Hormonal Regulation of Acute and Chronic Adaptations: *Resistance vs. Endurance Exercise*

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Current Research and Future Perspectives in Exercise Physiology 2017

Dedication

I began corresponding with Professor Viru in the 1980’s, moved to working with him in Tartu in the 1990’s …

Today I get to continue work with his younger protégées …

Professor Vahur Ööpik, Dr. Mehis Viru, and Dr. Martin Mooses

Over 20 years of coming to Tartu University and working with the faculty in the exercise sciences

Some have changed with age

Images not to scale

Topic today …
Exercise

- Power stimulant to physiological adaptation
- Invokes a multitude of plasticity responses
  - Molecular
  - Cellular
  - Tissue and organ

Exercise effects acute → chronic...
Training: Stimulus – Response Model

With the appropriate stimulus ("overload") we are able to have a physiological overcompensation that leads to adaptation and the potential for improved performance.

If training done correct – continued positive adaptation

Exercise

- Power stimulant to physiological adaptation
- Invokes a multitude of plasticity responses
  - Molecular
  - Cellular
  - Tissue and organ
- Variety of signaling mediators and moderators of these processes in response to exercise
Exercise

Acute
"Single Session"

Chronic
"Training"

Signaling

Non-Genomic

Genomic

Signaling Effects

**Mechanotransduction**

Refers to the processes through which cells sense and respond to mechanical stimuli by converting them to biochemical signals that elicit specific cellular responses.

**Hormones**

... chemical mediators and moderators of adaptation with exercise having endocrine, paracrine and autocrine actions

... a focus of Professor Atko Viru’s research pursuits

**Signaling Effects**

What happens at the cellular level?

- Non-genomic
- Genomic
Non-genomic …

Interaction – Non-genomic more than one pathway

Hormones

Genomic – classic, not all hormones

Hooper et al. Sports Medicine 2016

Delimitation …

Anabolic Effects

Hormones

... too much to discuss on this topic in 45 minutes, we could have an entire conference on just this alone

Pick and choose

Delimited focus

• Testosterone
• Growth Hormone
• IGF-1
• Insulin

• Cortisol

There are a multitude of other hormones. These are, however, the prevalent ones seen addressed in the literature
Testosterone

Anabolic
Non-genomic & Genomic

Generalized representative responses

Hackney et al. 1990

60 min; Moderate, High Intensity, Control


Galbo et al. 1979

Hackney et al. 1990

6 sets of the squat exercise at 80% 1 RM

Judelson et al. J Appl Physiol 1990; 120:01A-621
Growth Hormone (GH)

Anabolic
Non-genomic

Kraemer et al. 2009


CROSS SECTION DESIGN
6 sets of the squat exercise at 80% 1 RM

Insulin-like Growth Factor-1

Anabolic
Non-genomic
CROSS SECTION DESIGN

Exercise < VT

Exercise > VT

Single

6 sets of the squat exercise at 80% 1 RM

Supplement = β3-Butyrate + EAA
Placebo = Iso-caloric, nitrogen (NEAA)

Inulin

Anabolic
Amino Acids Uptake

Kraemer et al. 2009
Hackney et al. unpublished

Winder et al. J Appl. Physiol. 1979


Tarpenning et al. 2001

6 sets of the squat exercise at 80% 1 RM
Cortisol

Anti-Anabolic
Non-genomic & Genomic

Exercise 60 min; Moderate, High Intensity, Control

Training

60 min; Moderate, High Intensity, Control


6 sets of the squat exercise at 80% 1 RM

Hackney & Kelly 2017

Hackney et al. J Sport Sci 1993

Hackney & Kelly 2017
Effecting Factors

Exercise Stress – the interaction of intensity, volume, rest interval length, muscle mass involvement, muscle actions, & motor units recruited

Plasma volume shifts & changes in tissue blood flow

Training status & body fat

Nutritional intake & hydration

Genetics

Acute vs. chronic

Hormone Interactions

Protein synthesis

MAPK

tOR

MurF1

Atrogin-1

Akt

FOX01/3

Amplification

Synergistic

Hormone Interactions

Direct stimulatory effect

Indirect stimulatory effect

Inhibitory effect

These factors can influence and affect aspects of the Acute and Chronic hormonal responses to exercise

Tarpenning et al. 2001
Hormonal Effect - Outcome

- # target cell expressing receptors
- # functional receptors
- affinity level of receptors for hormone
- post-receptor amplification mechanisms

TARGET TISSUE \[\uparrow\text{Physiological Processes}\]

Training improves many aspects of the "down-stream" factors that affect hormonal outcomes

Down Stream Events

... are critical in affecting hormonal influence of EE towards mitochondrial biogenesis or RE towards contractile protein synthesis

Future
Summary

• EE and RE both invoke hormonal responses
  – proportion to intensity and duration (magnitude differences)
• EE and RE training attenuates most responses, but not all
• EE hormonal influence → mitochondrial biogenesis
• RE hormonal influence → contractile proteins
• EE and RE responses are affected by multitude of environmental and behavioral factor
• Hormonal interactions → amplify & synergistic acting
• “Down-stream” events help determine magnitude of hormonal influence

Take Home Points: Coaches & Athletes

• Hormone balance and + endocrine function:
  – Health is critical
  – Energy intake and caloric composition is important
  – Nutritional supplements can aid (caution-doping)
  – Rest, recovery and regeneration are necessary
  – Endocrine system aging ...

Thank You

Aitäh

Paldies

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Extra Slides

**GH Response**

- **Feeding Effect**
  - Variable response
  - Hyperglycemia → ↓
    - Rebound effect
  - AA select → ↑
  - Fatty acids → ↓
  - Mixed meal → ↓↑
  - Delayed response

- **Exercise Effect**
  - Intensity threshold
    - ≥ 50-60% VO₂max
  - Endurance ↑
  - Resistance ↑
  - Delayed response
  - Training ↓

AA = Amino Acids

**IGF-1 Response**

- **Feeding Effect**
  - Glycemia → NE
  - AA → NE
  - Fatty acids → NE
  - Mixed meal → NE

- **Exercise Effect**
  - Intensity threshold
    - ?
  - Endurance ↑
  - Resistance ↓↑
  - Training ↑↓

NE = No Effect

**Testosterone Response**

- **Feeding Effect**
  - Glycemia → NE, ↓
  - Protein → ↓↑
  - Fatty acids → ↓
  - Mixed meal → ↓
    - Fat dependent

- **Exercise Effect**
  - Intensity threshold
    - ≥ 60% VO₂max
  - Endurance ↓
  - Resistance ↑
  - Training ↓
Insulin Response

- Feeding Effect
  - Hyperglycemia → ↑
  - AA select → ↓
  - Fatty acids → ↑
  - Mixed meal → ↑↓

- Exercise Effect
  - Intensity threshold
    - ≥ 40% \( \text{VO}_{2\text{max}} \)
  - Endurance ↓
  - Resistance ↑↓
  - Training ↑↓

Cortisol Response

- Feeding Effect
  - Variable
  - Diurnal / Adiposity
  - Hyperglycemia → ↓↑
  - Rebound effect
  - Protein → ↑
  - Fatty acids → NE
  - Mixed meal → ↑

- Exercise Effect
  - Intensity threshold
    - ≥ 60% \( \text{VO}_{2\text{max}} \)
  - Endurance ↑
  - Delayed effect
  - Resistance ↑
  - Training ↓
  - Excessive ↑

Comparison of Other Hormones

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<thead>
<tr>
<th>Hormone</th>
<th>EE</th>
<th>RE</th>
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<td>Adrenocorticotropic hormone</td>
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<td>Insulin</td>
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<td>Growth hormone</td>
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Comparison of Other Hormones

Competitive Stress

Time to Exhaustion (min) at 100-110% VT
96.9 ± 10.8 (82.7 – 118.9)

Competitive scenario

Lane, Anderson & Hackney. EJAP 2016
Mean Data Only (n=27)

Exercise

Delayed Effect

CORTISOL (nmol/L)

HOURS

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

Exposure to physical activity and exercise can have an immediate and sustained effect on cortisol levels. The figure above illustrates the temporal and recovery relationships of cortisol levels following exercise. The green line represents the control (CON) group, the red line represents the anaerobic (ANA) group, and the blue line represents the aerobic (AER) group. The AUC (Area Under the Curve) is used to quantify the time-weighted average of cortisol levels over the exercise period.

Key Observations:
- Exercise-induced cortisol responses are immediate and sustained.
- The AER group shows a more pronounced delayed effect compared to the other groups.
- The recovery phase shows a gradual decrease in cortisol levels across all groups.

Further research is needed to understand the mechanisms behind these effects and their implications for health and performance.