VLa_{max} – glyoclytic power –
the secret weapon of elite endurance performance coaches

20% of the difference in performance between cycling amateurs and professionals, can be explained by VO_{2max}. 75% of the performance differences in these two groups is accounted for by differences in VLa_{max}.

Glycolytic power – or VLa_{max} – has proven a highly important metric in endurance sports over the past decade. In the highest ranks of sports, such as swimming and cycling, the integration of VLa_{max} as a metric has helped to understand athletic performance. Almost unnoticed in the past decade, VLamax has been a key metric to success for:

- Dr. Olbrecht – advisor to coaches whose athletes won 18 medals in Rio Olympic Games
- STAPS: Europe's most successful testing and coaching business, having Movistar, Katusha-Alpecin, Bora-Hansgrohe, et at. as their customers
- Sebastian Weber – one of cyclings most successful coaches in the past decade, worked with athlete such as: Alban Lakata, Tony Martin, Ivan Basso, André Greipel, Peter Sagan, et al.
- Dan Lorang – former head coach of the german triathlon federation, private coach of Jan Frodeno et al.

A high VLa_{max} allows for high performance in short events such as sprinting. On the other hand, high VLa_{max} causes higher glycolytic flux rate at sub-maximum intensities. This leads to high carbohydrate combustion, slower recovery from lactate accumulation, lower energetic contribution from fatty acids and lower performance at anaerobic threshold.

Aerobic & Glycolytic power

The maximum aerobic power is commonly measured as VO_{2max} – the maximum oxygen uptake capacity. Why is VO_{2max} important? For each milliliter of oxygen processed in the aerobic metabolism, energy is produced.

In the glycolytic metabolism (glycolysis) lactate (or pyruvate) is produced out of glucose. This anaerobic process (no oxygen is involved) also produces energy. The amount of energy produced per piece of glucose is much less compared to the aerobic metabolism. However, this type of energy is produced at a much faster rate. Therefore, glycolysis is much more important for shorter, high intensity efforts. For such short efforts, a high energy production in a short time is needed. As the amount of energy produced is proportional to the amount of lactate or pyruvate produced, VLa_{max} is a feasible way to measure glycolytic performance. VLa_{max} stands for max production of Lactate.

VLa_{max} hasn't been widely measured until now. Historically, very few, but highly successful coaches and sport scientists have used it. The reason for this? VLa_{max} wasn't easily accessible…yet.

The role of VLa_{max} in endurance performance

Glycolysis is not only important for sprinters, but has a tremendous effect on endurance performance. Glycolysis is the only way to utilize carbohydrates as a fuel during exercise. High glycolytic rates, enable high rates of utilizations of carbohydrates as a fuel. On the other hand, a high utilization of carbohydrates as fuel, reduces the need for fatty acids as a fuel- thus lowering fat metabolism. Furthermore, the maximum glycolytic power – or VLa_{max} – influences the glycolytic rate at endurance exercises. High VLa_{max} will trigger high lactate production during endurance exercises. This high lactate production lowers power at anaerobic threshold and the ability to recover from lactate accumulation.

Do you wonder what enables high performance at anaerobic threshold? Why do different athletes require different fueling strategies and carbohydrate intake? Why do different athletes encounter different abilities to utilize fatty acids as a fuel – even though those athletes might possess similar performance at anaerobic threshold? What allows certain athletes to change their race rhythm and attack their competition, with bouts of high power/energy output, again and again and again? If these questions are of interest to you – assessing VLa_{max} might – in most cases – be the answer to these questions.

Higher maximum glycolytic power (higher VLa_{max}) triggers higher lactate production rates at sub maximum / endurance exercises

Lets look at two identical athletes. These athletes share identical body weight and body composition (muscle mass, fat mass, etc.), identical efficiency (energy needed to produce one Watt of power), identical buffering capacity, identical aerobic capacity (VO_{2max}), but with two different VLa_{max}. The high VLa_{max} triggers higher lactate production rates at all sub maximum intensities. The athlete with the higher VLa_{max} possess a higher lactate production rate, for any given power output, when compared to the athlete with the low VLa_{max}.

For the athlete with a higher VLa_{max}, this higher lactate production results in a lower intensity at which lactate production equals lactate clearance. This is the mechanism of how a high VLa_{max} lowers anaerobic threshold- as shown below.

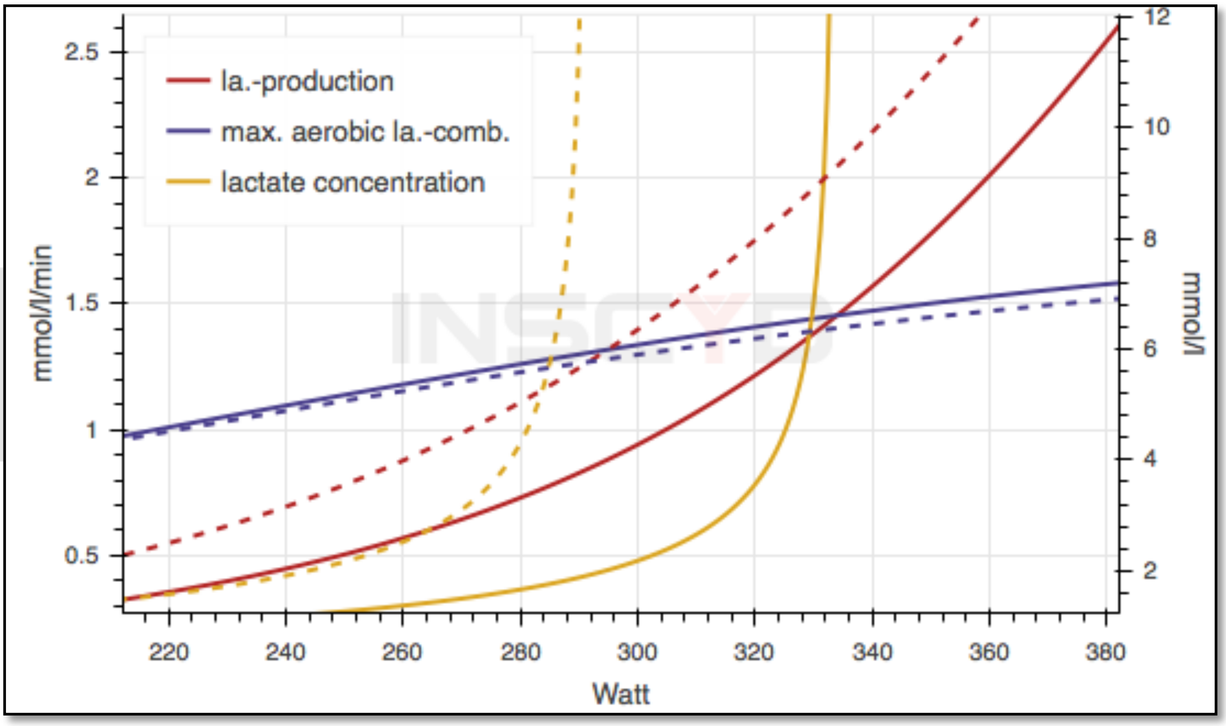

Fig 1: Muscle Metabolism in steady state conditions are shown here. The influence of a high vs. a low VLa_{max} on the lactate production, and anaerobic threshold is noted: all doted lines = high VLa_{max}, all solid lines= low VLa_{max}. Blue line shows the maximum possible lactate clearance rate by aerobic metabolism. The red line shows the lactate production. The yellow line shows the corresponding lactate concentration – for steady state conditions.

Higher lactate production rates come with the cost of higher carbohydrate utilization – therefore reducing fatty acid combustion

Muscles produce lactate using carbohydrates. Therefore, a high lactate production rate consequently results in higher carbohydrate utilization rates.
With a higher amount of energy coming from carbohydrates, as a consequence the fat combustion rate is lower.

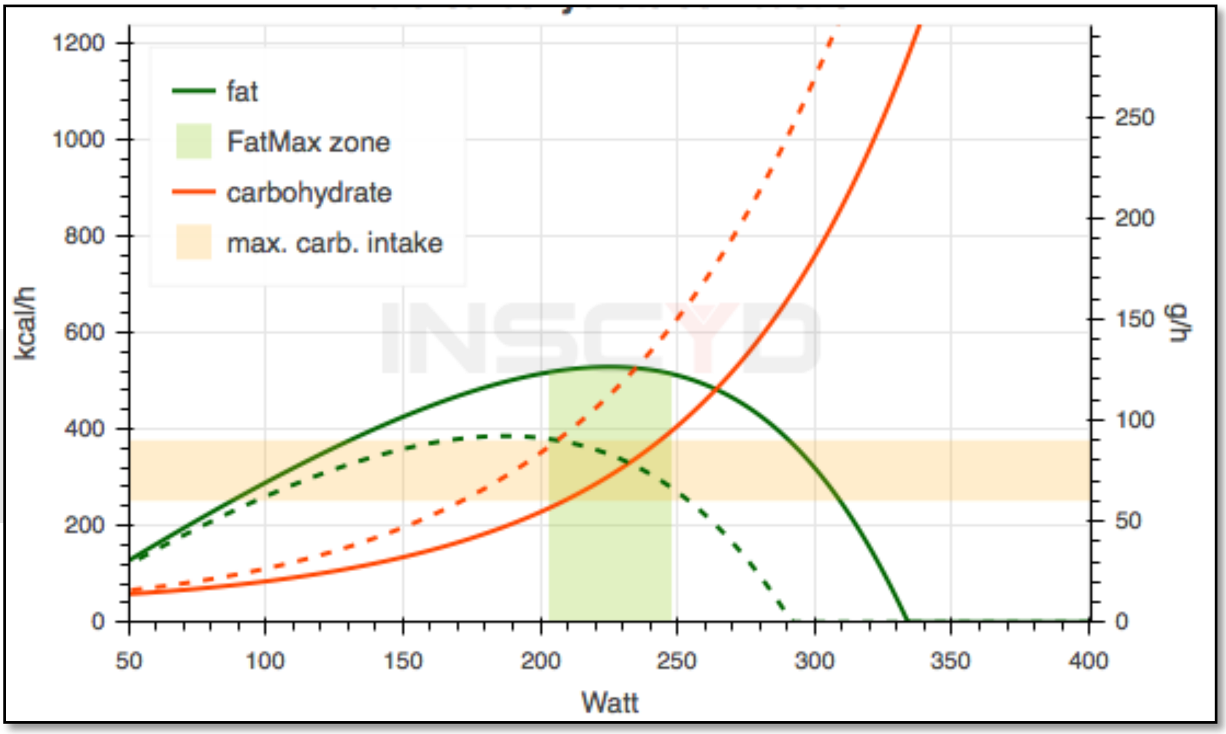

Fig 2: Carbohydrate combustion (red) and fat combustion (green) for a high VLa_{max} (dotted lines) and a low VLamax (solid line)

Measuring VLa_{max}

The tricky part with VLa_{max} is it historically was not easy to assess and monitor within high performance sports. In 2002, at the German Sport University Cologne, Sebastian Weber developed a test on the bicycle ergometer to measure VLa_{max} directly.

The method was verified comparing measured VLa_{max} to calculated values. Additionally, the measured VLa_{max} was compared to the glycolytic capacity of the muscle cell. This was determined by activity of the most important glycolytic enzymes (PFK – phosphofructokinase) obtained via muscle biopsies of the muscle vastus lateralis in cyclists.

In addition to direct assessments using sprint tests, VLa_{max} can be obtained from reverse calculation, using lactate concentrations, at workloads when oxygen demand is known.

As shown above, VLa_{max} influences anaerobic threshold and also lactate values in sub max tests. The latter being proven and discussed in the literature about the influences, and ways to analyze lactate curves. However, these findings actually opened up another possibility to assess VLa_{max}-: through indirect measurements of sub-max lactate levels, combined with reverse calculations. VLa_{max} is the main regulator of actual lactate production, which is one major determinant of lactate concentration. The other major determinant for lactate concentration is the combustion of lactate. This is related to the actual oxygen uptake, as the clearance of lactate – under load - is performed in the aerobic metabolism. Oxygen uptake - as a marker of the rate of aerobic metabolism, because this is where the oxygen gets used during exercise – is relatively easy to measure or even calculate in endurance exercises. As oxygen uptake is known, lactate production becomes the major determinant of lactate concentration. This opens the possibility to calculate backwards from lactate production rates at sub maximum testing conditions, in order to obtain the maximum lactate production rate = VLa_{max}.

Tracking VLa_{max}

VLa_{max} is highly adaptive to training and detraining. It may well account for a majority of changes in endurance performance throughout a season.

VLa_{max} isn't a static value that can't be changed by training. In fact, it is highly adaptive to training and detraining, and also seems to change with aging.
In cyclists, for example, VLa_{max} can vary during a season. This accounts for the majority of changes in endurance performance. As described above, a lower VLa_{max} increases endurance performance, by decreasing carbohydrate utilization and increasing power at anaerobic threshold. On the other hand, a lower VLa_{max} effects the performance at short, high intense, exercise bouts. Therefore, measuring higher endurance capacities in athletes throughout the season, using markers such as anaerobic threshold or FatMax alone, might be misleading. An increase of such markers might well be facilitated by a lowered $VLa_{max.}$ This increase, might be diametrically opposed to overall performance for any event in which short high power outputs are required.
In contrast this also means that monitoring VLa_{max} in conjuction with endurance markers, such as fat oxidation and anaerobic threshold, allows for a comprehensive understanding of the developing of the performance of an athlete.

Fig 3: Development of VLa_{max} (red) VO_{2max} (blue) and anaerobic threshold (purple) in a professional cyclist during one season: VLa_{max} is comparable high during the winter training (0.85 mmol/l/ls). Once the preparation for the season starts, with several training camps and races influencing performance, it begins to drop. In combination with an increase of VO_{2max}, the drop of VLa_{max} results in a tremendous increase power at anaerobic threshold. In May the VLa_{max} drops to a level at which it becomes diametrical to the sprint performance of this particular athlete. After a period of sprint training, VLa_{max} raises again just before the Tour de France. After the Tour de France, both VLa_{max} and VO_{2max} are low. As for September 2013 both values are increasing again. During this whole period from May to September, power at anaerobic threshold doesn't change much, even increasing a little bit – with lowered VO2max and VLa_{max}. This example shows how looking at anaerobic threshold only will blunt the view on the overall performance of the athlete: before the Tour de France, VO_{2max} and VLa_{max} were high, allowing for both high aerobic and high anaerobic power. In the fatigued state after the Tour de France, both performance indicators are low and the athlete clearly not at his best performance. However, this effect can't be seen with looking at anaerobic threshold only.

5 Training Tips to decrease VLa_{max}

1) Regular training

One of the most important rules to follow when it comes to lowering VLa_{max} is repetition. For some metrics of endurance performance, scientific studies have shown that regular training vs. a “weekend warrior” regime might not make a difference. However, this doesn’t seem to be true when it comes to lowering VLa_{max} to increase endurance performance. In order to achieve a solid and sustainable low VLa_{max}, it takes regular training. There is no shortcut here, but to workout regularly. Adding as little as a few hours per week, all the way to a few extra training days to a program can help here – even if it is for only 1h/day of extra training. A typical training schedule would include a minimum of 3 sessions per week, with the ideal number being 5-6 training sessions per week. This regular regime allows for recurring training stimulus, which is needed to trigger the desired adaptations

2) Never too easy, never hard

Another key to lower VLa_{max} is choosing the right training intensity. Studies have shown workouts – even with high volume – do not trigger the desired adaptation if the intensity is too low. Lowering VLa_{max} includes lowering glycolytic enzyme activity. Those enzymes are mostly located in the different kind of fast twitch muscle fibers. These muscle fibers possess a higher intensity threshold, which do not get recruited during low intensity endurance training. If a training doesn’t recruit the muscle cells which are targeted, no adaptation can be expected. Therefore mid range intensities – above base endurance but below anaerobic threshold – are preferable to lower VLa_{max}.

To trigger the recruitment of these targeted muscle fibers even more, it is highly beneficial to increase the force or torque which is involved in such a training. In cycling, for example, this can be done by lowering the cadence, therefore increasing torque and force. If this is done in combination with a slightly increased intensity, it provides a sufficient trigger to recruit, and therefore train, the targeted muscle fibers.

3) Avoid high intensity

The known and accepted concept of training is: a system which gets stressed/used by training adapts in order to increase its capacity “to better cope” with the stress / increased usage. With every short duration, high power effort- such as sprints, accelerations, surges, etc.- glycolysis is getting activated to a large extent. Such training stimulus can add up, and usually aren’t easily visible when training is analyzed only in a general perspective, such as looking for an average power or speed. It only takes a very few seconds ($<5s$) to activate glycolysis and provide a trigger to the muscle to use this system. Therefore, (in regard to general idea about how training works) repeated short, high intense bouts of exercises, are diametrical to the desired effect. Such efforts will effectively provide a stimulus, NOT to lower glycolytic power, and therefore will hamper the decrease of VLa_{max}.

4) Never fully glycogen replenished.

Another, effective way to help muscles de-adapt glycolytic power, and reduce VLa_{max}, is to cut back on the fuel for glycolysis. Training on empty glycogen stores hampers the training effect in general and should be avoided under almost any circumstance! However, training with lowered glycogen stores can help lowering dependence on glycogen as an energy source. The result of this type of training yeilds decreased lactate production, which helps detraining this system. This is especially successful when combined with mid range intensities, where power is still low enough to utilize fatty acids as a main energy source. Training on low (not empty!) glycogen stores with reduced carbohydrate substitution has shown great effect on VLa_{max} adaptation. You can use the fat – and carbohydrate utilization curves, within INSCYD, to effectively set the right training intensities for your athletes.

5) Repeated, spaced out efforts

All hacks mentioned above (1-4) should be combined and built in a highly specific, tailor made exercise profile, which includes: duration, intensity, torque and nutrition. The exercise should build a basic training principle for your athletes' training program. It is most effective, even needed, to repeat such efforts several times a week. The specific mid range intensities (combined with high torque) should be repeated several times during one training session. Those efforts should not accumulate, but be spaced out during one training session (for example: 4x20' mid intensity, high torque could be included once per hour in a 4h bike training).
How fast can changes be seen? Depending on the adaptability of the athlete, the quality and volume of such specific training programs as described here; first and stable changes in VLa_{max} can be expected to be seen after 6-8 weeks. However, it can take several months to achieve the full potential of VLa_{max} reduction.

5 Training Tips to increase VLa_{max}

1) Gym Training

A safe and highly effective way to increase glycolytic power is by specific gym training. Such training allows for specific training of targeted muscle groups and can be combined with different kind of endurance training methods.

The key to a gym training program, which triggers glycolytic power, to adapt and increase- is to create a set of exercises which includes a high activation of glycolysis. These exercises possess the following attributes:

i) duration: 12 – 30s per set are ideal. Such time durations, highly dependent on the work-rest ratio within a set though – allow for maximum activiation of glycolysis. Shorter durations will still trigger glycolytic energy supply, but is below the optimum. Any longer time duration per set might be too long to allow for sustained high activation of glycolysis.

ii) Movement speed / work-rest ratio: repetitions within one set should be continuous and not include any resting periods in between repetitions. Prolonged resting periods would allow for a slight replenishment of creatine phosphate in the muscle, increasing its availability as an energy source, potentially decreasing the involvement of glycolysis.

iii) Load: load should be medium to high, but in no case high enough to lead to complete failure at the end of the set. An exercise to failure may possess low pH levels in the muscle, hampering glycolytic energy production- and potentially reducing the training effect on glycolysis.

2) High intense, short interval training & Sprints

Similar to the mechanism found in specific gym training- short efforts can be used in high intensity interval and sprint training to help increase VLa_{max}. Such an exercise will possess an intensity high enough to trigger high glycolytic flux rates. Therefore, the needed intensity is just below maximum, for a given time duration of 10-30 seconds per repetition. The recovery time in between such efforts should be sufficient to let pH rise back to normal levels, enabling a full activation of glycolysis during the next effort.

3) Endurance training – only easy

If training for higher VLamax is carried out within an endurance training program, all other exercises need to be designed in a way to not hamper the desired training effects on VLa_{max}. It is important to avoid any mid intensity efforts, slightly below or above anaerobic threshold for long time periods. Such training is known to trigger a de-adaptation of VLa_{max} and would be in opposition to the desired goal of an increased glycolytic power.

4) Keeping fueled.

Training on a high fat and low carbohydrate diet has been shown to decrease the activity of glycolytic enzymes in the muscle. In order to allow for the high intense, glycogen depended training regimes needed, a constant, high fueling of carbohydrate is needed. Glycogen stores should never be depleted or reduced in order to allow for maximum fuel availability.

5) Training frequency

Similar to the decrease of VLa_{max}, an increase takes it time and there are no short cuts. First adaptations can be seen after a few weeks of training (6-8), while a full adaptation can take several months.

In order to achieve the desired effect on VLa_{max}, it is necessary to perform the specific exercises several days per week. Depending on other training around (specifc) VLa_{max} training, 2-4 times (most often 3 times) per week are effective. These exercises should be spaced out, and not accumulate within 2-4 days of training, but be separated by a rest day or a day with a different training purpose and therefore exercise regime.