Presentation objectives

1. Definition and importance
2. Relevance for ultra-endurance running
3. Relationship with fatigue
4. Practical applications
   - May, 10th, 10:00 - 10:30 h
   - New training strategies for the improvement of trail runners' running economy, Nicola Giovanelli (Sala 1 / Room 1)

Definitions

Oxygen cost
The volume of O\textsubscript{2} utilized to transport the subject's body over one unit of distance (mLO\textsubscript{2}·kg\textsuperscript{-1}·m\textsuperscript{-1})

Energy cost
The amount of energy spent to transport the subject's body over one unit of distance (Kcal·kg\textsuperscript{-1}·m\textsuperscript{-1} or J·kg\textsuperscript{-1}·m\textsuperscript{-1})

What is the difference?

Oxygen cost
O\textsubscript{2} reflects the quantity of ATP used when the aerobic metabolism provides all of the energy...

Energy cost
Energy released from O\textsubscript{2} depends on the substrate metabolized...
Caloric equivalent of O₂

- Carbohydrates have a greater energy equivalent than lipids
- The increase in carbohydrate metabolism is responsible for the greater energy

Lipids vs Carbohydrates

Peronnet and Massicotte, Can J Sport Sciences, 1991

Peronnet and Massicotte, Can J Sport Sciences, 1991

What is the difference?

Oxygen cost
O₂ reflects the quantity of ATP used when anaerobic metabolism provides all of the energy, but it is unable to account for variations in substrate use.

Energy cost
Energy released from O₂ depends on the substrate metabolized, which presents a better way to assess the energy used during running.

What does it happen with fatigue?

Fatigue
What is it?

Perceived fatigability
Performance fatigability

Homeostasis
Psychological state
Contractile function
Muscle activation

Physical and biochemical changes during exercise that lead to physiological and biomechanical changes.

Fatigue

Energetics

Biomechanics

Based on Ament and Verkerke, *Sports Med*, 2009

---

**Running economy and endurance running**

\[
v_{END} = \frac{E_{\text{max}}}{RE} = \frac{F \cdot VO_{2\text{max}}}{RE}
\]

Modified from di Prampero et al., *Eur J Appl Physiol*, 1986

---

**Determinants of endurance running performance**

Modified from Midgley et al., *Sports Med*, 2007
Energy substrates kinetics

Factors Governing Fuel Selection

What is the implication?

- Decrease efficiency of oxidative resynthesis of ATP, due to a shift of substrate utilization from carbohydrates to lipids
- The energy equivalent of O$_2$ decreases
  - the metabolic energy produced when 1 mL O$_2$ is taken up by the body decreases
Running economy and ultra-endurance running

- To optimize other factors associated with low-intensity endurance
- Runners choose strategies that lead to a deteriorated economy in ultramarathons

Millet et al., J Appl Physiol, 2012

RER and ultra-trail


Does the Running Economy Really Increase after Ultra-Marathons?

Gianluca Vernillo1,*, Grégoire P. Millet2 and Guillaume Y. Millet2

1 Human Performance Laboratory, Faculty of Kinesiology, University of Calgary, Calgary, AB, Canada. 2 CeRMA, Research Centre ‘Sport, Mountain and Health’, University of Verona, Verona, Italy. 3 Institute of Sports Sciences, University of Lausanne, Lausanne, Switzerland

Vernillo et al., Front Physiol, 2017
Methodological limitations

1. Specific conditions of the ultra-marathon need to be considered when designing the study protocol
2. Running economy changes between pre- and post-race should be consistent across individuals
3. Adequate familiarization sessions
4. Inserting a control group to reduce biased interpretations

Determinants of ultra-endurance running performance

Factors affecting running economy

Factors affecting running economy

Physiology
1. Higher utilization of fat as an energy substrate
2. Increased muscle damage
3. Greater neural input to the muscles

Biomechanics
- Increased mechanical cost
- Stride parameters
- Lower limb angles
- Vertical displacement of the body
- Changes in horizontal velocity during ground contact (i.e. braking)
- Trunk and pelvis orientation (i.e. posture)
Determinants of ultra-endurance running performance

1. The intrinsic nature is that of ultra-endurance performance
2. Better understanding of the limits of the adaptive responses of the human body
3. Performance optimization
   - To optimize strategies that lead to a deteriorated economy in ultra-marathons...
   - ...in order to contrast/compensate their deleterious effect of the economy itself

Why is the running economy important in ultra-endurance running?

Relationship EMG levels and VO\textsubscript{2}

1. Greater neural input to the muscle is required to produce the same resultant force
2. Linear relationship between EMG levels and VO\textsubscript{2}
3. Increased neural input to the muscle causes higher demands of VO\textsubscript{2} and a weakened RE

THANK YOU FOR YOUR ATTENTION

Gianluca Vernillo, PhD
gianluca.vernillo@gmail.com