:45. Anybody of Kyles ability and experience should simply add 90 seconds to their present day 1600 meter time to get their LT pace. If Kyle was tested right after completing the run he would produce a lactate value of about 2.5-3.0 mmol/L lactate per liter blood on a hand-held lactate analyzer after taking a drop of blood from his fingertip. Perfect!
2. Megan is similar to Kyle in that she has run for about a month and is running about 25 miles per week. In a track meet two days ago her coach ran all the girls in a 3200 meter race and Megan ran 14:05. Coach wants Megan to do a 4.5 mile tempo run today. How fast should she go? Unlike Kyle who had a 1600 meter time and added 90 seconds, Megan has a 3200 meter time, so she should add 2:30 to her 3200 meter time which

gives her 16:35 for 3200 meters. Now divide in half to get per mile pace for the tempo run, which is 8:18 per mile. Her total time for the route is 37:21. Anybody of Megan's ability should be able to add 2:30 to a 3200 exhaustive effort, divide in half and get their LT per mile pace. Like Kyle, Megan's blood should measure 2.5-3.0 mmol/L lactate at the conclusion of the workout.

3. Jack is a 400 meter runner moving up to do 800 meters this spring. He has trained for a month and is running about 25 miles a week or so. Yesterday, coach timed him for a 1600 meter at practice and it was 5:40. Today is the tempo run, let's go. Jack could not possibly do 4.5 miles at LT pace as he does not have the distance background for a session like that, now what? Let's do 18 laps on the track which is 4.5 miles, and make it interval style rather than a continuous run. Jack is like Kyle in that he has a 1600 meter mark. We know to add 90 seconds to that 1600 time for an LT pace of 7:10. Divide by 4 to get 400 meter lap splits, which is 1:47 per 400. Jack will run 16 laps as close to 1:47 as he can, and each time he gets to the start/stop line for the 400 he will stop and get 15 seconds recovery. No more rest than that after each lap. The total time of the workout should be 36:21 which includes the short recovery intervals. Jack should be able to do this session, and finish with a tested lactate value of 2.5-3.0 mmol/L. Anybody of his skill and ability should be able to replicate this workout, although it is a little boring!

Running at LT pace is valuable for developing the skill of tolerating small amounts of lactate/hydrogen ions over an extended distance, thus holding off fatigue. It is crucial in developing a running economy and is the interface between aerobic and anaerobic energy system work. LT runs should be done as tempo runs every 7-10 days in a season. The best training for shifting the HLRC (to the right of the graph) indicating greater economy, efficiency, and lactate tolerance is spot on present date lactate threshold pace for each person.