AEROBIC/ANAEROBIC ENERGY SUPPLY

By Caroline Hempel

The term "lactate threshold" is often used during training sessions and we all know what it feels like, but do we understand what is going on in our body? To understand lactate threshold we need to firstly understand aerobic versus anaerobic energy supply in our body.

The only usable form of energy for muscle activity is **ATP (adenosine-tri-phosphate**). ATP cannot be stored in the muscle but has to be generated constantly during muscle activity from an energy source that can be stored in the muscle. There are 4 main pathways to produce ATP in our muscle cells which are more or less efficient and require oxygen (aerobic) or no oxygen (anaerobic).

- **Hydrolysis of creatine-phosphate:** Creatine in creatine-phosphate serves as a carrier for the phosphate that is used to generate ATP and there is **no oxygen required (anaerobic)** but unfortunately this pathway is **depleted within 20 seconds** under maximal muscle activity! NO need to buy creatine sports supplements in my opinion!
  CrP → Kr + ATP

- **Aerobic glucose metabolism (oxidation of sugars):** This pathway has the highest degree of efficiency to generate ATP however **it requires oxygen**. Simple sugar (glucose) is metabolised to ATP inside the muscle cell. From 1 molecule of glucose 38 molecules of ATP can be created. Water and carbon dioxide are the by-products.
  1 $C_6H_{12}O_6$ (glucose molecule) + 6 O_2 → 6 H_2O + 6 CO_2 + 38 ATP

- **Anaerobic glucose metabolism**: Very similar metabolic reactions occur here though by the **lack of oxygen** the final step in the previous aerobic metabolism is interrupted and instead of CO_2 and H_2O **lactate is produced**. This alternative anaerobic pathway only produces 2 ATP per 1 molecule of glucose which is obviously very inefficient compared to the aerobic pathway.
  1 $C_6H_{12}O_6$ (glucose molecule) - O_2 → Lactate + 2 ATP

- **Oxidation of fat (triglycerides):** Triglycerides are stored inside muscle cells but to be used as an energy form it must be broken down first to free fatty acids (FFAs) and further complex metabolic reactions (β-oxidation) are necessary to use FFAs to generate ATP. Even though the yield of ATP in this process is much higher than that from metabolising simple sugars (depending on the type of fat up to 100 ATP molecules per 1 fat molecule) this pathways **requires even more oxygen**. Therefore per molecule of oxygen available only 5 molecules of ATP can be produced from fat, compared to 6 molecules of ATP from sugar. Oxygen is the major limiting factor in this pathway, therefore the body uses carbohydrates over fats as the preferred fuel during high-intensity exercise.

To summarise the efficiency of those 4 metabolic pathways in providing energy (ATP) we could say:

- From 1 molecule of **creatine-phosphate (anaerobic)** we can paddle 100m
- From 1 molecule of **glycogen** without oxygen **(anaerobic)** we can paddle 1500m
- From 1 molecule of **glycogen** with oxygen **(aerobic)** we can paddle 30 km
- From 1 molecule of **fat** with oxygen **(aerobic)** we can paddle >100 km

These numbers are obviously not accurate but show clearly the differences in efficiency to supply energy for muscle activity. Considering those numbers, oxygen for aerobic metabolism seems to be the most critical factor in generating ATP. However depending on the intensity of exercise there is a limit of oxygen supply to the muscle cells, through breathing and oxygen transport via the blood, to generate the amount of ATP necessary to perform at that level. Therefore the level of anaerobic metabolism will continuously increase with increasing work effort to assist with the generation of necessary ATP. In other words lactate will start to build-up as soon as the ATP requirements exceed the capacity of aerobic ATP synthesis.

Fortunately lactate is constantly reduced in the muscle through specific enzyme activity (lactate-dehydrogenases). The **lactate threshold** is a steady-state level and the current exercise intensity at which anaerobic metabolism causes lactate to accumulate in the blood at the same rate as it can be removed through lactate-dehydrogenase enzymes. Obviously the lactate threshold is different in every paddler. The effects of training on the lactate threshold are mostly explained by a variety of muscular and cardiovascular adaptations that occur with training, for example increased efficiency of lactate-dehydrogenases, improved muscular oxygenation through increased heart-minute-volume and vascularisation, etc… (see other article in this series).