Running Performance

Chemical Energy \[\xrightarrow{\text{Aerobic}}\] Mechanical Energy

- Development of useful Mechanical Energy
  - Neuromuscular coordination
  - Transforming energy
    - Rate
    - Efficiency

Exercise Intensity

- Exercise intensity during running increases …
  - 
  - 
- The amount of energy transformed from chemical to mechanical increases
  - Aerobically: ATP $\to$ HOH $\to$ CO2
    - $\text{VO}_2$
  - Anaerobically: ATP [La]

Exercise Tests
**VO₂max**

- \( V \)
- \( O_2 \)
- \( \text{Max} \)
- ‘dot’
- \( \text{VO}_2^{\text{max}} \) Maximal rate of oxygen consumption
  - \( \text{ml/kg/min} \)
  - \( \text{L/min} \)

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**Graded Exercise Test**

- vs. Stress test
- Guidelines
  - Mode
    - Running vs. biking
    - Walking vs. running
  - Time
  - Intensity
    - Graded
VO2max

• What does VO2max measure?
• What is its value to athletes?
• Why do people stop exercising at VO2max?

History

— _______________________________

vs.

— _______________________________
Cardiovascular/Aerobic Model

- High intensity exercise is limited by the development of anaerobic conditions in the active muscles.
  - Oxygen delivery to the muscles plateaus forcing the muscles to rely on anaerobic metabolism for energy supply.

Does a plateau exist?

- Plateau observed in 30% of subjects (Noakes 1998b; Doherty et al., 2002).
- Seldom identified in children (Rowland, 1993).

- The __________________ does not imply that exercise can continue indefinitely.
  - Exhaustion is real
- The __________________ that sufficient oxygen is still being delivered to muscles.

Plateau

- If a plateau does exist, that means that __________ flow is being delivered to muscles.
- That means that the heart fatigues before skeletal muscles.
  - Ischemic?
  - Healthy runners do not terminate GXT due to chest pain.
  - …but, there must be some type of protective mechanism to avoid the heart from fatigue.
  - Meaning that the capacity of the heart limits VO2max.
Central Governor Model

- The heart is at the greatest risk of developing ____________ during exercise.
- A ‘governor’ monitors the state of oxygenation of the heart (and maybe other organs such as the brain and diaphragm).
- When ____________ approaches safe limits, the brain is informed and muscle recruitment is altered.
  - Result: Fatigue, exhaustion, pain
  - Individual exercise capacity may be a result of coronary blood flow, heart/skeletal muscle efficiency, contractility, and/or elasticity.
Coronary Circulation

- Cardiac muscle receives oxygenated blood via coronary arteries (originating in aorta) not internally through chambers.
- Deoxygenated blood is returned via coronary veins.
- About 20% of oxygen is extracted from the blood.
- Ischemia: Inadequate blood flow.
- Cardiac Output = ___________ of oxygen is extracted from the blood.

- SV: Amount of blood extracted from the Left Ventrical each beat.

Achieving VO2max

- VO2max:
  - Low work rates combined with inefficient hearts and muscles (poor contractile performance).
    - Inefficient transformation of energy from chemical to mechanical
  - VO2max
  - High work rates combined with efficient hearts and muscles.
    - Produce less heat

Muscle Power Model

- Athletes of differing abilities may differ in contractility performance of individual muscle fibers (regardless of type).
Summary Part 1

• VO2max
  – Plateau or not?
  – Explained by
    • Cardiovascular Model
      – Inability of muscles to receive adequate oxygenation
    • Central Governor Model
      – Protective limit to cardiac muscle
    • Biomechanical Model
      – Differential contractility performance between humans

Factors that affect VO2max

• Age __________________ per decade (after 25 yo)
• Gender ____________________
  – Higher body fat content, smaller muscle mass.
• Fitness and Training
  – Training can increase VO2max __________________
• Altitude
  – VO2max decreases about ___________________ (3280 feet) above 1200 m (4000 feet).
    • LV ~2200 feet
    • Mt Charleston ~8000-10,000 feet
• Ventilatory muscle action

Running Economy
Running Economy

- ml/kg/min for a given speed

Running Economy

- ml/kg/m for a given speed

Running to cover a distance aerobically

Energetic Cost (ml/kg/m)

- Running
- Walking

Hreljac, 1993, MSSE
Holt, Hamill, & Andres, 1991 MSSE
Rate of Oxygen Consumption at a set speed with different stride lengths

- VO2 (ml/kg/min)
- Stride Length

Rate of Oxygen Consumption at different speeds with different stride lengths

- SF changes slightly
- ‘U-shaped’ curve
- Little change in VO2 near PSF.
- PSF important as velocity increases.

Running Economy

- Improved (better, greater) Running Economy = lower VO2 per speed.
Factors that Affect Running Economy

• Running style
  – Up/down movement
  – Biomechanical factors
  – Technique / type of activity

Factors that Affect Running Economy

• Muscle capacity to store energy
  – ________________ (i.e., springs)
  • Tendon, titan, ...

Factors that Affect Running Economy

• Fitness and training
  – People become more economical with training.
    • ________________ without changes in VO2max

• Age
  – Children ________________ runners than adults.
    • But become more economical with age.
      – Training, weight gain, running mechanics, elastic
Factors that Affect Running Economy

• Fatigue
  – Running economy is _______ (e.g., end of a long run).
    • Maybe due to damage to elastic material.
      – Stretch-shortening cycle

• Gender
  – _______ running economy.
    • …but because body composition varies between gender, maybe women would be more economical if this was controlled.

• Ethnicity
  – May be a factor … but _______ or culture effect.
    • African pygmies were about 10% more economical than Caucasians when running but not when walking.

Factors that Affect Running Economy

• Added weight (clothing and shoes)
  – Running economy is influenced by what is worn.
    – _______ has a greater negative effect on running economy.
      • 0.5 kg ______________ increased RE 3.5% 
      • 0.5 kg ______________ increased RE 7.2%
      • ~1% increase in RE ______________.
        – Shoes weigh about 160 g (racing flats) to 310 g (trainer)
        – Orthotics weigh about 80 g
Factors that Affect Running Economy

- Environmental conditions
  - Running uphill
  - Running surface
    - Sand, snow, soft surfaces
      - worse RE
    - "tuned" track?

- Environmental conditions:
  - Wind
    - overcome air resistance
    - 6 m/s or 4 min 30 s a min/mi
    - Drafting reduces energy cost
    - Greatest effect at speeds 18 kph (11.2 mph)
      - Follow within 1 m (i.e., as close as possible)
    - On TM, set grade to 1-2 %

Summary: Part 2

- Running Economy
  - vs. VO2max
- Factors that influence RE
  - Running style
  - Fitness/training
  - Age
  - Fatigue
  - Gender
  - Ethnicity
  - Added weight
  - Environmental conditions
    - Grade, surface, wind