

Physiology Current trends

I. Contribution of the Energy Systems

- A: Energy derived from all three systems simultaneously rather than sequentially (Gastin 2001)
- B. Equal contribution of aerobic and anaerobic energy between 1 and 2 minutes (75 seconds)
 - 1. VO₂ max reached at 45 +/- 11 seconds in 800 meter runners tested on the track (mean velocity 120% VO₂ max) (Thomas et al 2005)
 - a. VO₂ maintained for 33 +/- 6 seconds
 - b. decrease seen in VO₂ max over final 38 +/- 17 seconds of 800
 - 2. Peak VO₂ reached after 75.9 +/- 7.5 seconds in 1500 meter race (mean velocity 107% VO₂ max) (Hanon 2007)

C. Aerobic

- 1. O₂ delivery most important in delaying fatigue ((Hepple 2002)
 - a. does not correspond to blood supply
 - b. determines rate of inorganic phosphate accumulation
 - c. affects calcium release
- 2. O₂ supply paramount (Richardson 1999)
 - a. not limited by capacity of mitochondria
 - b. only in hyperoxia is capacity of mitochondria approached (Richardson 2000)
 - c. decrease in supply results in reduction of VO₂ max
 - d. diffusion gradient from blood to muscle cell
- 3. Central fatigue (Amaan 2007)
 - a. due to interference with central command and/or
 - b. indirectly via inhibitory afferent feedback on central motor drive due to low O₂ transport
- 4. Optimal training intensity to develop VO₂ max in elite runners
 - a. dependent on initial VO₂max (Midgley 2006)
 - b. low intensity sufficient for untrained individuals (40-50% VO₂ max)
 - c. some authors suggest 80-90% VO₂ max
 - d. 95-100% of VO₂ max is current recommendation.

D. Anaerobic

- 1. Peripheral fatigue related to accumulation of metabolic byproducts (Amann) 2007
 - a. inorganic phosphate
 - b. impaired calcium release
- 2. Impaired calcium release from sarcoplasmic reticulum contributes to fatigue (Allen 2007)
 - a. reduced amplitude of action potential resulting from extracellular K accumulation
 - b. reduced effectiveness of SR Ca channel opening
 - c. inorganic phosphate combines with calcium in SR
- 3. Concentration of inorganic phosphate in myoplasm contributes to fatigue (Allen 2001, Westerblad 2002)
 - a. during fatigue stores of Ca in Sr declines which mirrors SR Ca release
 - b. inorganic phosphate moves from myoplasm to SR and causes precipitation of CaP(i)

II. Adaptations

A. Genetic Component

- 1. Untrained muscle (wrist flexors) of elite distance runners demonstrated greater endurance than sedentary controls (Park 1988)
- 2. Untrained Kenyan boys and elite runners demonstrated lower oxygen cost than Caucasian counterparts (Larsen 2003)
 - a. peak VO₂ similar
 - b. muscle fiber type similar
 - c. trainability similar
- 3. Aerobic component

B. Lactate/Anaerobic Threshold

- 1. Fatigue following a 6k run at OBLA was peripheral (Skof 2006)
 - a. impaired excitation-contraction coupling
 - b. twitch torque recovered rapidly
 - c. single MVC slow to recover

III. Recovery

- A. Recovery following high intensity exercise (uphill running.) (Lattier 2004)
 - 1. Passive recovery- no differences
 - 2. Active recovery (50% maximal aerobic speed) no differences
 - 3. Low frequency electrostimulation no differences
- B. Recovery following 5x300 m at 77% peak velocity with 1 minute active rec. (Skof 2006)
 - 1. Fatigue was peripheral caused by contraction mechanism disturbances
 - 2. Subjects with high lactates demonstrated considerable decrease in twitch torque at low levels of stimulation
 - 3. Twitch torque recovered rapidly
 - 4. Exceeded pre exercise values by 11% at 10 minutes recovery
 - 5. Potentiation lasted until 40th minute of recovery

IV. Running economy

- A. Speed at which subject tested determines which runner most economical Daniels 1992
 - 1. long distance runners more economical at slower speeds
 - 2. middle distance runner more economical at faster speeds
- B. Kenyan elite runners and untrained boys more economical than Caucasian (Larsen 2003)

V. Training

- A. Basis for high intensity interval training (4 protocols for 4 weeks in 38 cyclists) (Laursen 2005)
 - 1. increased ventilatory threshold
 - 2. increased peak VO₂
 - 3. increased Anaerobic capacity
 - 4. no increase in plasma volume
 - 5. changes peripheral rather than central
- B. Review of changes following HIT (Laursen 2002)
 - 1. Improved endurance performance
 - 2. no changes in glycolytic enzymes
 - 3. no changes in aerobic enzymes
 - 4. may be due to increased buffering capacity
- C. Manipulating training
 - 1. Different HIT programmes needed for varying levels of fitness (Esfarjani 2007)
 - 2. HIT at V.VO₂ max for 60% of time at T(max) needed for elite runners
 - 3. Athletes performing above 90% VO₂ benefited more from IT at 105% of vVO₂ max than IT at 100% vVo₂ max (Millet 2003)
- D. Interval training vs. traditional endurance training
 - 1. Intensive cycle intervals 6x30 seconds" all out" equal to 90-120 continuous cycling (Gibala 2006) (untrained subjects)
 - 2. similar increases in muscular oxidative capacity
 - 3. no differences in decrease of muscle glycogen

VI. Warm Up

- A. Warm up with slow running, bounding and stretching and sprinting (Skof 2007)
 - 1. maximal torque twitch increased
 - 2. twitch contraction time shortened
- B. Warm ups with slow running and stretching
 - 1. muscle activation: no significant change
 - 2. twitch contraction time: no significant change

VII. Resistance training

- A. Trained distance runners have seen an 8% improvement in RE following resistance training
 - 1. possibly due to improved motor unit recruitment
 - 2. possibly reduced ground contact time
- B. Not expected to improve VO₂ max
 - 1. may improve LT in untrained
 - 2. unlikely in trained
- C. Plyometrics
 - 1. a six week training program utilizing plyometrics resulted in improved 3k performance
 - 2. improved running economy

3. improved 3k time (2.7%)
 4. No change in VO2 max
 5. no change in lactate threshold
- C. Significant increase in lower leg musculotendinous stiffness
1. increased counter movement jump
 2. improved 5 bound test

VIII. Flexibility

- A. Running economy negatively related to sit and reach test performance in elite distance runners (Jones 2002)
1. least flexible runners most economical
 2. stiffer musculotendinous structures reduce aerobic demand
 3. this reduced demand due to greater elastic return during shortening phase