Energy Deficiency and Nutrition in High Performance Sports

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I just burned 2,000 calories

That’s the last time I leave brownies in the oven while I take a nap.
Overview

1. Introduction & Definitions
   • Energy Balance and Energy Deficiency in Athletes

2. Consequences of Energy Deficiency
   • Endocrine and Metabolic Effects
   • Performance Effects

3. An Example from the Rowing World

4. Possible Counterstrategies
   • Exercise Strategies
   • Dietary Strategies
Energy Expenditure in High Performance Sports

Normal Population (n=173)

- **Swimmers**: 2.0 – 2.7
- **Dist. Runners**: 1.8 – 2.8
- **LW Rowers**: 2.85 ± 0.9
- **XC-skiers**: 3.4 – 4.0
- **Road Cyclists**: 3.5 – 5.5

*Hill & Davies, 2002

Black et al., 1996; Westerterp et al., 1986; Sjödin et al. 1986

Westerterp, 2001
Exercise and Energy Balance in Sports

Meeting energy needs is a nutrition priority for athletes. […] Energy balance occurs when energy intake […] equals energy expenditure […].”

ACSM Position Stand on Nutrition and Athletic Performance (2009)

Is energy balance really the goal of athletes?
Energy Balance

Energy Intake

Exercise Expenditure

Non-Exercise Activity Thermogenesis

Resting Metabolic Rate

Energy Expenditure
Pathways to Energy Deficiency

Reduced Intake

• Weight limitations (lightweight rowing)
• Endurance sports
• Anti-gravity sports
• Aesthetics
• Disordered Eating
• Eating Disorders

Increased Expenditure

• Energy turnover ↑
• Muscle mass ↑
Energy Imbalance in Sports

Energy Intake

Exercise Expenditure

Non-Exercise Activity

Thermogenesis

Resting Metabolic Rate

$\Delta E^{total} = \Delta E^{kinetic} + \Delta E^{potential} + \Delta U$

Weight loss
Return to Equilibrium – Energy Conservation

\[ \Delta E^{total} = \Delta E^{kinetic} + \Delta E^{potential} + \Delta U \]
Energy Balance is a Moving Target

Loucks, 2007

Energy Intake

Exercise Expenditure

Energy Balance

Loucks, 2007
Using RMR to Quantify Energy Conservation in Athletes

**Indirect Calorimetry**

**Whole-Body Imaging**

\[
RMR_{\text{meas}} \quad \text{vs.} \quad RMR_{\text{pred}} = \sum_{i=1}^{n} k_i \times T_i
\]

- Skeletal Muscle
- Brain
- Organs
- Adipose Tissue
- Bone
- Residual
Quantifying Energy Conservation in Athletes

Female Athletes:
Exercise-Associated Menstrual Disturbances

Koehler et al., AJP Endo Metab 2016
Key Metabolic Hormones are Suppressed in ED State

Leptin:
- Signals energy status

T3:
- Thyroid hormone
- Involved in RMR

GH:
- Growth hormone

IGF-1:
- Insulin-like growth factor
- Anabolic effects on bone and muscle
- Stimulated by GH

Cortisol:
- Stress response

Insulin:
- Anabolic effects
- Muscle glycogen storage

Loucks & Thuma 2003
Energy Deficiency Creates a State of Semi-Starvation

- Energy Deficiency → ↓ Leptin
- ↓ Leptin → ↓ T3/T4
- ↓ T3/T4 → ↓ IGF-1
- ↓ IGF-1 → ↓ Insulin
- ↓ Insulin → ↓ Androgens/
- ↓ Estrogens
- ↑ Ghrelin
- ↑ Cortisol
- ↓ Leptin
- ↓ Insulin
- ↓ Androgens/
- ↓ Estrogens
- ↑ Ghrelin
Energy Deficiency Creates a State of Semi-Starvation

- ↓ Bone formation
- ↑ Bone resorption
- ↓ Cortisol
- ↓ IGF-1
- ↓ Insulin
- ↓ Androgens/Estrogens
- ↑ Ghrelin
- ↑ Protein Synthesis
- ↑ Protein Breakdown

Shapses 2012; Locher 2016; Carbone 2014; Pasiakos 2014;
Energy Deficiency – Impacts on Performance

Young elite swimmers, 12-wk training

Two groups:
- MD: Menstrual Disturbances
- Reg: Regular Menses

Energy Intake: ~30%↓ in MD

Energy Availability:
- MD: ~10-12 kcal/kg FFM
- Reg: ~30-37 kcal/kg FFM

Van Heest et al. 2014
2015 Australian Rowing Team
4-wk Intensified Training:
1600 – 2000 T2 minutes (+20-50%)

△ Body Weight: -1.6 kg (2%)
△ Fat Mass: -2.2 kg (-18%)

Woods et al, PLOSone 2017
Possible Counterstrategies

Working Hypothesis:
**Exercise + high protein** can shift weight loss

Away from lean tissues
- Skeletal Muscle
- Bone

Further towards fat loss

*Murphy & Koehler, 2017*
Working Model: Acute CR Intervention

- Controlled Exercise (60% VO$_{2peak}$)
- Controlled Diet (CR or EB)
- Functional Tests (Strength, Fat Ox, VO$_{2peak}$ etc.)
- Body Composition
- Blood
An appropriate energy intake is the cornerstone of the athlete’s diet because it supports optimal body function […]

ACSM Position Stand: Nutrition and Athletic Performance (2016)

• Your team nutritionist/dietician is right worrying about calories

• Weight is not a good measure of energy status
  • Metabolic adaptations = energy conservation
  • Suppression of non-vital functions (growth)

• Evidence of performance decrements

• Counterstrategies: Exercise & High Protein?
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Thank you for your attention!

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