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# Exercise Metabolic Testing

## MORE THAN JUST BRAGGING RIGHTS

BY BEN GREENFIELD

A triathlete's $VO_2$max number can be a good basis for bragging rights in the endurance sports arena. If you know this number, which defines your maximum aerobic capacity, and it's a good number, you can talk trash while hanging at the pool edge, chatting in spin class or stretching on the track. Conveniently, your true athletic superiority can be gauged not by race results, lap splits or age-group rankings, but instead by a simple number that easily defines aerobic dominance. How close is your $VO_2$max to that of Greg Lemond, Steve Prefontaine or that obscure Norwegian cross-country skier whose name nobody can remember?

But as a measurement that originated in the second century with Greek physicians blowing into sheep bladders, is the $VO_2$max really that valuable? Think about it this way: Having a big $VO_2$max number is like owning a Ferrari engine. Imagine that this Ferrari engine is dumped into an old pickup truck chassis. It is useless. Unless the engine is perfectly installed in an actual Ferrari automobile, it will never perform to its full potential. Likewise, unless you have the ultimate combination of economy, efficiency and experience, your high $VO_2$max is worthless.

The process of determining $VO_2$max is demanding and unpleasant. The test begins with the attachment of a mask or other breathing device to your face. Through this mask, a computer measures your exhaled and inhaled gases during a graded exercise protocol on the bike or treadmill. The test concludes when you reach an extreme state of fatigue, at which point an exercise physiologist excitedly scribbles down some numbers that represent your maximum aerobic capacity, typically expressed in milliliters of oxygen per kilogram per minute.

*Properly measuring $VO_2$ max involves breathing into a mask that measures the make up of all the gases the athlete inhales and exhales. The device then translates those numbers onto a computer screen.*

Ben Greenfield

So if the process is so uncomfortable, and a high $VO_2$max number is useless without a Ferrari body, why even bother to test? Indeed, if all you're looking for is the bragging rights that come with a high $VO_2$max, you may want to save your cash for a couple of good racing tubulars.

But before you abandon the idea, consider the following: Many athletes do not realize that a significant amount of important test data is collected before reaching the terminal point of maximum pace, peak power and puke factor in a $VO_2$max test. Some of this other data is the focus of the exercise metabolic test, or EMT, a close cousin of the $VO_2$max test protocol that has been used in nutrition physiology for many years.

The EMT and $VO_2$max test use similar equipment and protocols, but the focus of the EMT is caloric utilization and specific physiological data points rather than peak aerobic capacity. In fact, during an EMT, the test subject is taken to only approximately 85 percent of peak aerobic capacity, since higher exercise intensities do not yield much useful information for an endurance athlete. But prior to the 85 percent intensity mark, several important variables are collected during the EMT, including:

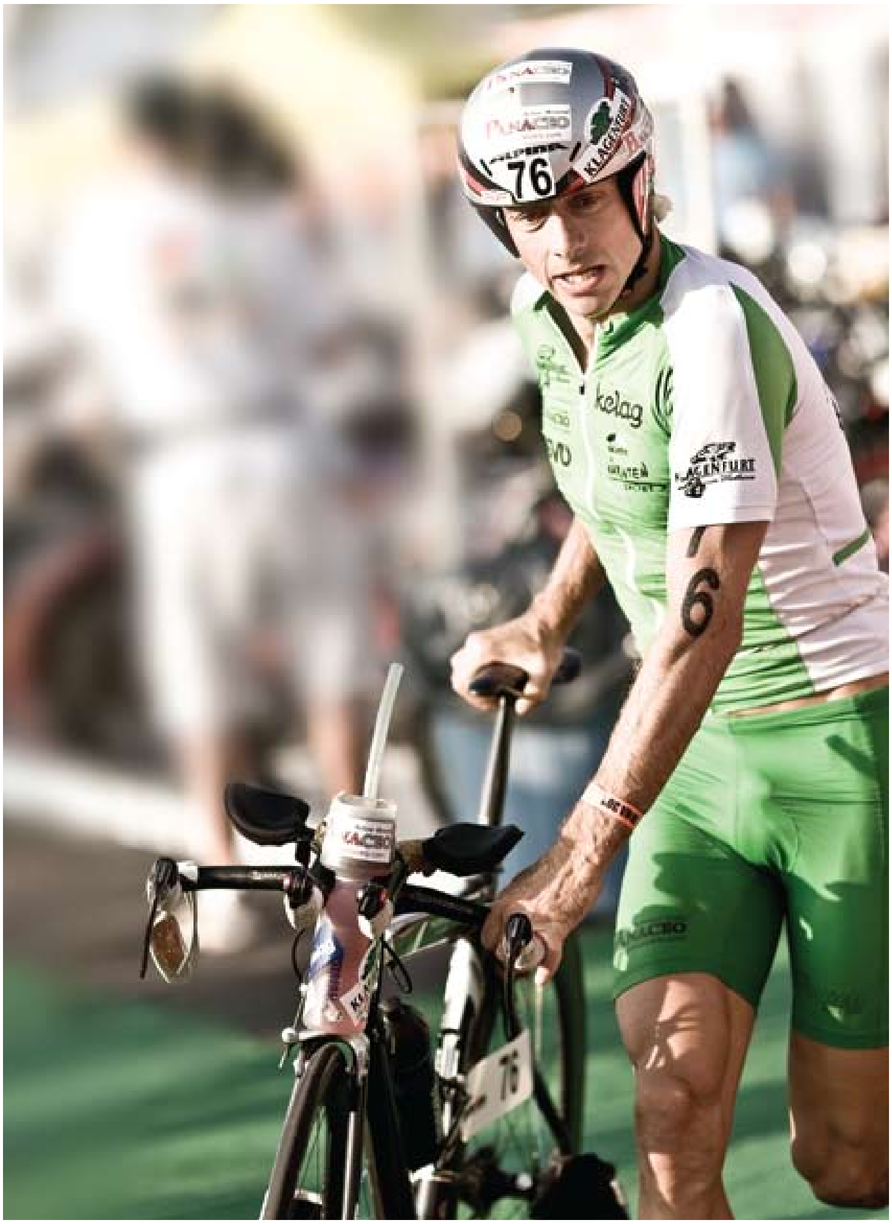
**1) ENERGY EXPENDITURE.** In an exercise physiology lab, the amount of energy, or calories, that the body uses during exercise can be measured using an indirect calorie measurement. A direct calorie measurement would require exploding the body inside a closed chamber and measuring the amount of heat released. For most people, this obviously does not conjure up a pleasant image.

However, the mask, tubes and gas analyzer used during an EMT offer a far more humane if less direct method of calorie measurement. It is based on the principle that the ratio of carbon dioxide produced to oxygen consumed will yield an accurate estimate of the total number of calories used for energy, as well as the percent contribution from both carbohydrate and fat.

Therefore, for any given intensity, whether measured by perceived exertion, heart rate, wattage, speed or incline, an athlete can obtain a precise calculation of exactly how many carbohydrate and fat calories are burned for energy. This information is valuable in determining the number of post-workout calories necessary to replenish fuel stores. In addition, several exercise physiology studies indicate that most athletes can replace approximately 30 percent to 40 percent of the calories they burn during exercise. This principle can allow an individual who knows total caloric expenditure to generate a customized race-day fueling plan.

**2) AEROBIC THRESHOLD.** At a specific exertion level during the EMT, the body reaches a point of maximum fat burning called the aerobic threshold. For every endurance athlete, and especially for half-Ironman and Ironman-distance triathletes, the aerobic threshold value signifies the point of maximum endurance efficiency. This is because the human body can only store approximately 1,500 to 2,000 calories of carbohydrate but can store more than 30,000 calories of fat. Therefore, at the aerobic threshold, there is little risk of "bonking" or "hitting the wall"—that is, running out of carbohydrate energy.

By working at aerobic threshold heart rate, pace, or powering through long, slow distance workouts, an athlete can build confidence that his or her body can work for hour after hour with limited fatigue. In most individuals, the aerobic threshold is reached at 50 percent to 60 percent of maximum intensity, or about 20



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heartbeats below anaerobic threshold.

**3) ANAEROBIC THRESHOLD (AT).** The AT is nearly synonymous with the lactate threshold (LT). This is because at a certain point during exercise, blood lactate begins to accumulate in the muscles faster than it can be removed. As the lactate builds, the body's production of hydrogen ions begins to increase. The only way to buffer these acidic hydrogen ions is through the formation of carbon dioxide, which is then exhaled by the lungs and can be measured via a gas analyzer. During the EMT, a significant increase in carbon dioxide production signifies a physiological point very close to LT.

In most individuals, AT occurs at about 85 percent intensity, which is the rationale for bringing an EMT test subject only to this point. Above AT, the body begins to consume large amounts of oxygen, resulting in rapid fatigue and drainage of valuable carbohydrate stores. In training or racing, most endurance athletes spend very little time at such high exercise intensities. Thus, knowledge of AT or LT is paramount for any endurance athlete who is concerned about proper pacing and avoiding the dreaded bonk.

Once these three EMT data points are collected, a customized nutrition, training and racing profile can be created. Let's take a look at an example of how the EMT can be successfully used in a triathlon program:

JoAnn is a 35-year-old age group triathlete who aims to complete an Ironman triathlon in June. At the beginning of the year, she decides to undergo an EMT on her bicycle. Since she will be training with a heart-rate monitor, she wants training and racing recommendations based on heartbeats per minute. She also wants to know how many calories she should consume during the race and the size of the caloric deficits she creates during her training sessions.

At the lab, an exercise physiologist straps a heart rate monitor to JoAnn's chest and attaches a neoprene mask to her face. After a 10-minute warm-up on the lab's indoor bicycle trainer, the EMT begins.

JoAnn begins the test by cycling at a resistance of 50 watts for three minutes. At the end of this stage, her resistance is increased in increments of 25 watts. This pattern continues until JoAnn's carbon dioxide to oxygen ratio reaches approximately 0.85, which indicates about 85 percent intensity. She reaches this intensity at a resistance of 175 watts 18 minutes into the test. After a brief cool-down, she sits down with the exercise physiologist to review her data.

The physiologist points out that nine minutes into the test, at a heart rate of 132 beats per minute (bpm), she was burning 60 percent fat, 40 percent carbohydrate and a total of 600 calories per hour. On a graph that shows total fat calories burned, this heart rate turns out to correspond to the peak of her fat utilization, indicating maximum fat burning intensity, or aerobic threshold. JoAnn can now program her heart rate monitor with a training zone that is three bpm above to three bpm below 132 bpm. Thus, during her long-distance bike rides, her heart rate monitor alarm will begin to beep whenever she is below 129 bpm or above 135 bpm. She can use this same alarm during the Ironman to ensure that she is cycling at maximum efficiency without risking premature fatigue.

The test results also show that at a heart rate of 154 bpm, JoAnn's carbon dioxide production begins to peak, indicating increased lactate production and AT. From this value, JoAnn knows that she can train her body to effectively buffer hydrogen ions and improve cardiovascular fitness if she performs her interval training sessions at intensities near 154 bpm, or AT.

She also knows that if she exceeds 154 bpm during the Ironman, her valuable carbohydrate stores will begin to deplete rapidly. So during her longer training rides, although she may stray outside her aerobic threshold of 129 to 135 bpm, especially on hills, she should practice avoiding intensities that exceed 154 bpm because the body has a difficult time returning to peak fat utilization after crossing the anaerobic threshold barrier.

The exercise physiologist also gives JoAnn a table that indicates the total number of calories, carbohydrates and fat her body uses at each heart rate. If JoAnn knows her average heart rate during any given training session, she can simply match this number to the same heart rate on the table.

For example, every Wednesday she trains for one hour on the bicycle at an average heart rate of 148 bpm. According to the table, she burns 780 calories per hour at this heart rate, with 600 calories from carbohydrate and 180 calories from fat. JoAnn can now make sure to replace those 600 calories of carbohydrate with proper post-workout nutrition. For example, she might fuel with 200 calories of carbohydrate immediately after the workout and consume 400 additional carbohydrate calories an hour later.

As mentioned previously, she can see from this table that at her maximum fat-burning intensity of 132 bpm, which is also her target Ironman heart rate, she is using 600 calories per hour. Multiplying this number by 30 percent to 40 percent results in a value of 180 to 240 calories. During her long rides at aerobic intensity, JoAnn can now practice a nutritional intake within this range to prepare for Ironman.

As her fitness increases over the subsequent six months, Joann's metabolic values will change, so she plans on repeating the test four to eight weeks before the Ironman. Most likely, her aerobic threshold and AT will occur at higher heart rates and higher caloric values. Finally, if she ever decides to train with a power meter, she can use the same tables and graphs to see how the wattage on her bicycle correlates with any of these heart rate values and data points.

Since JoAnn completed her EMT on the bike, she should not use these same heart rate training zones for running. If an athlete is equally economical and has a similar training history and experience in both running and cycling, the heart rate training zones for running will be about 10 beats per minute higher than the cycling heart rates. Because of the stored energy in the wheels of a bicycle, most people are more efficient at cycling than running.

Since the cycling leg is the longest leg of most triathlons, JoAnn was advised to undergo her initial EMT on the bike. But if she wants to accurately pinpoint her exact running heart-rate zones, she should repeat her test on a treadmill.

And, of course, if JoAnn truly desires to take home the aerobic trophy and brag to her friends about her athletic superiority, she may just decide to take the EMT to the limit and find out her $VO_2max$ number. But the practical applications of her $VO_2max$ will pale in comparison to those of the information collected during her EMT.

Since the base phase and off-season are the ideal periods to dial-in your proper training intensity zones and begin practicing appropriate nutrition intake, now is the perfect time to take an EMT. You can begin by contacting your local exercise physiology lab or sports performance center.

Expect to pay $100 to $200 for this test but insist beforehand that you be given full nutrition information for each heart rate during the test rather than just your heart rate training zones or thresholds. If you are able to harvest all possible information from your EMT, it will be well worth its cost in time and money.

***Ben Greenfield is director of sports performance at Champions Sports Medicine (Champsportsmed.com) in Spokane, Wash., where he manages bicycle fitting, run gait analysis, swim stroke analysis, blood lactate testing and exercise/resting metabolic analysis. As the head coach for Pacific Elite Fitness (Pacificfit.net), he trains all levels of triathletes from around the world and hosts a free nutrition and performance podcast at Bengreenfieldfitness.com. For coaching inquiries or training information, e-mail him at ben@bengreenfieldfitness.com.***

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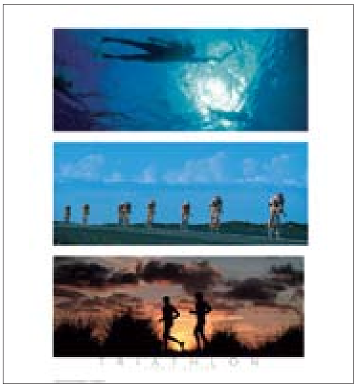

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