Lactate Production and Kinetics

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Lactate Threshold

Refers to the exercise intensity where there is an abrupt increase in either of muscle or blood lactate.

To improve the detection of this threshold, researchers transform the lactate values to their $\log_{10}$ expression.
Converting data to a log form produces data that fit different linear functions below and above the threshold.

It is difficult to detect a single point that represents a threshold phenomenon.
Other Lactate Threshold Terminology

**Anaerobic threshold** - first used in 1964 and based on increased blood lactate being associated with hypoxia. Now known to be an oversimplification, and should not be used.

**Onset of blood lactate accumulation** (OBLA) - the maximal steady state blood lactate concentration, which can vary between 3 to 7 mmol/L.

*Research has shown that there is considerable similarity in each of the exercise intensities obtained from the different lactate threshold methodologies.*

**Remember** that the limitation to exercise above the LT is not the increased blood and muscle lactate but the associated increase in acidosis and other markers of muscle fatigue.

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What causes the LT?

- 🎉 Production of lactate
- 🎉 Removal of lactate
- 🎉 Fast twitch motor unit recruitment
- 🎉 Imbalance between glycolysis and mitochondrial respiration
- 🎉 Ischemia
- 🎉 Muscle hypoxia
- 🎉 Redox potential (NAD⁺ / NADH)

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From Brooks, Fahey, White and Baldwin, 2000; p.200

**Figure 10-2** Arterial lactate concentration and rates of lactate appearance ($R_L$) and disappearance ($R_d$) plotted as a function of oxygen consumption ($\dot{V}_O_2$) in one subject. SOURCE: Stanley et al., 1986.

**Figure 10-3** The mean values (± SD) for glucose disappearance and lactate appearance at rest and at 25 to 30 minutes of exercise ($r = 10$). The star is significantly different from rest ($P < 0.008$). SOURCE: Stanley et al., 1986.

From McArdle, Katch and Katch, 2001; p.303

**Figure 14.13** Top: Relationship between blood pH and blood lactate concentration at rest and during increasing intensities of short-duration exercise up to maximum. From Daniels JB, Hermansem L. Acid-base balance after maximal exercise of short duration. J Appl Physiol 1972;32:58. Bottom: Blood pH and blood lactate concentration in relation to exercise intensity expressed as a percentage of maximum. A decrease in blood pH accompanies an increase in blood lactate concentration.

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**Katz & Sahlin, Acta Phys Scan, 1987**

- **Normoxia**
- **Hypoxia, 14% O₂**

- 50-67% VO₂ max

**Katz & Sahlin, JAP, 1988**

- Lactate (mmol/kg dry wt.)
- Pyruvate (mmol/kg dry wt.)


- **for vastus lateralis**
- Flux = mmol/kg wet wt.

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Lactate is not a dead-end product of catabolism

Lactate can be consumed by less active muscle, or active slow twitch muscle, as well as be a gluconeogenic precursor for liver gluconeogenesis—(Cori Cycle)

Lactate Transporters

- Lactate leaves most tissues by an ATP-dependent facilitated transport system
- Both a lactate and proton are transported - lactate-proton symport
- The transporter is bi-directional
- The transporter is stereo-specific for L-lactate
- The transport process is saturable
- The transport process capacity is modified with training and inactivity
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- Some transporters function with other molecules (eg. pyruvate)


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**Lactate (monocarboxylate) Transporter Isoforms**

**Note:** the muscle/fiber type preference to ST muscles

- **MCT1 is main transporter in skeletal muscle**
- **Predominates in FT muscle fibers**


**Intra-Cardio-Myocyte Lactate Shuttle**


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**Canine gastrocnemius muscle**

**Whole body (rat) lactate removal**


**RTA** = Red tibialis anterior

**S** = Soleus

**RG** = Red gastrocnemius

24 hr/day, 7 days


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**Rat hindlimb muscles**

<table>
<thead>
<tr>
<th>Training Type</th>
<th>Speed</th>
<th>Grade</th>
<th>Duration</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderate training</td>
<td>21 m/min</td>
<td>8%</td>
<td>1 hr/day</td>
<td>5 days/week</td>
</tr>
<tr>
<td>Intense training</td>
<td>31 m/min</td>
<td>15%</td>
<td>1 hr/day</td>
<td>5 days/week</td>
</tr>
</tbody>
</table>

"Red" muscle: (52% SO, 46% FOG, 2% FG)

"White" muscle: (4% SO, 14% FOG, 82% FG)

6 mmol/min for 20 kg muscle


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