

# The Bike Doc: The ins and outs of VO<sub>2</sub>max

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Riding fast is a matter of natural ability, training and desire. All three factors play an important role in keeping the big ring spinning. When discussing natural ability, many people throw around the term "VO<sub>2</sub>max," which means maximum oxygen consumption. Many of our clients can recite the definition of VO<sub>2</sub>max, but few have a good grasp of what VO<sub>2</sub>max really means. To help clarify things, we will be writing a two part series of basic exercise physiology articles. Today is the first installment and will cover VO<sub>2</sub>max. Next week, we'll jump into the world of lactate threshold (LT).

## **VO<sub>2</sub>max?**

Maximal oxygen consumption (VO<sub>2</sub>max) is the maximum amount of oxygen that can be used by the body for maximal sustained power output (exercise). Since the body uses oxygen to convert food into energy (ATP), the more oxygen you can consume, the more energy, power, or speed you can produce. VO<sub>2</sub>max defines an endurance athlete's performance ceiling, or the size of his or her "engine." Research has shown that VO<sub>2</sub>max significantly determines performance in endurance-based events such as cycling, triathlon, running, and Nordic skiing.

Remember, however, that VO<sub>2</sub>max is only *one* piece of the rider's performance puzzle. Ability to perform in a race also depends on lactate threshold, appropriate peaking, nutrition and tactics (to name just a few).

Let's return to the "engine" analogy. If we were to race two cars, one a dragster with a large engine and the second a stock car with a much smaller engine, which one would win? You can't say. If we raced them a quarter mile down a drag strip, the dragster with a larger engine would win. However, if we raced them 400 miles, the stock car would win even with a smaller engine. Why? The dragster may be fast for short bursts, but it can't maintain its speed for an extended period of time. The same is true with two cyclists. If Bill had a high VO<sub>2</sub>max but a moderate LT, and Tom had a moderate VO<sub>2</sub>max but a ridiculously high LT, Tom would likely find himself victorious in a head to head race up L'Alpe d'Huez. Although Bill has a higher VO<sub>2</sub>max, Tom can maintain a higher workload for a longer period of time. We'll elaborate on this more next week when we discuss lactate threshold.

## **How is VO<sub>2</sub> Max measured?**

Many endurance athletes already have some idea of what a VO<sub>2</sub>max test entails: an incremental increase in exercise effort until the participant is unable to continue increasing his or her workload. The athlete can perform the test using any number of exercises: running, cycling, rowing, and even swimming. Because VO<sub>2</sub>max will vary between sports for various individuals, athletes will generally perform the test in his or her preferred sport. Regardless of the testing modality used, all the tests do the same thing. They take a happy-go-lucky individual and turn him or her into a grimacing, suffering, and most importantly, gasping test subject. As exercise intensity increases, a machine calculates oxygen consumption (VO<sub>2</sub>) by collecting and analyzing the test subject's inspired and expired air. With each incremental increase in power output by the athlete, more muscle mass is employed and more oxygen consumed. VO<sub>2</sub> will thus increase linearly with exercise intensity until the

body reaches its maximum ability to consume oxygen. At this point, oxygen consumption will level off, or plateau, when the subject reaches his or her VO<sub>2</sub>max.

Once the test analyzes the data, the athlete is given a numerical value of his or her VO<sub>2</sub>max. This number can be expressed in two forms. The first is called your absolute VO<sub>2</sub>max (liters O<sub>2</sub>/minute) and will likely fall between 3.0-6.0 l/min if you're male, and 2.5-4.5 l/min if you're female. The second is called your *relative* VO<sub>2</sub>max (milliliters O<sub>2</sub>/kilogram body weight/minute). For those who recall their science classes, the difference is in the units that follow the number. The relative VO<sub>2</sub>max takes into account the athlete's body weight, whereas absolute VO<sub>2</sub>max does not. You can, therefore, impress your friends by quickly increasing your relative VO<sub>2</sub>max by merely losing some weight!

There are a few requirements to have a useful and representative VO<sub>2</sub>max test:

- The test must employ at least 50 percent of the test subject's total muscle mass. Sports such as cycling, running, swimming and Nordic skiing all qualify. (Note that VO<sub>2</sub>max values for cyclists are generally 5-10 percent lower than those of runners or Nordic skiers due to less active muscle mass being utilized.)
- The test must be of sufficient duration to maximize cardiovascular responses. The length of suffering is usually 6-15 min.
- Finally, a highly motivated individual must perform the test. (The more pain and suffering during the test, the better the data).

### How do you measure up?

The following are examples of absolute and relative VO<sub>2</sub>max values of untrained, moderately trained, and elite aerobic individuals.

#### **FEMALE**

<b>Training Status</b>	Untrained	Trained	Elite
<b>Absolute(l/min)</b>	< 3.0	3.0-	>3.0
<b>Relative</b>	26-42	40-60	55+

#### **MALE**

<b>Training Status</b>	Untrained	Trained	Elite
<b>Absolute(l/min)</b>	< 3.0	3.5-	>4.0
<b>Relative</b>	36-52	50-70	60+

**Source:** Costill, D.L. and Wilmore, J.H. (1994). *Cardiorespiratory Function and Performance. Physiology of Sport and Exercise. Champaign, IL: Human Kinetics.*

### **Factors affecting VO2max**

There are three primary factors that can affect VO2max: altitude, age and gender.

- **Altitude:** An increase in altitude results in a decrease in air density and the partial pressure (or amount) of oxygen in the air. Therefore, you can expect a 5-7 percent loss in VO2max from sea level to 5,000 feet.
- **Age:** Peak physiological function occurs at about 30 years of age. VO2max decreases approximately 30 percent between the ages of 20 and 65, with the greatest decline after age 40. However, decreases in VO2max can be extremely variable and can - at least partially - be offset by training.
- **Gender:** In general, females tend to have lower VO2max values than males (15 percent to 20 percent less). This is primarily due to differences in body composition, hemoglobin content in the blood, and heart size. Females, on average, have a higher percentage of body fat, lower content of hemoglobin in their blood, and have a smaller adaptation of heart size in response to endurance and resistance training. It is important to note that these differences are "in general" - there are always exceptions.

### **What does it all mean?**

Well, it depends on who you are and how much you have already been training when you take your VO2max test. Research has determined that approximately 80 percent of an individual's VO2max is genetically determined. Depending on your current training level, VO2max may be enhanced through progressive endurance training. Untrained individuals have the potential to increase their VO2max by 15-20 percent, but well-trained athletes are unlikely to realize an increase in VO2max of greater than 3-5 percent. So, if you've been training well for the past year and your VO2max is in the 50's, don't hold your breath to be the next Lance. The good news is that your lactate threshold is highly trainable, and elevating your LT will put the hurt on your friends or fellow racers. Since many elite athletes share comparable VO2max values, lactate threshold is often a better measure of fitness and endurance performance. And that is a perfect segue into our discussion next week....