Interpreting Results from your Cadence V_{o2Max} Test

Congratulations! You have just taken the first step toward increasing your ability as an endurance athlete. Testing your ability is important in order for you to train correctly and determine if you are getting the benefits you are looking for. Knowing your abilities and periodically how you are doing will help you progress as an athlete and get the most out of your training. Not everyone reacts to a given training bout exactly the same so it is important to know if your training style leads to results. The only way to know that for sure is periodic testing.

If you are new to this type of analysis there is no doubt you had a lot of information thrown at you from your experience at Cadence. We know it can be daunting with lots of new information so we have developed this guide to explain the results you obtained at your testing session.

This guide is meant to help explain your testing results. Please follow along with your results and handouts obtained during your testing session. Within your VO_{2max} testing packet you should have a VO_{2max} test summary page, VO_2/VCO_2 Graph, Ventilation Graph, and the Energy Expenditure bar graph.

1. Test Summary Page:

NAME: **DATE:**

TIME min	VO2 STPD L/min	VO2/kg STPD ml/kg/m	METS	VCO2 STPD L/min	VE BTPS L/min	RER	RR BPM	Vt BTPS L	FEO2 %	FECO2 %	HR bpm	AcKcal Kcal	FatKcal Kcal	Power	RPE
1	2.85	37.78	10.80	2.32	58.65	0.84	23.85	2.44	15.45	4.71	141.88	13.67	7.56	250.00	4.00
2	3.56	47.24	13.50	3.28	75.80	0.92	24.59	3.08	15.39	5.23	156.88	17.51	4.56	280.00	5.00
3	3.91	51.77	14.79	3.79	85.55	0.97	26.04	3.29	15.49	5.35	160.25	19.40	1.87	310.00	5.00
4	4.27	56.53	16.15	4.27	98.38	1.00	29.01	3.40	15.72	5.24	167.50	21.33	0.01	340.00	6.00
5	4.56	60.45	17.27	4.76	112.62	1.04	31.44	3.58	16.03	5.11	174.25	23.02	0.00	370.00	7.00
6	4.88	64.64	18.47	5.48	136.82	1.12	37.63	3.65	16.54	4.85	179.50	25.05	0.00	400.00	8.00
7	5.11	67.74	19.35	6.09	159.34	1.19	43.69	3.65	16.92	4.63	182.25	26.63	0.00	430.00	9.00
8	5.22	69.17	19.76	6.76	193.49	1.30	54.60	3.56	17.49	4.23	188.13	27.79	0.00	460.00	10.00

Below is an explanation of the variables recorded during your test and displayed on the summary page printed in your handouts. All data is reported as a one minute average of each stage during the test.

Time (min): This is the minute to minute average of your test. The last minute will only include the last full minute of completion. So if you went 30 sec. into the last stage you will not see it here, but it will be included in the peak measurement. The peak values are reported as the peak 15 sec. average you achieved during the test, at any stage but typically it occurs in the last minute.

VO_2 STPD (L/min): This is your rate of oxygen consumption in liters per minute. This value does not take into account body mass. Larger individuals have more metabolically active tissue that requires oxygen, and hence they will generally have higher absolute values than smaller individuals. This higher absolute VO_2 is not always due to fitness level, but simply a larger body size.

VO_2/kg (ml/kg/min): This is the rate of oxygen consumption per kilogram of body mass per minute. It is your VO_2 expressed in L/min divided by your body mass in kilograms. **The largest value in this column is**

your VO_2 max, and this is the value that is typically reported and compared between individuals, although your absolute number is also important. Note that fat is relatively inert metabolically. Consequently, if you have a fairly large % of fat, then you may have an unexpectedly low VO_{2max}. Losing body fat and maintaining cardiovascular fitness will increase relative VO_{2max}. Such a difference is huge when you look up values relative to the norms for age and sex. Oxygen consumption depends mostly on the demand for oxygen in exercising muscle. Running and cross country skiing require work from greater muscle mass and typically will result in a higher VO_{2max} than cycling. Thus, **VO_{2max} tests are sport and mode specific.**

METS: A MET or metabolic equivalent is the metabolic rate at a given level of exertion divided by the resting metabolic rate, which is about 3.5 ml/kg/min. This is a convenient way for exercise physiologists to compare levels of exertion among different size individuals and for different activities. One MET equals 3.5 ml/kg/min so if you divide VO_2 for a given workload by body mass (kg) this gives you an idea of how many times harder than Rest a particular effort is.

VCO2 STPD (L/min^{-1}): This is the rate of CO_2 production in liters per minute. Knowing this value is important for determining what substrate (fat vs. carbohydrates) you are burning for fuel and aiding in the determination of lactate threshold. More on this is detailed in the VO_2/VCO_2 Graph section.

VE BTPS (L/min): VE is the minute ventilatory volume. This is to how many liters of gas you exhale each minute. It is the product of the tidal volume (V_t in liters) multiplied by your breathing frequency (breaths/ min). A sharp rise in VE is an indication that the lactate threshold has been reached but is not always present and many times hard to distinguish. This "sharp rise" is known as ventilatory threshold. More on this is detailed in the Ventilation Graph section.

RER (Respiratory Exchange Ratio): This value, which is also sometimes known as the Respiratory Quotient (RQ), is the ratio of oxygen consumption to CO_2 production. At an RER of 0.8 fat is the primary fuel source. As exercise intensity increases more carbohydrates are burned for energy. At an RER of 1.0 the individual is burning mostly carbohydrate. It is important for a good max test that an RER of 1.1 is reached to signify a good effort by the athlete. If a subject ends a test and barely gets over 1.0 then it is a sign they are fatigued or gave up prematurely. At the end of a max test it is typical to see RER's within the 1.15-1.25 range. RER is sensitive to what an individual has eaten and how recently they have done so. Values of RER can be used to convert rates of oxygen consumption into amounts of metabolic energy since the energy gained from breaking down a given fuel source depends on what it is metabolized (fat vs. carbohydrate, etc.) and the chemical pathways that are used to extract energy.

RR (BPM): This is the respiratory rate in breaths per minute.

V_t BTPS (L): This is your tidal volume expressed as a standard temperature, pressure, and humidity. It is the amount of gas expired each breath.

FEO2 (%) and FECO2 (%): The % concentrations of O_2 and CO_2 in your exhaled breaths (in air the $\%O_2$ is 20.93 and % CO_2 is 0.03%), respectively. When you are active you use up O_2 and produce CO_2, which results in concentrations in your exhaled breaths that are less than and greater than those in air, respectively.

HR (bpm): This is your average HR for the stage.

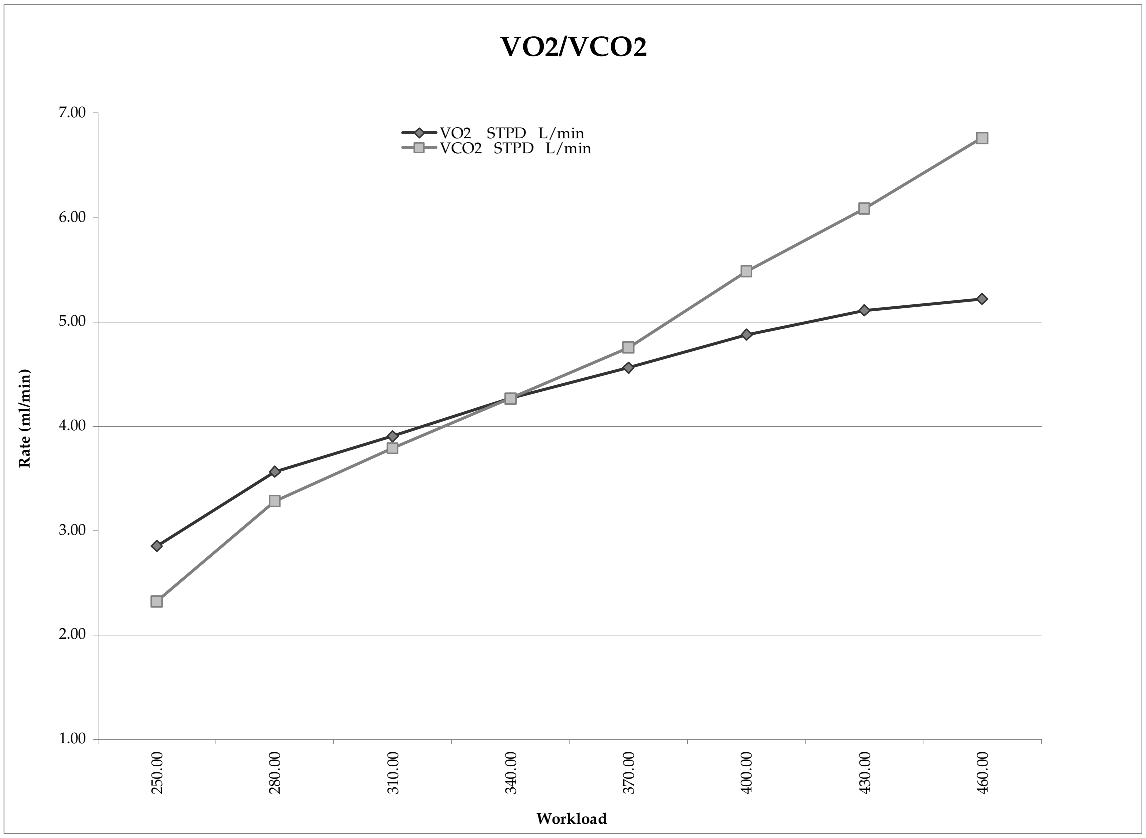
AcKcal (Kcal): This is the amount of Calories you burned during each stage and at each workload based on the oxygen consumption. For every Liter of oxygen it is about 4.73 Calories.

FatKcal (Kcal): This is the amount of Fat Calories you burned during each stage and at each workload based on the oxygen consumption and RER values.

Power (W), Speed (MPH), Grade (%), Pace (miles/min): This is the amount of work you performed per unit of time. Power for cycling is the product of cadence x torque. One Watt = 1 J/sec.

RPE: The Rating of Perceived Exertion is a subjective scale from 0-10 of how hard you feel the effort is. It is based on the physical sensations a person experiences during physical activity, including increased heart rate, increased respiration or breathing rate, increased sweating, and muscle fatigue.

2. VO_2/CO_2 Graph:

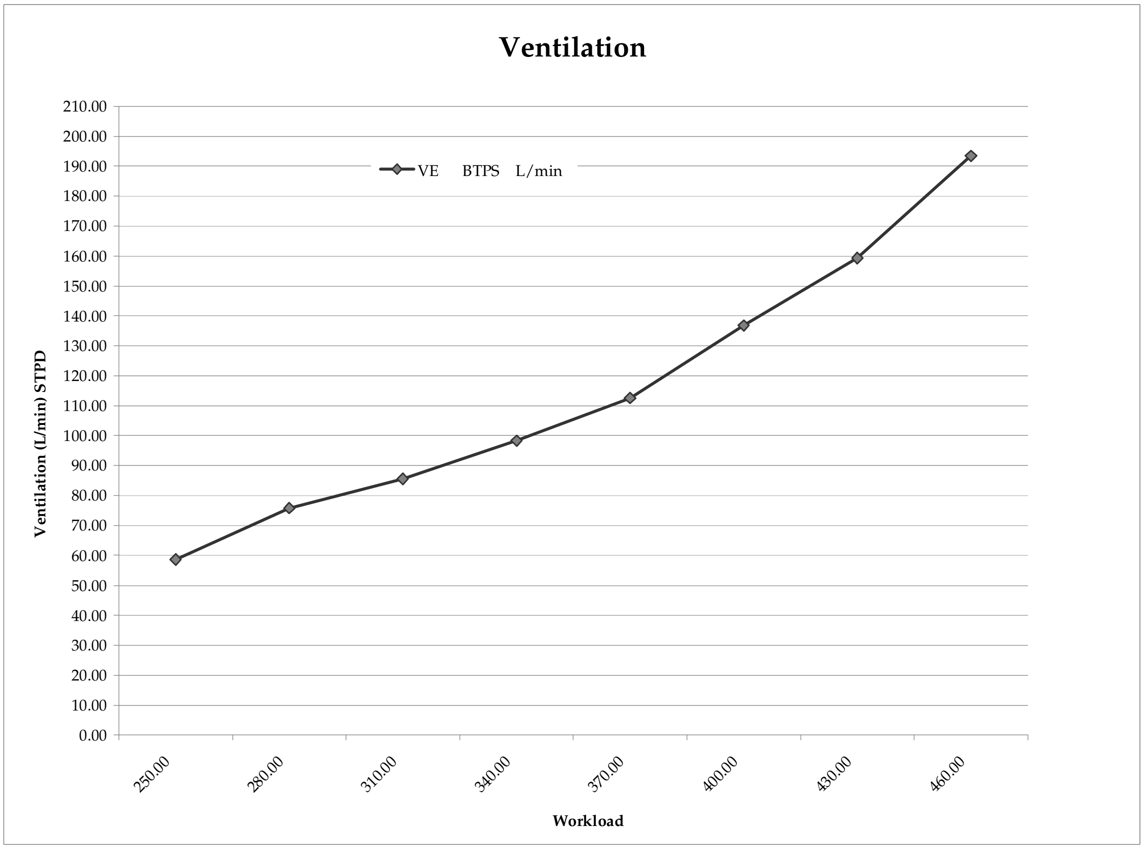


As exercise intensity increases more oxygen is required to burn fat and carbohydrate to do work. Under steady state and relatively easy workloads the increase in O_2 consumption is matched by an increase in CO_2 expiration. As intensity approaches your maximal ability to produce energy under aerobic (with oxygen) conditions (a.k.a. your lactate threshold) the amount of CO_2 expired starts to significantly increase. At this workload the production of energy via aerobic metabolism is simply to slow for how fast you need the energy. In order to maintain your exercise you switch to a faster, yet much less efficient, anaerobic energy metabolism. This comes at the cost of producing fatiguing metabolic by-products. If these by-products are allowed to increase, you will slow down. Lucky for you, your body has a built in buffering system to help slow down the proliferation of these fatiguing products.

The reason for this increase in CO_2 production, which causes RER to rise above 1.0, is due to the buffering of these by-products (lactate and hydrogen ions) by sodium bi-carbonate. During this process the reaction gives off extra, non-metabolic CO_2, and this causes CO_2 to increase faster than O_2 as intensity increases. If intensity continues to increase even this buffering system cannot contain the extra production of lactate and its associated by-products, and soon you will slow down. Because of this process it is possible to estimate threshold simply by viewing the graph of O_2 and CO_2. Measuring the actual lactate production is regarded as the best method for determining lactate threshold, but using this graph is a good way to confirm an individual's lactate threshold workload.

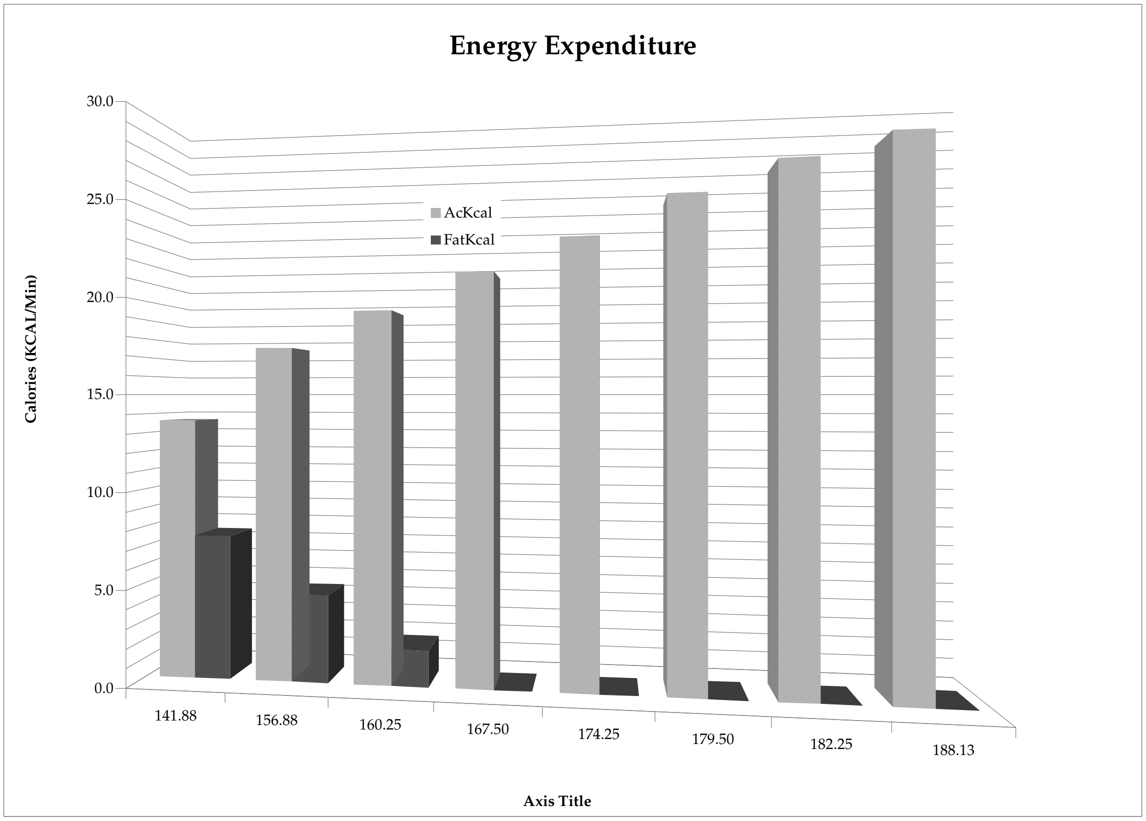
On the graph above you can see CO_2 start to increase around 280 watts and then seriously starts to increase around 310 watts. This second sharp increase signifies a serious jump in lactate production and thus the subjects lactate threshold.

3. Ventilation Graph:



This graph of ventilation displays the rate of breathing in L/min for each minute of the test. The workload is usually displayed as heart rate in beats per minute but power loads can also be easily determined by looking back at the corresponding stage on your summary page. A sharp increase in minute ventilation indicates the peak level of sub-maximal exercise where energy demands exceed the circulatory systems ability to deliver oxygen. This shift is partially related to the buffering of lactic acid by sodium bicarbonate in the blood (the same process we discussed in the previous graph). This buffering produces extra CO_2 which is a strong feedback mechanism within the body for increasing ventilation.

4. Energy Expenditure Graph:



The final graph denotes the actual calories (AcKcal) expended during each stage of the test in grey and also the fat calories (FatKcal) burned in dark grey. We can determine the number of calories you burned directly by the amount of oxygen consumed and CO_2 expired. For every Liter of oxygen it is about 4.73 Calories and using the RER values it is possible to determine from which substrate these calories are coming from, fat or carbohydrate. For endurance athletes the more fat they can burn at a given workload and the longer they can burn fat as the workload increases, the more carbohydrates, which are a limited source of energy fueling about 1.5-2 hours of exercise, you can spare during your event and the fresher you will be in the end. This graph is useful to determine how strong your aerobic system is and also to pinpoint the training zone boundary between Z2 and Z3 levels. It is usually apparent at which workload an athlete significantly decreases fat oxidation and this point is important for determining where an individual shifts from burning a majority of fat to mostly carbohydrate.