Energy Deficiency and Nutrition in High Performance Sports

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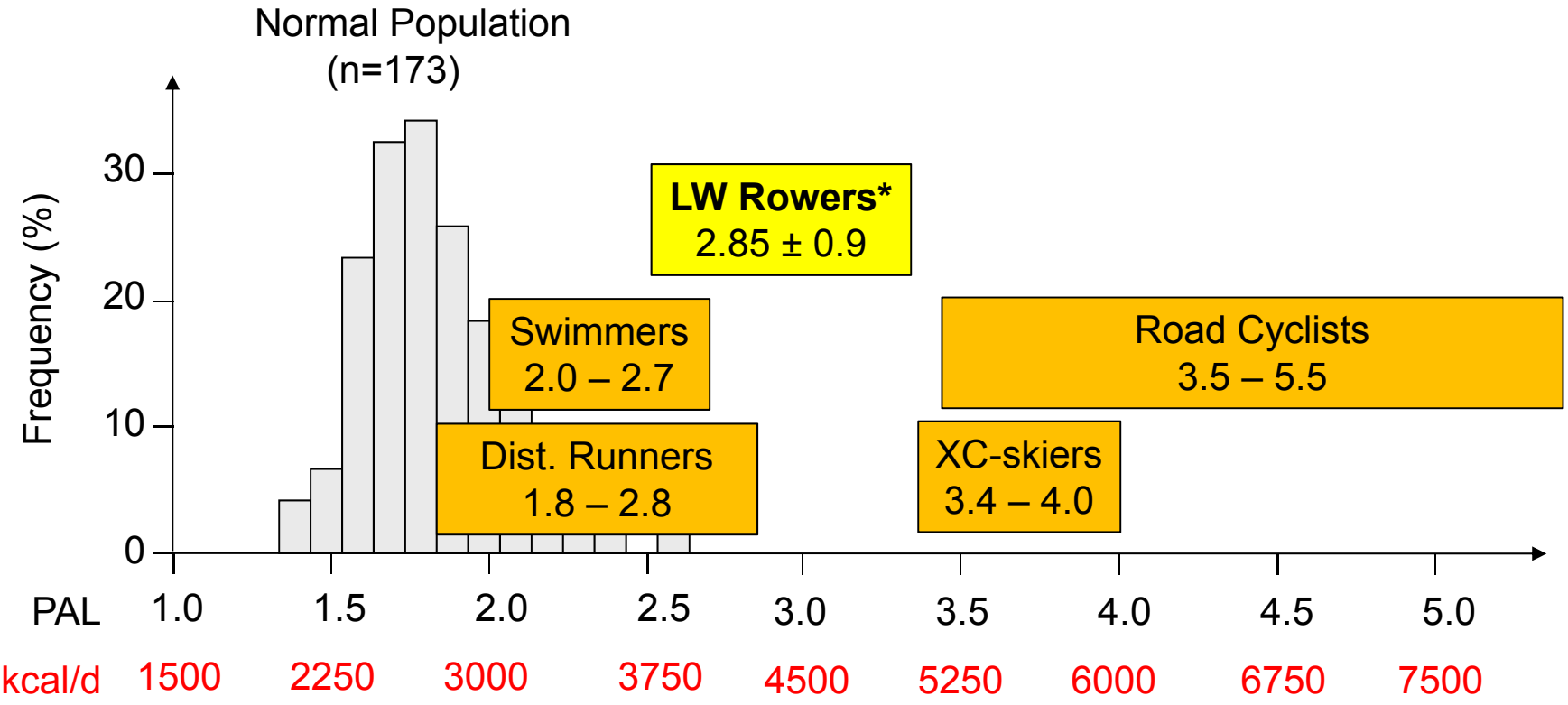
I just burned
2,000 calories
That's the last time I leave brownies
in the oven while I take a nap

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



Westerterp, 2001

***Hill & Davies, 2002**

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

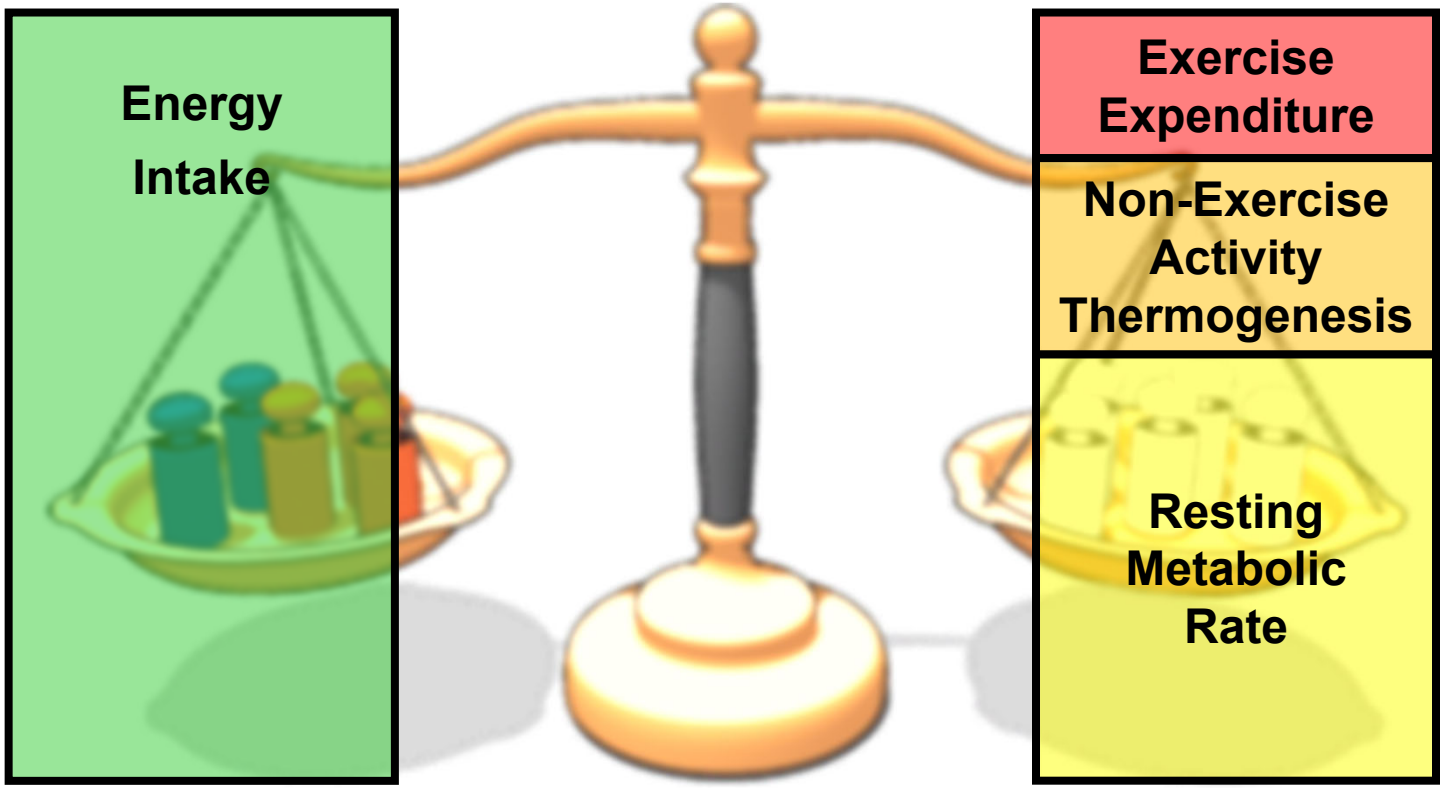
Exercise and Energy Balance in Sports

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 <u>energy balance</u> really the goal of athletes?

Energy Balance

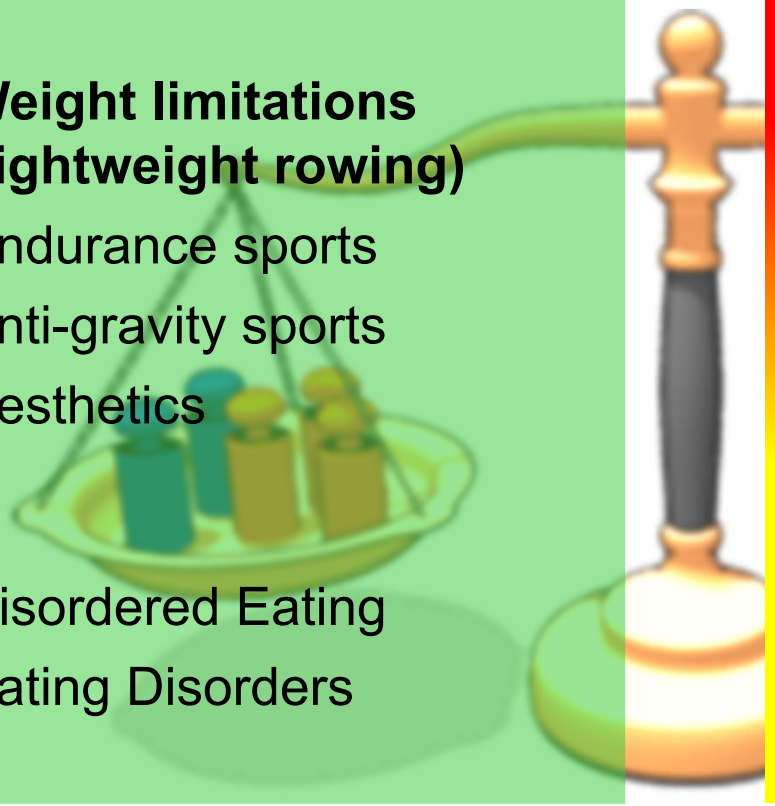


Pathways to Energy Deficiency

Reduced Intake

- **Weight limitations (lightweight rowing)**
- Endurance sports
- Anti-gravity sports
- Aesthetics

- Disordered Eating
- Eating Disorders

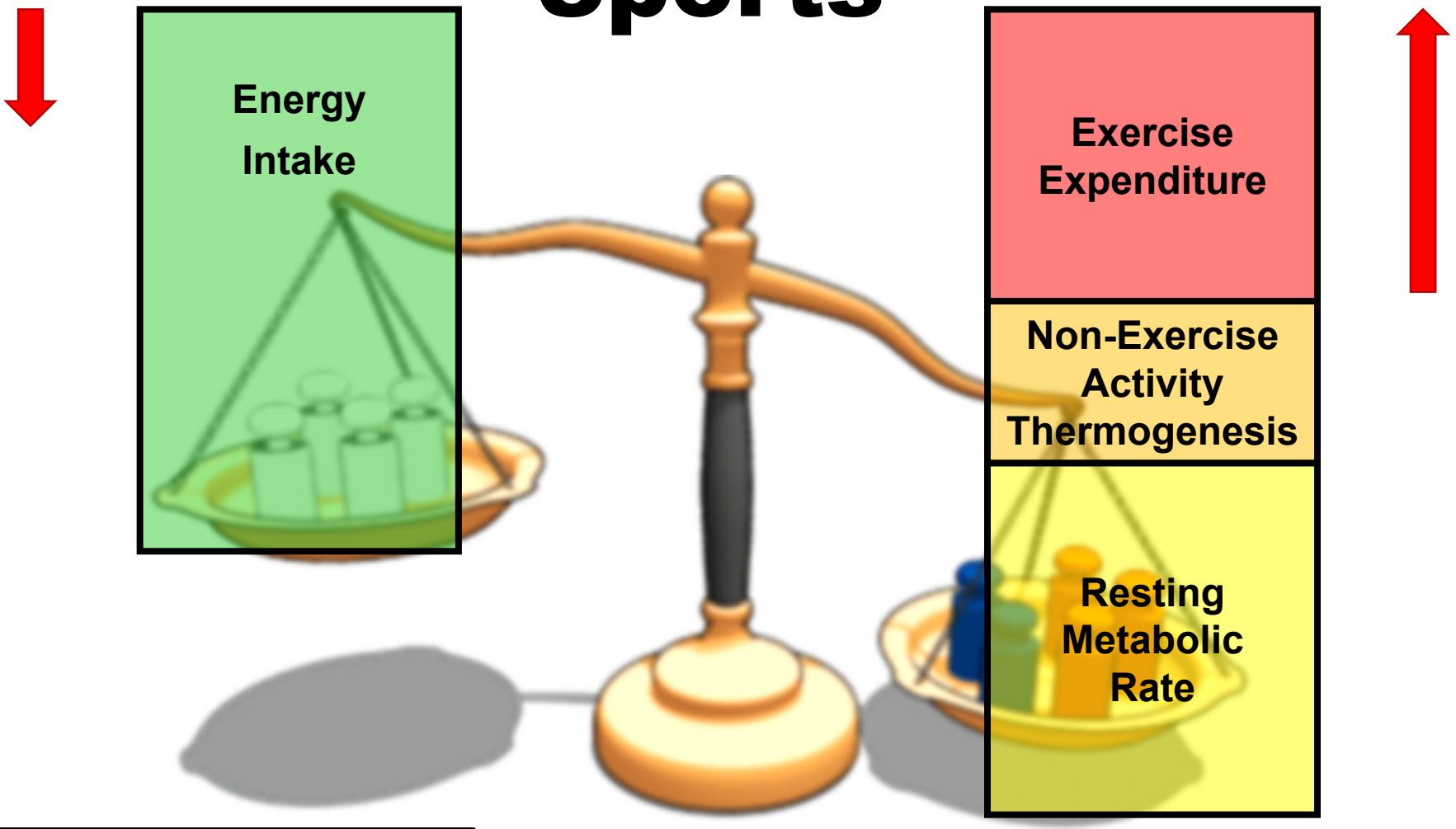


Increased Expenditure

- **Energy turnover ↑**

- **Muscle mass ↑**

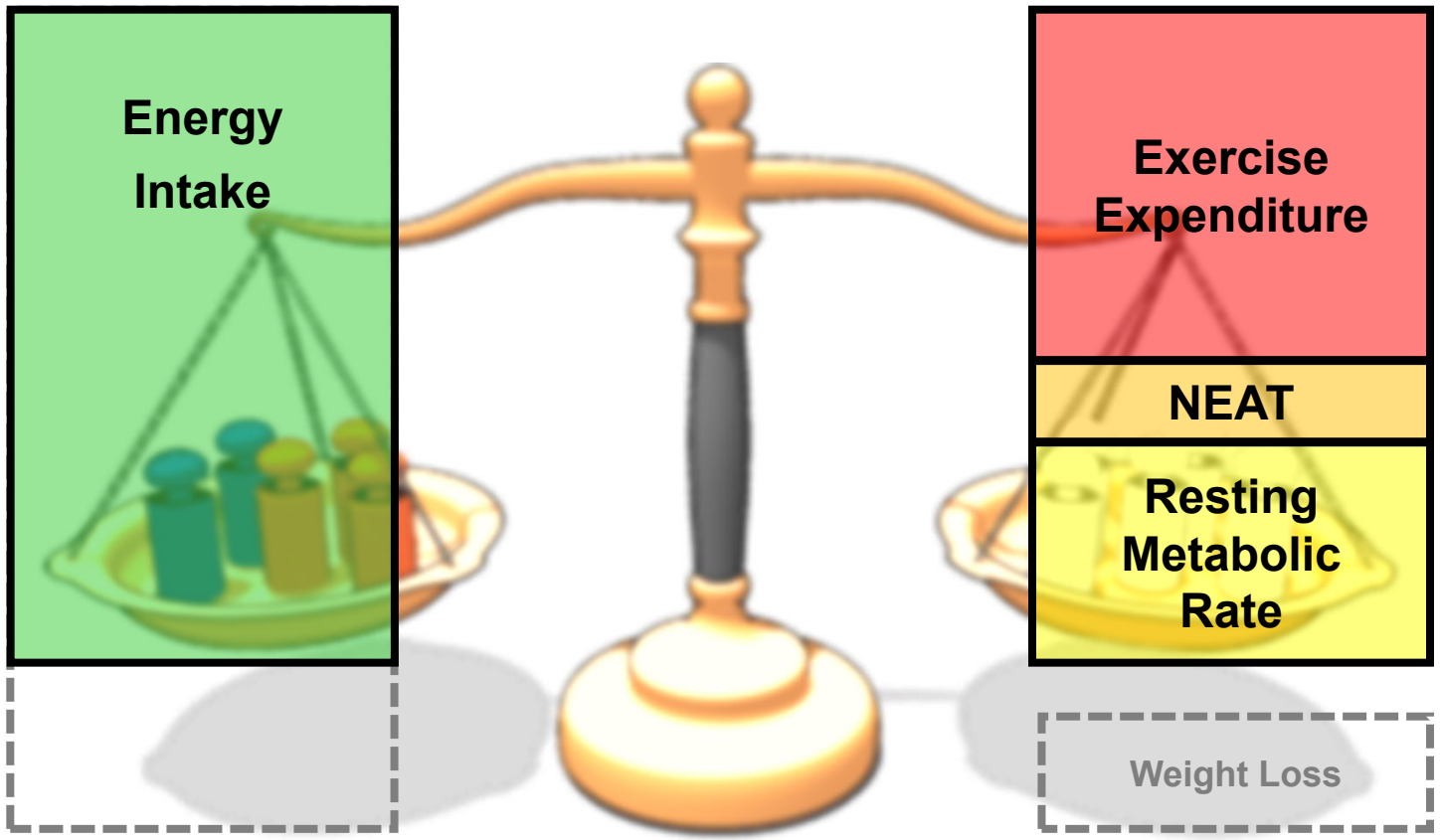
Energy Imbalance in Sports



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

Weight loss

Return to Equilibrium – Energy Conservation

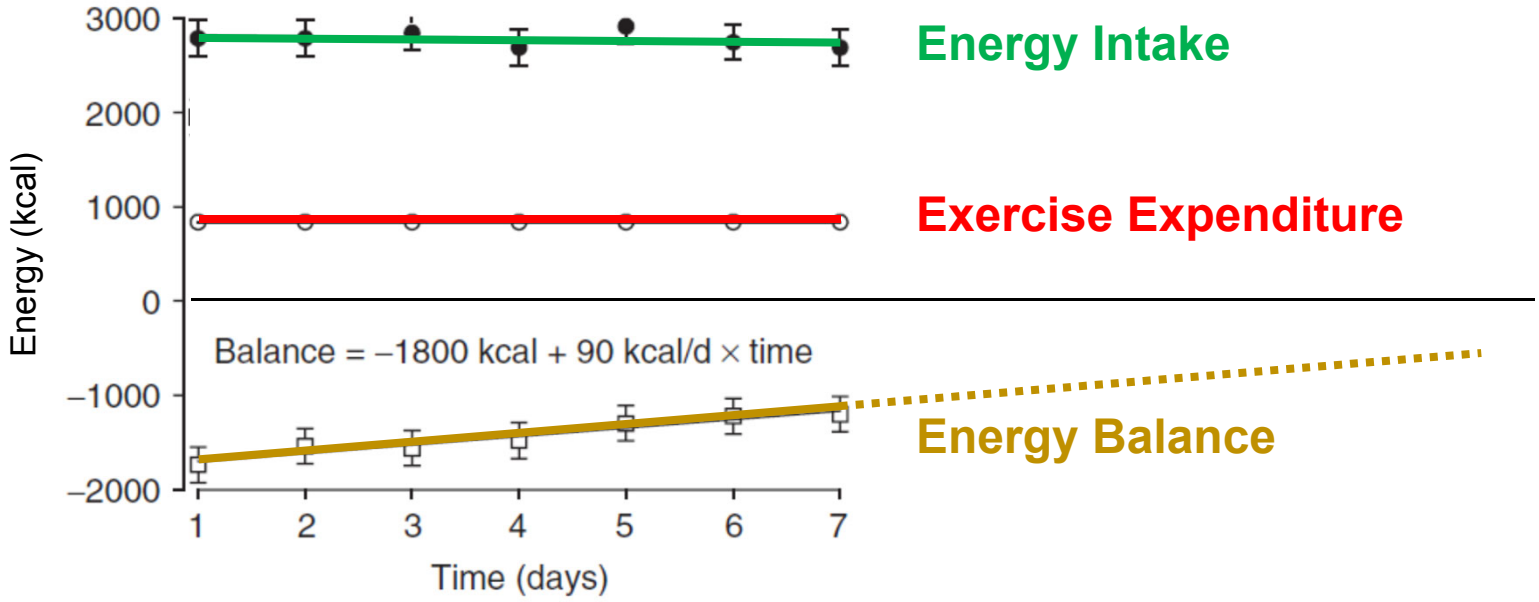


$$\Delta E^{total} = \Delta E^{kinetic} + \Delta E^{potential} + \Delta U$$

Weight Stability

Energy Expenditure

Energy Balance is a Moving Target

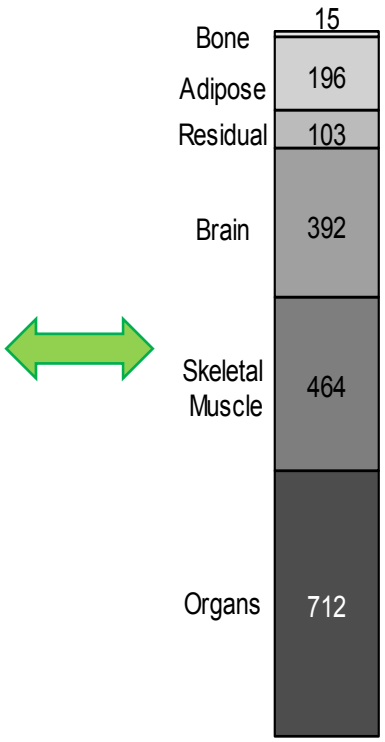


Loucks, 2007

Using RMR to Quantify Energy Conservation in Athletes

Indirect Calorimetry

Whole-Body Imaging

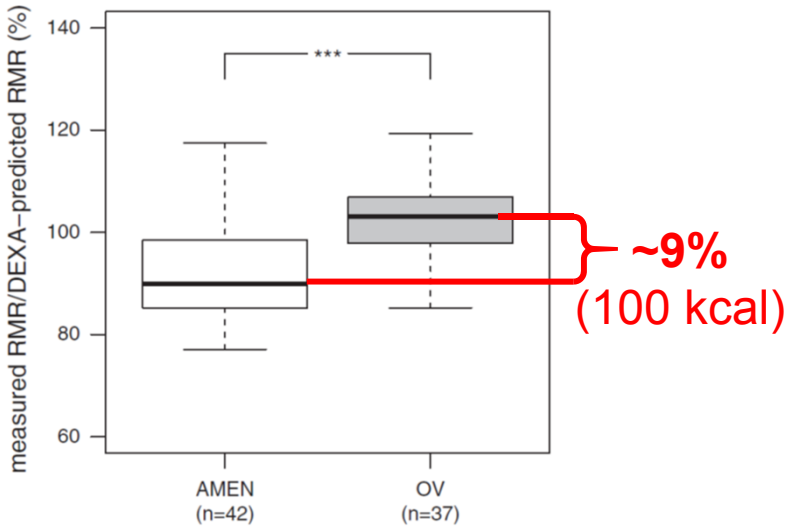


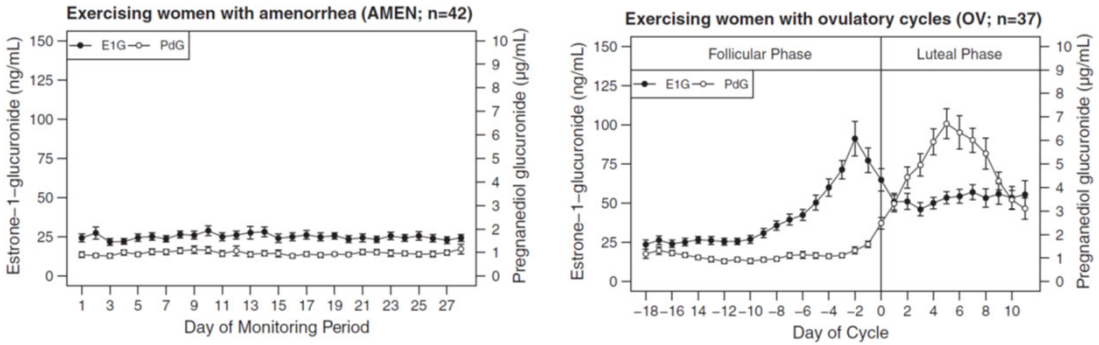
$$\text{RMR}_{meas} \quad \text{vs.} \quad \text{RMR}_{pred} = \sum_{i=1}^{n} k_i \times T_i$$

- Skeletal Muscle
- Brain
- Organs
- Adipose Tissue
- Bone
- Residual

Quantifying Energy Conservation in Athletes

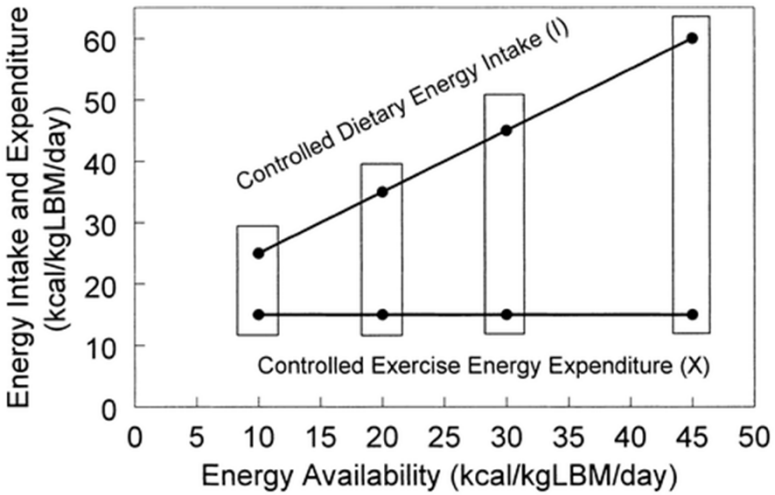
Female Athletes:
Exercise-Associated Menstrual Disturbances

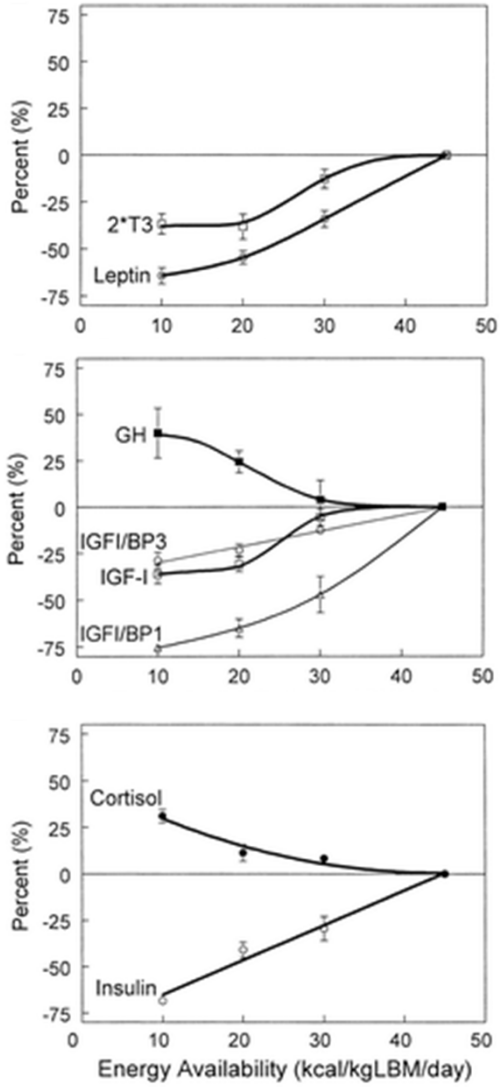




Koehler et al., AJP Endo Metab 2016

Key Metabolic Hormones are Suppressed in ED State





Leptin:
- Signals energy status

T3:
- Thyroid hormone
- involved in RMR

GH:
- Growth hormone

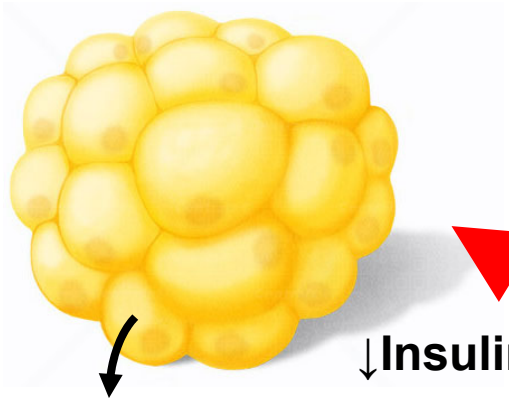
IGF-1:
- Insulin-like growth factor
- Anabolic effects on bone and muscle
- Stimulated by GH

Cortisol:
- Stress response

Insulin:
- Anabolic effects
- Muscle glycogen storage

Loucks & Thuma 2003

Energy Deficiency Creates a State of Semi-Starvation



↓Leptin

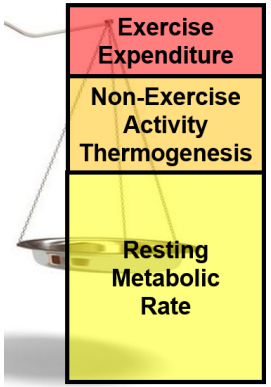
↓Insulin

↑Cortisol

↓T3/T4

↓Androgens/
↓Estrogens

↓T3/T4



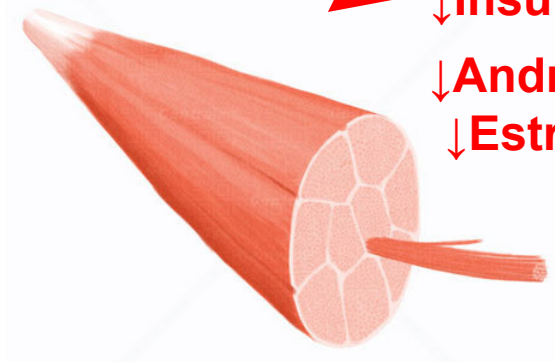
Energy Expenditure

Energy Deficiency

↑Cortisol

↓IGF-1

↑Ghrelin



↓Insulin

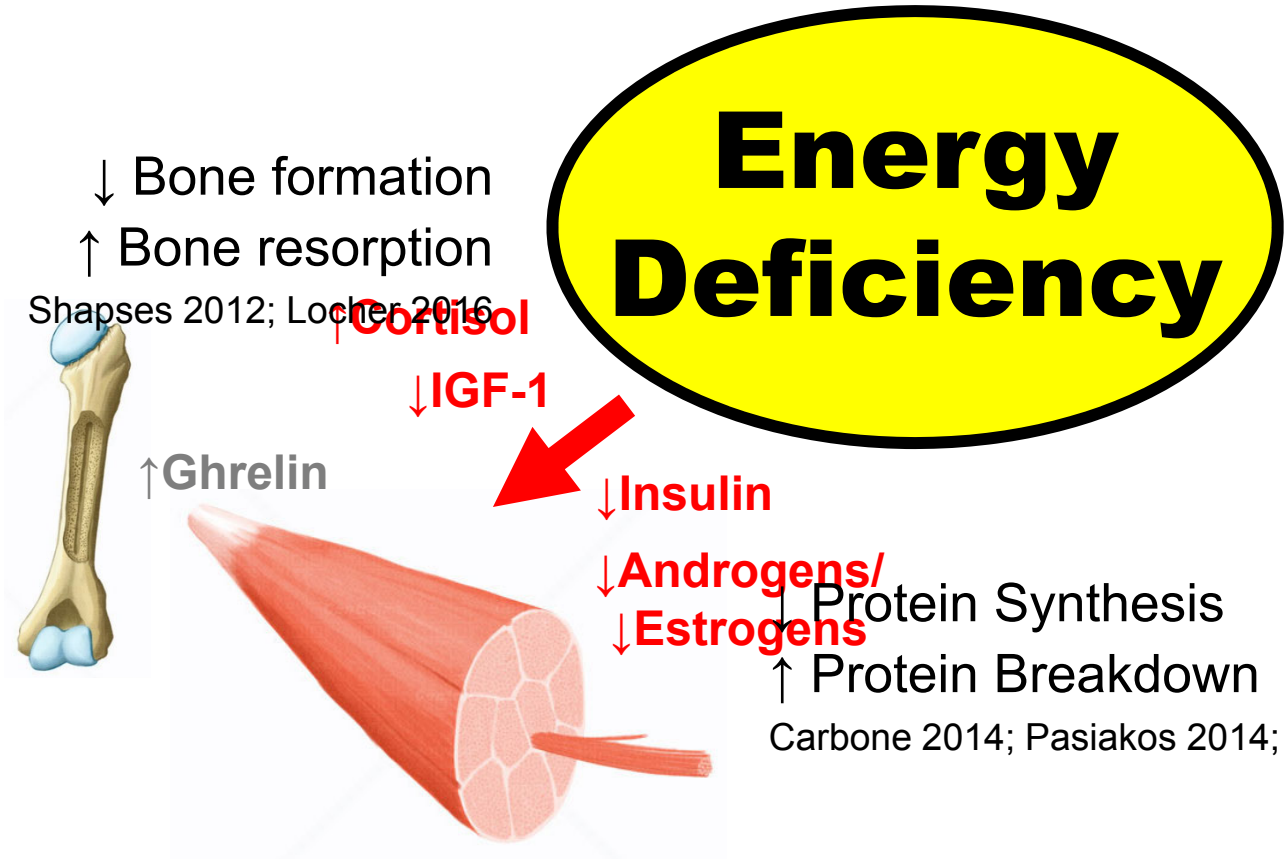
↓Androgens/
↓Estrogens

↑Ghrelin

↓Leptin

↓Insulin

Energy Deficiency Creates a State of Semi-Starvation



Energy Deficiency – Impacts on Performance

Young elite swimmers, 12-wk training

Two groups:

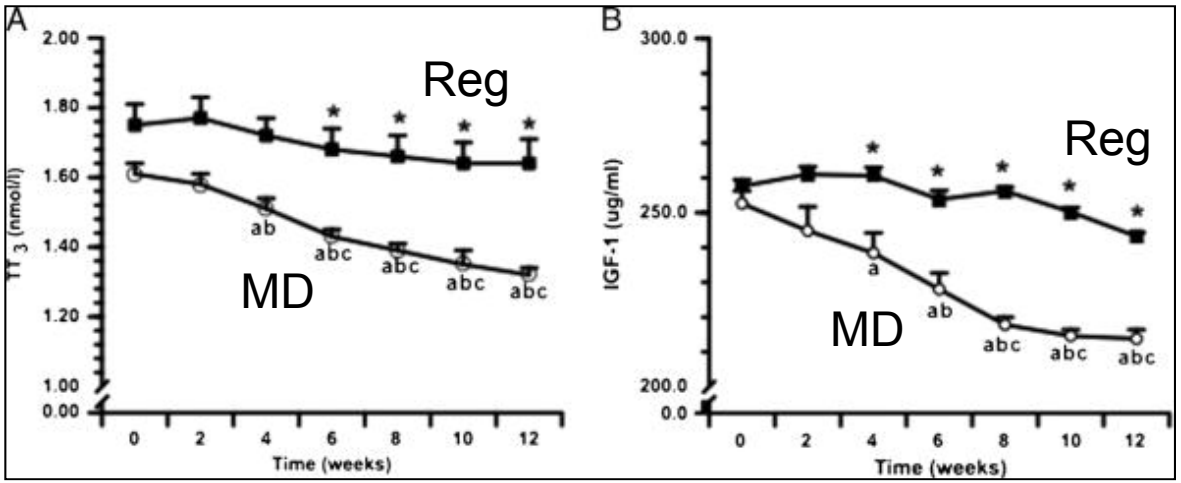
- MD: Menstrual Disturbances
- Reg: Regular Menses

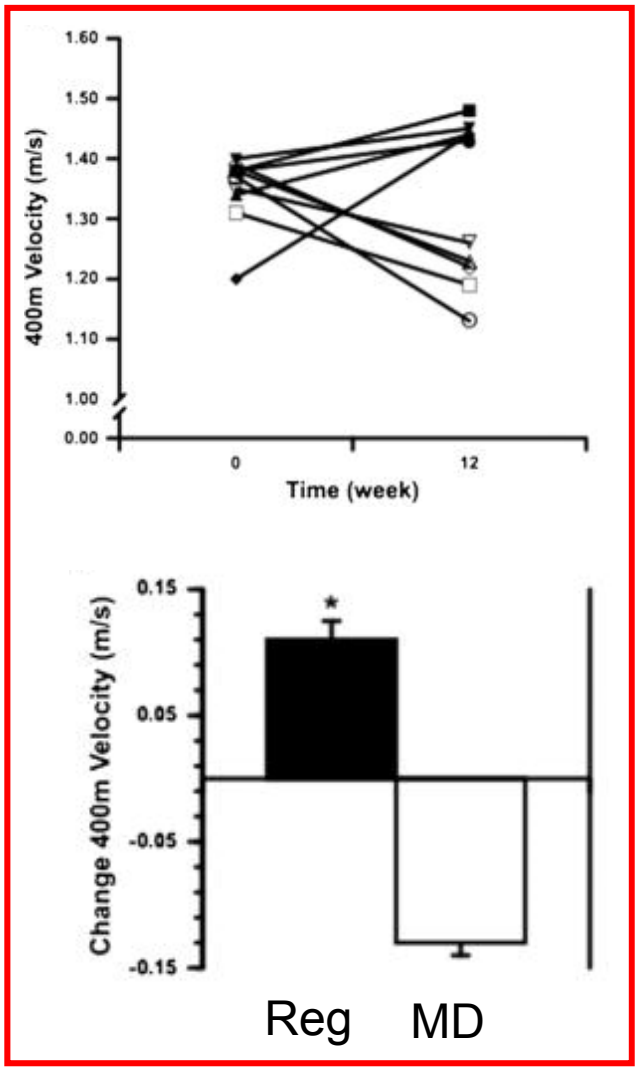
Energy Intake: ~30%↓ in MD

Energy Availability:

MD: ~10-12 kcal/kg FFM

Reg: ~ 30-37 kcal/kg FFM





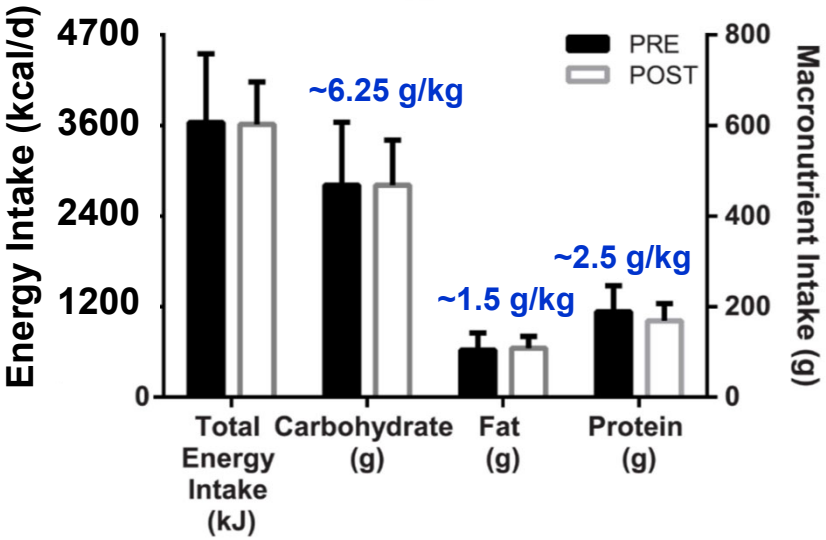
Van Heest et al. 2014

An Example from the Rowing World …

2015 Australian Rowing Team

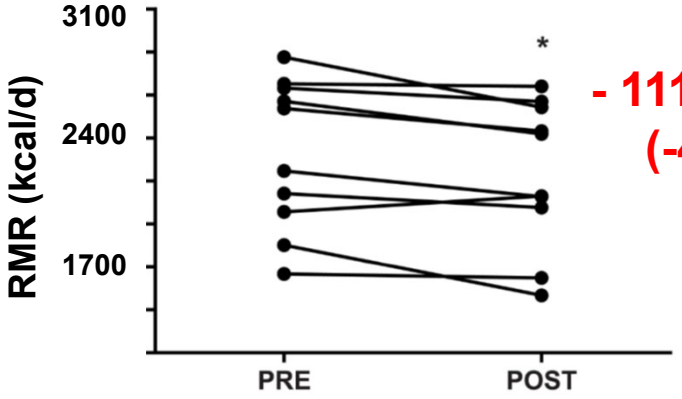
4-wk Intensified Training:

1600 – 2000 T2 minutes (+20-50%)

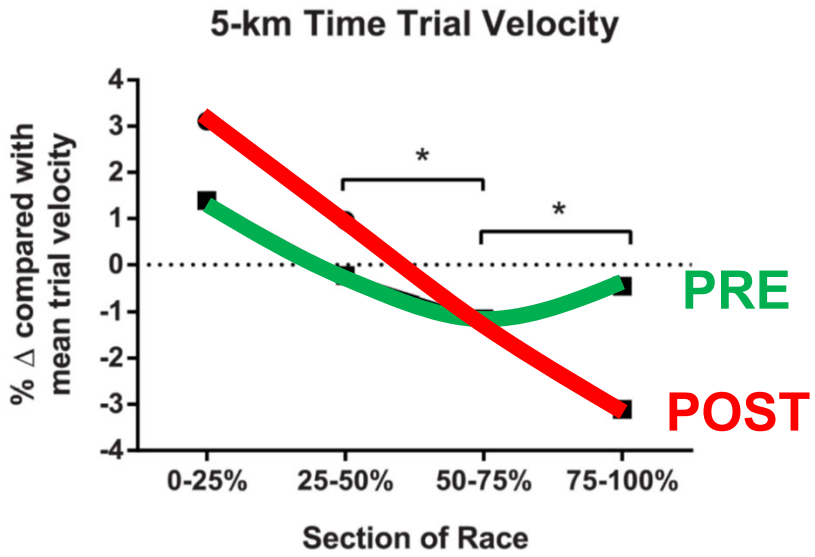


Δ Body Weight: -1.6 kg (2%)

Δ Fat Mass: -2.2 kg (-18%)



- 111 kcal/d (-4.8%)



Woods et al, PLOSone 2017

Possible Counterstrategies

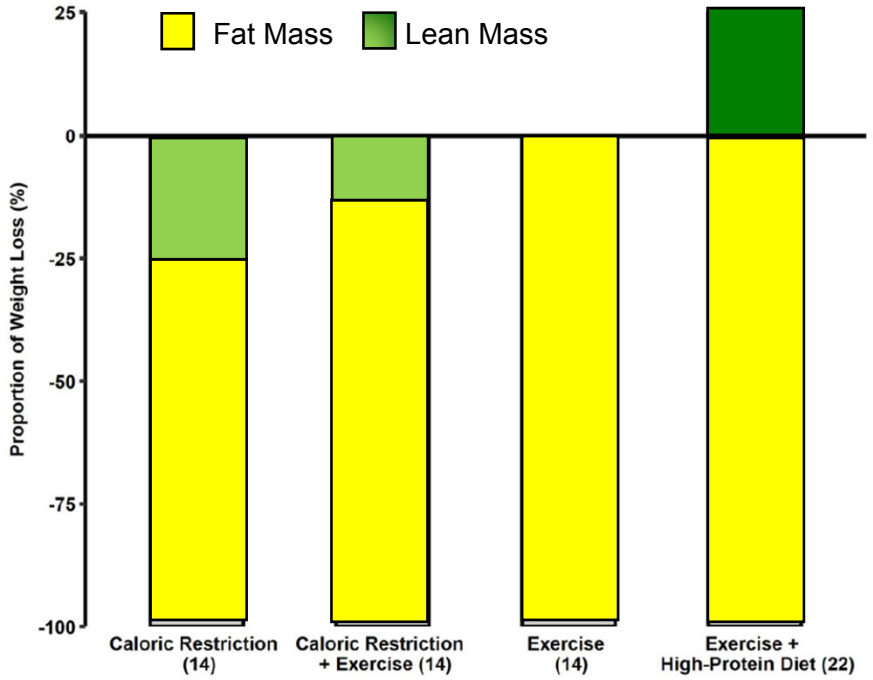
Working Hypothesis:

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

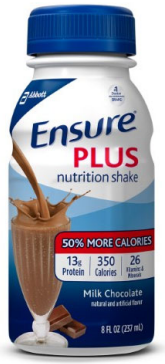
Functional Tests
(Strength, Fat Ox, VO_{2peak} etc.)

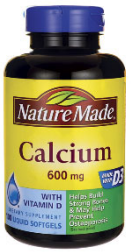
Body Composition

Blood

Controlled Exercise (60% VO_{2peak})

Controlled Diet (CR or EB)





0 1 2 3 4 5

Time (d)

Summary

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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USDA

FOOD FOR HEALTH
UNIVERSITY OF NEBRASKA COLLABORATION INITIATIVE

Nebraska Beef Council

DAAD
Deutscher Akademischer Austausch Dienst
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Thank you for your attention!

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