Energy Production During Supramaximal Exercise

- **Supramaximal:**
  - Intensities greater than ________________.
  - 100 m sprint in 10 seconds
    - Average speed = 10 m/s = 22 mph
    - This would require 140 ml/kg/min
      - ACSM equation
        - \( \text{VO}_2 = 0.2 \times \text{speed} + 0.9 \times \text{speed} \times \text{grade} + 3.5 \)
        - \( \text{VO}_2 = 0.2 \times 60 \) m/min + 0 + 3.5
        - \( \text{VO}_2 = 123.5 \) ml/kg/min
  - Either way, the \( \text{VO}_2 \) requirement is far greater than any \( \text{VO}_2 \max \) ever recorded.
    - Energy is transformed from chemical to mechanical from other ____________________.

Metabolic Pathways

...to produce ATP

- **Anaerobic:** without O2
- **Aerobic:** with O2

Oxygen-Independent Metabolic Pathways

- ____________________
  - There is enough storage to support about 3-7 seconds of contractions.

Oxygen-Independent Glycolysis

- Pyruvate is transported into mitochondria and enters the Kreb’s cycle.
  - Nicotinamide adenine dinucleotide (NAD) must be available to accept hydrogen ions.
  - If NAD is not available, pyruvate can accept hydrogen ions to form lactic acid
- Takes place in the ____________
  - Requires some energy (i.e., energy investment) to yield energy.
  - ATP is generated at a fast rate.

Oxygen-Independent Metabolic Pathways

- **Fate of glucose**
  - Glucose broken down to ....
    - Next stage is conversion to Acetyl-CoA
      - This happens in the mitochondria
      - This happens in sarcoplasm
  - The biochemical steps leading up to creation of pyruvate or lactic acid are the same.
    - Therefore, some references refer to ‘aerobic’ and ‘anaerobic’ glycolysis.
  - Noakes emphasizes that ___________ refers to the production of ATP without O2.
  - **Oxygen-Independent Glycolysis**
    - Lactic acid is end-point
Lactate Metabolism

• _________ is an end point of glycolysis.
• At normal body pH _______, lactic acid will rapidly dissociate to form lactate.
• Therefore, the terms lactate and lactic acid are commonly used interchangeably.
  – Lactic acid is unstable and is rapidly converted to lactate.

Lactate Metabolism

• Muscles produce and use lactate.
• Rate of production increases with exercise intensity.
• Classic view: _________ was associate with fatigue, cramps, side-stitch, post-exercise muscle soreness.
  – Proteins denaturize in acidic environments.
• Contemporary: _____________.

Lactate Threshold

• The point during a graded exercise test where there is a ___________ in lactic acid concentration.
  – The basic concept is that this point signifies when ATP is being generated to a greater extent _________.
  – Therefore, this point is also known as:
    • Anaerobic Threshold
    – This is actually a little different. This threshold coincides with the point where there is a systematic increase in exhaled CO2.
    – This could coincide with the lactic acid (e.g., buffering mechanism).
    – Lactic acid concentrations have exceeded some predetermined levels (e.g., 4 mmol).

• At low __________, lactic acid levels remain low.
  – Evidence suggests that ATP is being produced aerobically.
• At faster running speeds, lactic acid levels increase.
  – Classic: muscles became progressively more anaerobic (i.e., more [La] produced).
  • The point of increase is not always easy to identify and is debatable.
  – Contemporary: [La] is a _____________.

• Lactic acid is used by muscles (the ones producing as well as others), the _________.
• Lactic acid levels are a result of the difference between production and use.
• There is not necessarily a clearly defined _________ of increase in [La].

• Another method for looking at the levels of lactic acid is identifying the speed ___________ at which a specific level of concentration is reached
  – e.g., 2, 3, or 4 mmol/L
• This corresponds to the _________ concept.
Lactate Metabolism

• Lactic acid levels __________________.
• Noakes uses the term ‘_____________’ to represent the exercise intensity at which blood lactate concentrations begin to rise visibly.
  – However, he is careful to note that no threshold exists even though identifying a lactate turnpoint suggest there is a threshold.
  – Lactate levels are a ____________________________.

Biochemical Explanations for Increased Lactate

• At high intensities, ______________ is the main fuel.
• Glucose is oxidized to _______ if NAD is available.
  – If NAD is not available, lactate is produced.
  – _______ is transported out of the muscle cell.
    • To prevent acidic build up in muscle cell?
    • If so, then lactate is benefiting performance.

Lactate Turnpoint

• The exercise intensity (i.e., running speed) associated with the point where lactate begins to rise visually may be ____________
  – Training has the effect of shifting the lactate turnpoint to a higher running speed.
• Determining the lactate turnpoint is time-consuming.
  – It may not offer any increased predictability compared to velocity at VO2max.

Lactate Shuttle

• Brooks:
  – Lactate is an important ________________.
  – Active muscles produce and use lactate at rest and during exercise.
  – Lactate that is produced as an end-product of glycolysis is ____________________________.
    • Released into the blood stream where it can be used by other muscles (e.g., heart, other muscles)
    • Released into the blood stream where it can be used by the liver (production of blood glucose).
  – The lactate turnpoint represents the point where production of lactate ________________.
  – The Lactate Shuttle represents the movement of lactate away from active muscles.
    • Does this represent a mechanism of transport of fuel between cells?

Lactate and Exhaustion

• If lactate is infused into the bloodstream, it has no noticeable effects.
  – It is important to prevent build up of hydrogen ions (and formation of lactate helps prevent this).
• Lactate levels are not necessarily high after prolonged exercise (e.g., marathon).

Lactate Removal after Exercise

• Is lactate a cause of muscle soreness?
• Lactate levels can return to normal levels ________________ post-exercise.
• Muscle soreness can occur after long races in which the intensity is below the lactate turnpoint.
  – Lactate levels are not high.
Metabolic Adaptations to Training

- Main metabolic adaptations:
  - Increased VO2max.
  - Increased capacity to store muscle and liver glycogen.
  - Increased use of fat as fuel.
  - A shift in the lactate turnpoint to a ____________________.

- Causes?

Metabolic Adaptations to Training

- Increased capillarization
  - The number of ______________ surrounding muscle fibers increase with training.
    - Facilitates transport of oxygen and fuel to muscle.

- Glycolytic pathway adaptations
  - Sprint training leads to increase of certain glycolytic enzymes & ability to tolerate high levels of acidity (better buffering capabilities?).

Metabolic Adaptations to Training

- Changes in the mitochondria
  - Increases in ___________________.
    - Increase ability to _______________.
    - Leads to a reduce level of lactate production (at low levels of intensity).
    - Causes a shift of the lactate turnpoint to faster speeds.

- Changes in muscle contractility
  - Does training change the ability of muscle to generate ______?
    - Increased myosin ATPase activity?
    - Enhanced calcium handling?
  - Increased capacity to _______________.
    - Neuromuscular Recruitment Model: increased ability of brain to recruit muscles (e.g., coordination, effectiveness).
    - Short-term training benefits are not from metabolic changes.

Effects of Training and Detraining

- The effect of training can be seen quickly.
  - VO2max can be ________________ of intensive training.
    - To sustain improvements, training frequency, intensity and duration need to be manipulated to increase training volume and intensity.
  - VO2max can decrease quickly with detraining.
  - Detraining and Tapering are different concepts

Heredity Capacity to Adapt to Endurance Training

- Is there a specific gene that leads to superior endurance ability?
- Some sedentary people have high VO2max values (Powers, p 266).
- …pick your parents wisely ….