

VO2 Max



VO2 max, or maximal oxygen uptake, is one factor that can determine an athlete's capacity to perform sustained exercise and is linked to [aerobic endurance](#). VO2 max refers to the maximum amount of oxygen that an individual can utilize during intense or maximal exercise. It is measured as "milliliters of oxygen used in one minute per kilogram of body weight."

This measurement is generally considered the best indicator of an athlete's cardiovascular fitness and aerobic endurance. Theoretically, the more oxygen you can use during high level exercise, the more [ATP](#) (energy) you can produce. This is often the case with elite endurance athletes who typically have very high VO2 max values.

VO2 max should not be confused with the [lactate threshold \(LT\)](#) or [anaerobic threshold \(AT\)](#), which refers to the point during exhaustive, all-out exercise at which lactate builds up in the muscles during exercise. With proper training, athletes are often able to substantially increase their AT and exercise longer at a higher intensity.

How Is VO2 Max Measured?

Measuring VO2 max accurately requires an all-out effort (usually on a treadmill or bicycle) performed under a strict protocol in a sports performance lab. These protocols involve specific increases in the speed and intensity of the exercise and collection and measurement of the volume and oxygen concentration of inhaled and exhaled air. This determines how much oxygen the athlete is using.

An athlete's oxygen consumption rises in a linear relationship with exercise intensity -- up to a point. There is a specific point at which oxygen consumption plateaus even if the exercise intensity increases. This plateau marks the VO2 max. It's a painful point in VO2 max testing where the athlete moves from aerobic metabolism to anaerobic metabolism. From here, it's not long before muscle fatigue forces the athlete to stop exercising. The test usually takes between 10 and 15 minutes and requires an athlete to be completely rested and motivated to endure the pain long enough to find the true VO2 max.

Vo2 max also can be estimated. There are a variety of protocols used to estimate VO2 max, one is called the [Bruce Treadmill Test](#), but none are as accurate as direct testing.

Can You Change Your VO2 Max?

Research shows that although VO2 max has a genetic component it can also be increased through training. The two methods for increasing VO2 max include increases in both training volume and intensity. Research also indicates that the less fit an individual is, the more they can increase their VO2 max through training. In fact, novice exercisers have been able to increase VO2 max by 20 percent through proper training. Fit athletes have a harder time increasing their VO2 max, most likely because they are already so near their genetic potential.

Aside from genetic factors, three other components have a large influence on VO2 max:

- **Age** - Although it varies greatly by individual and training programs, in general VO2 max is the highest at age 20 and decreases nearly 30 percent by age 65.
- **Gender** - Many elite female athletes have higher VO2 max values than most men. But because of differences in body size and composition, blood volume and hemoglobin content, a woman's VO2 max is in general about 20 percent lower than a man's VO2 max.
- **Altitude** - Because there is less oxygen at higher altitude an athlete will generally have 5 percent decrease in VO2 max results with a 5,000 feet gain in altitude.

VO2 Max Highs and Lows

VO2 max results vary greatly. The average for a sedentary individual is close to 35 ml/kg/min. Elite endurance athletes often average 70 ml/kg/min. One of the highest recorded VO2 max results (90 ml/kg/min) was that of a cross country skier. Cyclist Lance Armstrong's VO2 max was reported at 85 ml/kg/min.

Does a High VO2 Max Mean Better Athletic Performance?

Most elite athletes will have VO2 max values well over 60ml/kg/min, this number alone is not a guarantee of elite performance. A high VO2 max may indicate an athlete's potential for excellent aerobic endurance, but many other factors can determine the winner of a particular race. Some of these factors include:

- [Skills Training](#)
- [Psychological Preparation](#)
- [Lactate Threshold Training](#)
- [Rest and Recovery](#)
- [Nutrition](#)

Bruce Protocol Norms for Men

VO2 Max Norms for Men - Measured in ml/kg/min						
Age	Very Poor	Poor	Fair	Good	Excellent	Superior
13-19	<35.0	35.0-38.3	38.4-45.1	45.2-50.9	51.0-55.9	>55.9
20-29	<33.0	33.0-36.4	36.5-42.4	42.5-46.4	46.5-52.4	>52.4
30-39	<31.5	31.5-35.4	35.5-40.9	41.0-44.9	45.0-49.4	>49.4
40-49	<30.2	30.2-33.5	33.6-38.9	39.0-43.7	43.8-48.0	>48.0
50-59	<26.1	26.1-30.9	31.0-35.7	35.8-40.9	41.0-45.3	>45.3
60+	<20.5	20.5-26.0	26.1-32.2	32.3-36.4	36.5-44.2	>44.2

Also See: [VO2 Max Norms for Women](#)

VO2 Max Norms for Women

VO2 Max values for Women as measured in ml/kg/min						
Age	Very Poor	Poor	Fair	Good	Excellent	Superior
13-19	<25.0	25.0-30.9	31.0-34.9	35.0-38.9	39.0-41.9	>41.9
20-29	<23.6	23.6-28.9	29.0-32.9	33.0-36.9	37.0-41.0	>41.0
30-39	<22.8	22.8-26.9	27.0-31.4	31.5-35.6	35.7-40.0	>40.0
40-49	<21.0	21.0-24.4	24.5-28.9	29.0-32.8	32.9-36.9	>36.9
50-59	<20.2	20.2-22.7	22.8-26.9	27.0-31.4	31.5-35.7	>35.7
60+	<17.5	17.5-20.1	20.2-24.4	24.5-30.2	30.3-31.4	>31.4