CLIENT: Example Client
TEST DATE: xx/xx/2017 10.30
PHYSIOLOGIST: Simon Clark

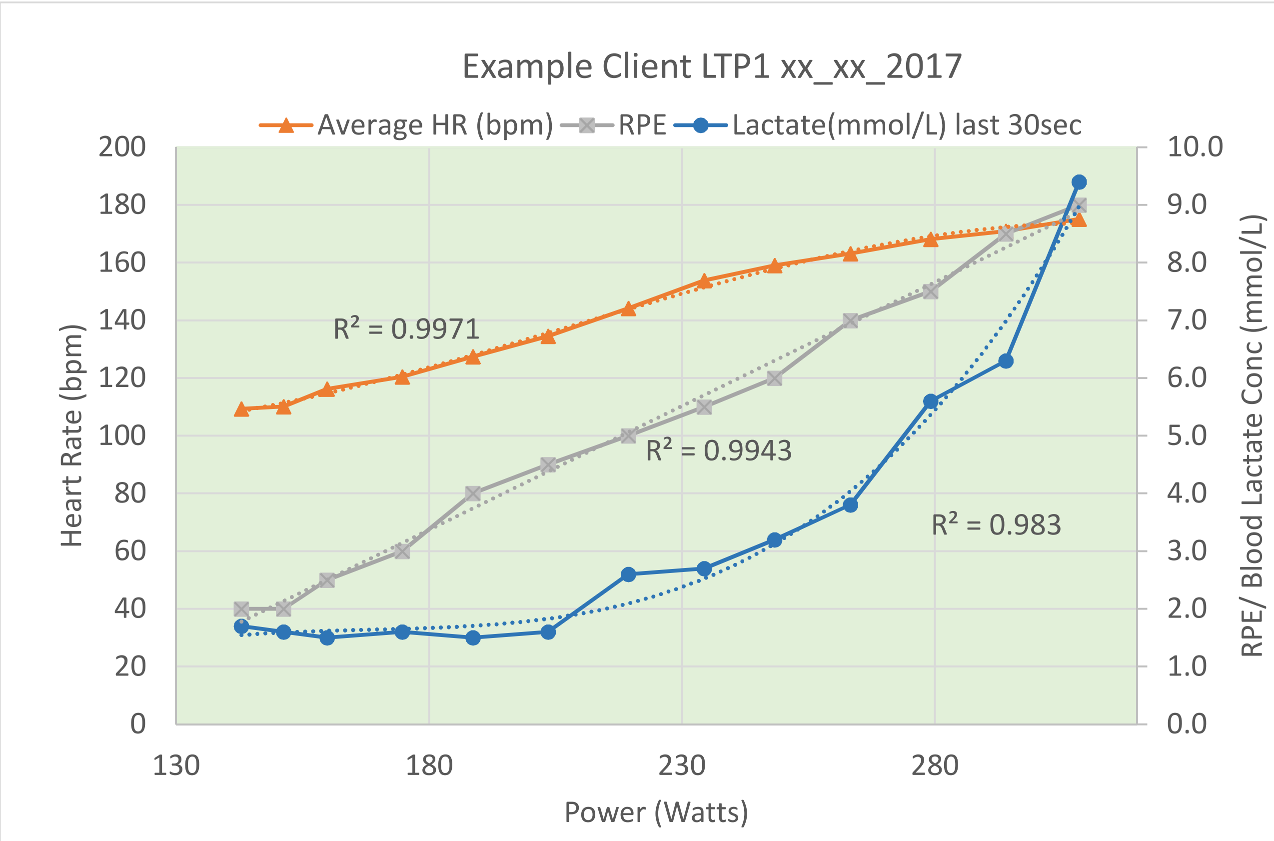
LACTATE THRESHOLD HEART RATE & POWER PROFILING

Lactate Threshold profiling has been referenced more and more frequently in scientific literature as a consistent physiological assessment for predicting endurance performance and potential for success in competitive cycling (Faude et al, Sports Med, 39 (6), 2009; 469-490). Blood lactate is produced anaerobically when oxygen available to the muscles is not in abundance, but acts as an aerobic fuel at rest and during exercise. Lactate is also an extremely trainable physiological marker and indicator of the capacity of both anaerobic and aerobic energy systems, for any level of cycling ability. The lactate threshold turning point is known to represent a similar effort to that of an hour long time trial. The lactate threshold power-to-weight is a critical parameter when climbing against gravity is involved. The advent of power meters, and ability to determine power outputs and heart rates at lactate threshold allow us to define accurate training ranges for effective stressing of targeted energy systems as to improve the capacity of these systems. Importantly, structured training at specific intensities and durations as part of a personalised periodisation programme should provide the quickest returns on performance progression for the investment of valuable training time. (Gladden, Review. J Physio 558.1, 2004: 5-30.)

Hi Example Client,

Great work last week! A representative lactate threshold and power / heart rate profile was acquired during your visit. I can present you with your biometric data as the following:

Results –



POWER (Actual mean Wattage)	BLOOD LACTATE CONCENTRATION (mmol/L)	CADENCE (rpm)	AVERAGE HR (bpm)	RELATIVE PERCEIVED EXERTION (RPE) (1-10)
143	1.7	89	109	2.0
151	1.6	95	110	2.0
160	1.5	92	116	2.5
175	1.6	91	120	3.0
189	1.5	90	127	4.0
204	1.6	90	135	4.5
219	2.3	87	144	5.0
234	2.7	86	154	5.5
248	3.2	86	159	6.0
263	3.8	85	163	7.0
279	5.6	84	168	7.5
294	6.3	81	171	8.5
309	9.4	67	175	9.0
R^2	0.983	-	0.997	0.994
Resting	**1.8**	**88** (average)	**-**	-
Recovery 10min	**5.8**			

Each data-channel was positively and highly correlated over the range of work load (power output x time) investigated in your assessment. R^2 coefficient values were in the order of **0.98 to 0.99** for Heart Rate, Blood lactate concentration and Relative Perceived Exertion (RPE) versus Power (work-rate), trend-lines shown on graph, confirming the uniform validity of the assessment. Blood lactate was fitted to a third order polynomial curve for estimation of lactate threshold values as shown in the table below (defining lactate thresholds).

Data Interpretation:

At rest and under steady-state exercise conditions, a balance exists between blood lactate production and blood lactate removal. The Onset of Blood Lactate Accumulation (OBLA) refers to the point of intensity of exercise at which there is an abrupt increase in blood lactate levels which leads to the complete exhaustion of an athlete within minutes. This turning point is representative of when your metabolism switches from predominantly aerobic metabolism of fat (adipose tissue) and glycogen (stored and ingested carbohydrate) to predominantly anaerobic glycolysis and the production of greater quantities of lactate in the active skeletal muscles and blood. Coyle, EF. et al Exerc Sports Sci Rev 23: 25-63, 1995.

Your resting lactate concentration (**1.8 mmol/L**) reflects the general turnover of lactate production and clearance by your metabolically active skeletal muscle and liver at rest. Muscle composition (i.e. the proportion and composition of aerobic/anaerobic muscle fibres), diet, stress, fatigue and illness will all influence this value. The brain, heart and blood also produce and metabolise lactate but at much lower levels during resting periods. Your heart rate and relative perceived exertion (RPE) was proportional to a power-output range between **143** to **309W**, at an average cadence of **88rpm**.

At baseline intensities and work rates (power) up to **204Watts**, your lactate concentration (1.6 mmol/L) is stable and consistently drops below your resting value (1.8 mmol/L) for these lower work rates, which is a sign of good aerobic conditioning, economy and efficiency at these intensities. Although this maybe improved further i.e. even more aerobic with lower lactate values, deriving energy from stored and ingested fats (triglycerides) as opposed to processing glycogen/lactate.

Working at intensities higher than your 'first' aerobic turning point at around **204/219 Watts** elicits a gradual accumulation of lactate in your blood, to **265 Watts** (**3.8 mmol/L**, **heart rate of 159bpm, RPE 6.0**) and is close to your second anaerobic turning point which is predominantly reliant on carbohydrate metabolism (termed MLSS in this report). After this point, lactate accumulates more rapidly until **309Watts** where you reach volitional exhaustion and the end of the assessment.

The results indicate you have a [redacted] Your peak lactate levels are in fact typically quite high, indicating a strong, yet restricted aerobic conditioning at this intensity meaning your anaerobic capacity/ Type II muscle fibers are under much stress.

[redacted]

You should have sufficient muscle fiber foundation recruited by neuromuscular strength training to build longer lasting adaptations to create the correct balance of aerobic and anaerobic conditioning for your objectives. This is achievable through a well-structured periodisation schedule and concurrent strength/endurance training programme.

Lactate Clearance

These observations are confirmed by the ability of your metabolism to clear the peak levels of lactate, and return to resting values. The quicker this is (analogous to heart rate), the more efficient your aerobic capacity and lactate distribution. The slower it is, the more inefficient your metabolism. This value is also reflective of the type of cycling (distance and intensity) you usually participate in.

The results show that your level returns to **5.8 mmol/L** after **10 minutes**, having reached a peak of **9.4 mmol/L** (309W). Your peak blood lactate clearance (**0.47 mmol/L/min, 0.0054mmol/L/min.kg-1**) was not complete (**47% recovered**). This value is in the upper quartile (0-25%, well above average) range of blood lactate clearance, and suggests your ability to recover from this peak accumulation from work above your threshold is high.

Improvements in lactate clearance are generally a positive consequence of training the lactate system at higher intensities for a better power-to-weight at lactate threshold as well as cycling efficiency.

In contrast to aerobic metabolism, higher intensity efforts should be fuelled by an optimal proportion of energy derived from anaerobic metabolism, once sufficient oxygen is not available to provide all of the energy requirements. An over-worked aerobic metabolism still requires available fuel in the form of pyruvate and lactate from anaerobic use of glucose and degradation of glycogen. Again, this emphasises the need for the synergistic proportion of Type I/II muscle fibers needed to perform well in cycling, depending on the discipline of focus (sprinting, climbing, time-trial, criterium and track). Beneke et al, Br J Sports Med 2001; 35 (3): 192-6.

Defining Lactate Threshold

The lactate turning point (also termed LT) is the workload and heart-rate at which you are able to sustain at a Maximal Lactate Steady State (MLSS) in the blood, before the onset of blood lactate accumulation (OBLA). This represents your endurance ability for the highest intensity for the longest steady-state sustainable duration before exhaustion and depletion of glycogen without supplementary nutrition.

Two methods for defining your MLSS have been performed on your lactate-power curve; see table below. The average value from both estimations is **283Watts** at **171bpm** and **5.7 mmol/L** of lactate in the blood. This equates to a LTP power-to-weight ratio of **4.35 Watts/Kg** at a current weight of **65.0Kg (tbc)**.

As lactate threshold power improves, a cyclist is able [redacted]. This is referred to as the training 'dead-zone' and is highlighted by a 'step' in the lactate curve around threshold. A significant 'step' in your blood lactate versus power curve **does exist** just below your threshold power and heart rate values, suggesting an optimal distribution of training volume intensities. [redacted]

Sweet-spot training (a specific intensity as defined on your physiological training zone intensities) is believed to be a convenient zone to train in for the 'return of investment' on training time, but this does not take advantage of lower intensity riding or pushing your limits for specific conditioning needed in particular events or races, and has no scientific evidence of its effectiveness even though many cyclists implement this type of training.

Your overall average LTP/HR values have been used to scale your personalised training zones, heart rate and power levels (located below). These are an important indication of targeted metabolic pathways for effective training prescription, depending on the overall performance objective.

Example Client LTP1	2017 Lactate Threshold Profiling (LTP1)		
	XX-XXX- 2017		
Threshold Method of Estimation	Power (Watts)	Heart Rate (bpm)	Lactate (mmol/L)
User defined	-	-	-
D-mod (Bishop et al, 1998)	286	172	5.9
Tangent Intercept	279	170	5.5
AVERAGE LTP/HR	**283**	**171**	**5.7**
Blood Lactate Clearance	**0.36 mmol/L/min (0.00472 .kg-1) to weight**		
Lactate Threshold power-to-weight	**4.35 Watts/Kg @ 65.0kg**		
Average Cadence	**88 rpm**		

Calculated training zones, scaled to LTP (283 Watts, 4.35 Watts/Kg). LTHR 171bpm

Level	Zone (Purpose)	Typical Duration interval/session	Wattage		Heart Rate		RPE
			Power (Watts)		Heart Rate (bpm)		
			From	To	From	To	
1	Active Recovery	30 - 90 min	0	139	approx 90	135	< 2
2	Endurance	60 - 300 min	141	200	136	152	3 - 4
3	Tempo	60 - 180 min	203	255	153	164	5 - 7
	Sweet Spot		235	275	160	171	6 - 7
4	Lactate Threshold	8 – 30 min	255	297	165	177	7 - 8
5	VO2MAX	3 – 8 min	300	340	178	max	8 - 9
6	Anaerobic Capacity	0.5 – 3 min	342	425	na	na	10
7	NeuroMuscular Power	< 0.5 min	425	n/a	na		na

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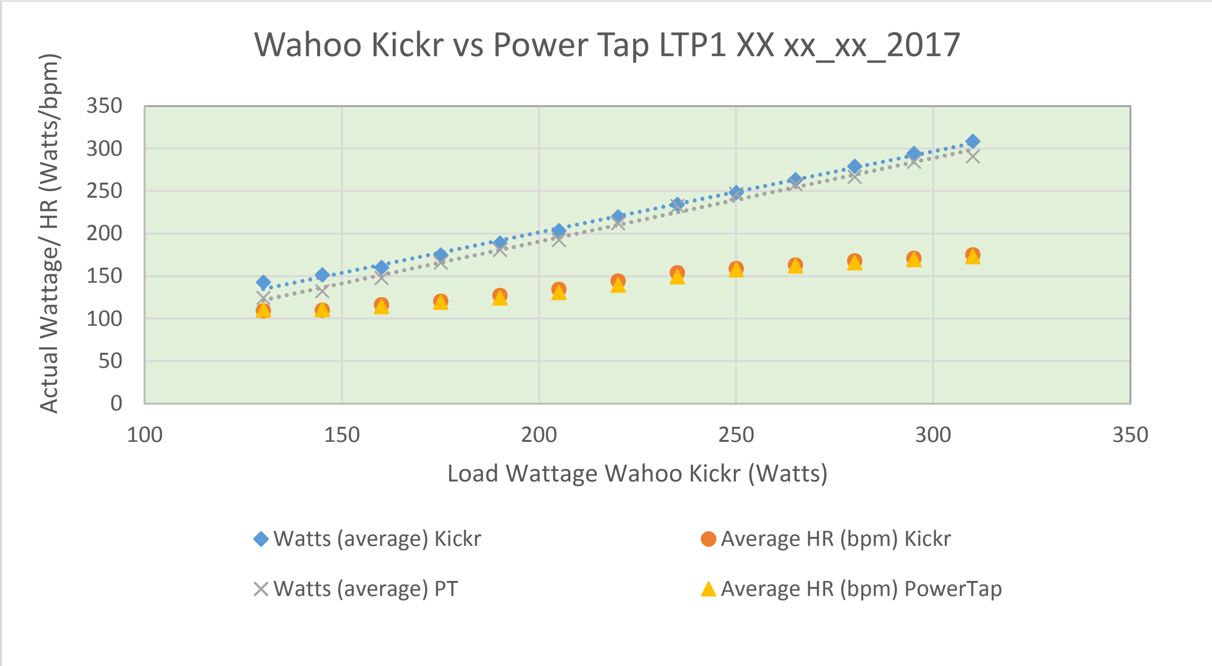
Power reading comparisons Wahoo KICKR vs PowerTap



From the comparison of nominal calibrated Wahoo KICKR power measurements against your Power Tap mobile ergometer we can see there is a small although constant linear discrepancy throughout the power range assessed, average difference of -10W (-5.2% average RE). This difference seems to be more significant at the lower and upper end of the power range (<200W, >300W). For that reason you should correct your scaled lactate threshold training zones as necessary for use with that power meter only.

Step (Watts) CT Load	KICKR (Actual) Watts (average)	POWER TAP Watts (average)	*Difference WK-PT Watts*	*% Error*
130	143	124	***18***	*12.9*
145	151	132	***19***	*12.6*
160	160	148	***12***	*7.6*
175	175	166	***9***	*5.2*
190	189	181	***8***	*4.2*
205	204	193	***11***	*5.4*
220	219	212	***7***	*3.4*
235	234	232	***2***	*0.8*
250	248	247	***2***	*0.6*
265	263	258	***5***	*2.0*
280	279	267	***12***	*4.5*
295	294	284	***10***	*3.3*
310	309	291	***18***	*5.8*

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Conclusions and Objectives

Your cardio-respiratory and lactate-power kinetics evaluated as part of this report are consistent not as optimally aligned as they could be for better performance. My conclusions based on these observations are as follows:

- Good aerobic efficiency to 204Watts, lactate levels up to this intensity remains below or near your resting value. This could be improved further utilising a [redacted]
- Gradual accumulation of lactate from 204W to 234Watts suggesting a [redacted]
- Rapid accumulation from 234-309W, concurs with the termination of the assessment and indicates an [redacted]
- You should focus on improving you lactate threshold power as a main determinant of event performance for lower cardiac stress and longer duration (improved glycogen stores). Once threshold MLSS (LT Power) has been breached lactate accumulates rapidly suggesting a restricted maximal aerobic conditioning and anaerobic fatigability. This should also be addressed by [redacted]
- You should also focus on your ability to recover from [redacted]

An achievable improvement in your absolute aerobic capacity by recruiting more muscle mass or change in the relative proportion of Type II glycolytic (anaerobic) / Type I (aerobic) oxidative muscle fibre recruitment is warranted to [redacted]

I will archive this report as part of your training folder, and will act as the baseline for a follow-up comparison later in the season. Please familiarise yourself with your training zones and keep this report available for future reference.

Safe riding!

Simon

Principal Physiologist (BASES Professional)

Blood lactate can be used as a fuel in aerobic metabolism when oxygen is available. This tells us that LT is an invaluable window into the proportion of absolute aerobic capacity (indicated by VO_{2max}) available before the anaerobic power of the cyclist becomes more engaged i.e. a 'big aerobic engine'. Whereas VO_{2max} measures the absolute capacity of the combined cardiovascular and respiratory systems to deliver blood and oxygen to the tissues, lactate threshold (LTP/LTHR) values take mechanical efficiency into consideration and is an indirect measure of the ability of the muscles and tissues to utilise oxygen. This is exemplified by the rate of recovery from peak lactate concentrations to reach resting values. The faster the return to resting lactate values, the stronger the aerobic metabolism, and is therefore an indication of the relative size of the aerobic capacity and the ability to re-convert lactate to glucose and glycogen in the liver (known as the Cori cycle). This also relies on the ability to metabolise fat efficiently. Van Schulenbergh Int J Sports Exerc 2000, 32 (6):1135-9.