ALTITUDE, HYPOXIA, EXERCISE AND TRAINING. How we are interesting in?

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ALTITUDE ZONES

8848m
Extreme
PiO₂ = 73-43

5500m
High
PiO₂ = 96-73

3000m
Moderate
PiO₂ = 124-92

1500m
Low
PiO₂ = 150 Torr

0m

Hypoxia
↓ PiO₂
↓ PAO₂
↓ PaO₂
Disruption in homeostasis
Adjustments in cardiovascular, respiratory, endocrine systems

Roach & Kayser
LOW ALTITUDE

• Athletic performance is not significantly reduced.

• In spite of normoxic conditions a certain decrease of arterial oxygen saturation occur during high intense exercise in certain types of exercise (sport events).

• Special interest in muscle deoxygenation occur due to regional hypoxia during isometric interval of muscle contraction, which may cause fatigue.
A two channel Near Infrared Spectroscope (NIRS)
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• Alpinists showed more oxygenated forearm muscles during less intense isometric contraction, were occlusion is not significant.

• Alpinists have more oxygenated forearm muscles also during intense forces, where occlusion dramatically reduced blood flow.
MODERATE ALTITUDE

- Performance of sportsmen significantly reduces.
- Arterial reduction of oxygen saturation caused increase of ventilation (HVR) and heart rate.
- Exercise induced arterial hypoxia (EIAH) increased and caused significant muscle and brain deoxygenation.
- Acclimatization during climbing in such environment became important.
Alpinists have not dramatic problems in their performance. They do not compete by principle: *citius, altius, fortius*. They regulate their movements to secure the goal of climbing: *reaching the summit*.

**Reduced intensity** of their activity

- Technical equipment and group work
- Extreme solo climbing (free climbing)

Subjects with **lower body weight** can produce similar absolute force but higher relative force (per BW).

Subjects with **higher strength and general endurance performance** can perform better.
Gros Natalija

**Čas:**
- **mar.08:** 398
- **nov.08:** 372
- **apr.09:** 387

**Tel. Masa:**
- **mar.08:** 50
- **nov.08:** 51
- **apr.09:** 50

**O2 ex:**
- **mar.08:** 6,5
- **nov.08:** 6,436
- **apr.09:**

**CO2ex:**
- **mar.08:** 4,164
- **nov.08:** 5,494
- **apr.09:**

**O2rec:**
- **mar.08:** 1,817
- **nov.08:** 1,667
- **apr.09:**

**CO2rec:**
- **mar.08:** 1,52
- **nov.08:** 2,232
- **apr.09:**

**ΔLA:**
- **mar.08:** 4,1
- **nov.08:** 3,7
- **apr.09:** 5,4

**ΔFS:**
- **mar.08:** 186
- **nov.08:**
- **apr.09:**

**ΔVo2/t:**
- **mar.08:** 0,24048
- **nov.08:** 0,1603
- **apr.09:**

**ΔVco2/t:**
- **mar.08:** 0,16048
- **nov.08:** 0,2028
- **apr.09:**

**ΔVe/t:**
- **mar.08:** 7,53769
- **nov.08:** 7,58065
- **apr.09:** 7,2868

**ΔLA/t:**
- **mar.08:** 0,61809
- **nov.08:** 0,59677
- **apr.09:** 0,5891

**ΔFS/t:**
- **mar.08:** 16,7337
- **nov.08:** 15,659
- **apr.09:**
Training for better performance at moderate altitude & acclimatization

- Continuous, prolonged exercise
- Intermittent (interval) exercise

Valid only for responders?

Altitude training

- Continuous acclimatization at altitude for > 3 wks
- Intermittent acclimatization at altitude with interruptions (? Days) of sea level.
SPECIFIC INTEREST FOR TRAINING OF MOUNTAIN SOLDIERS

ENDURANCE

- Aerobic power
- Strength endurance (dynamic & static)
- Extreme endurance
- Reduced nutrition
- Extreme temperatures
Characteristics of specific military operation.

Characteristics of soldiers available.

**SELECTION**

- Limiting training period.
- Specific training strategy
- Individual approach to increased performance
INDIVIDUAL TRAINING

• Estimation of real time performance (testing)
• Estimation of training characteristics
• Planning based on realised training and results of training

TEAM TRAINING

• Detecting of differences in performance of subjects in the group.
• Strategy of the whole group training, dependent of the goal of operation and time left to start of operation.
SPECIFIC INTEREST FOR ASCERTAIN EFFECTS ON CARBOHYDRATE AND FAT METABOLISM RELATED TO ADAPTATIONS ON:

- altitude & hypoxia
- endurance training
- nutritional manipulations
HIGH ALTITUDE
$PO_2$ differences remains also after acclimatization.

- $SaO_2$, $Eri$, $Hb$, $Hct$
- $CaO_2$ (Arterial blood $O_2$ content)

- muscle mass & capilarization
- mitochondrial density
- $oxydation$
- phosphorylation ($ADP \rightarrow ATP$)

P.O. Astrand: Textbook of Work Physiology
ESTIMATION OF ACCLIMATIZATION

Exercise testing before, during and after altitude or normobaric hypoxia by using:

- treadmill and/or cycle ergometers
- normoxic and hypoxic conditions
Acute normobaric hypoxia testing during low or moderate exercise intensities.
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SPECIFIC INTEREST FOR TRAINING OF MOUNTAIN SOLDIERS

- PREACCLIMATIZATION
- ACCLIMATIZATION
- DEACCLIMATIZATION
- REACCLIMATIZATION

- In “REAL” environment (activities in mountains)
- In “SIMULATED” environment - passive or active living in “NITROGEN HOUSES”.
EXTREME ALTITUDE
Up to date we have ascertained:

• Response of organism during incremental exercise testing before and after high-altitude alpinist expeditions:
  • For estimating possible training effect.
  • Whether the training effect remained also after a month after returning from expedition (detraining).
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• Response of organism during incremental exercise testing before and after high-altitude alpinist expeditions when subjects were exposed to normoxic and hypoxic conditions.

• For estimating possible training & acclimatization effect.
• Whether the training & acclimatization effects remained also after a month after returning from expedition (deacclimatization).
Institute Jožef Stefan Laboratory
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Kandare Franc
Kapus Nejc
Štrumbelj Boro
Cukjati Iztok
Rant Tomaž
Burnik Stojan

Big Boss
Thank you