Physical activity results in an...

- Increased rate of energy expenditure
- Increased rate of body fluid loss

Findings of surveys:
- Physically active people don’t eat enough and they don’t drink enough
- Tend to supply needed energy and fluids after they needed them
Ultimate Question:
How can a figure skater stay on the right side of the fence?

Think about this...

- If I were to ask you which of the following has a ‘good’ connotation and which has a ‘bad’ connotation...
  - Carbohydrate (good or not so good?)
  - Protein (good or not so good?)
  - Fat (good or not so good?)
Effect of Diet on Performance

- 102 Minutes
  - 65% carbohydrate diet after 7 wks. training
- 65 Minutes
  - 21% carbohydrate diet after 7 wks. training
- 35 Minutes
  - Both groups before training

Adapted from Costil, et al. 1995

Exercise Intensity and Fuel Usage

Fuel Used by Muscle (Percent of Carbohydrate)

- Walking: 40%
- Jogging: 50%
- Running: 80%
- Sprinting: 95%

Adapted from Costil et al., 1985
Carbohydrate Delays Fatigue During Intermittent Sprinting


- **High-carbohydrate diet**
  - 87 Minutes — 22, one-minute sprints completed

- **Non-caloric Placebo**
  - 60 Minutes — 15, one-minute sprints completed

---

Carbohydrate Concentration Important for Optimal Fluid Absorption

Ryan, AJ. et al J. Appl. Physiol. 84: 1581-1588, 1998
Problems with energy inadequacy

- Poor training benefit
- Problem maintaining existing lean mass
- Lowering of metabolic rate
- Increasing difficulty with normal eating
- Lower energy / nutrient intake
- Reduction in athletic performance
- Increased risk of injury

Possible relationship between energy deficits and disordered eating.

1. Exercise occurs without sufficient energy intake.
2. Body adapts to inadequate energy by lowering metabolic rate
3. Weight gain or increase in body fat % occurs because of increased metabolic efficiency
4. The exerciser reduces energy intake further to maintain desired weight and/or body composition
5. Metabolic rate is reduced more, reducing the amount of energy that can be consumed still further.
6. Eventually, an eating disorder may occur from this cycle.

Traditional View of Energy Balance

24 hour Energy Intake \( \div \) 24 hour Energy Burned = Energy Balance

Examples:

- 3000 kcal intake over 24 hours = Perfect Energy Balance
  - (weight stays the same)
- 3000 kcal intake over 24 hours
  - 2500 kcal burned over 24 hours = Positive Energy Balance
  - (weight goes up)
- 3000 kcal intake over 24 hours
  - 3500 kcal burned over 24 hours = Negative Energy Balance
  - (weight goes down)

New view of energy balance

Deviations in within-day energy surpluses and deficits are as important factors in outcome variables (body fat, performance, concentration ability, etc.) as the 24-hour energy balance end-point.
Driving from New York City to Salt Lake City: Fueling Options

Option 1: Negotiate with your automobile. Don’t fill up now, but convince your car that you will give it all the fuel it needed once you get to Salt Lake.

Option 2: Tell your car you are going to fill it up with all the fuel it needs for the entire trip before you leave New York. The car has to figure out where it will put all the fuel…

Option 3: Tell your car you will fill up the tank before you leave New York, and stop every 300 miles to refill the tank all the way to Salt Lake.

Option 1: You’re going to need a much smaller engine (i.e., less muscle mass)

Option 2: You’re going to need a much larger gas tank (i.e., more fat storage)

Option 3: You can support a larger engine and a smaller gas tank (i.e., more muscle and less fat)
Note that all eating patterns lead to perfect energy balance (see circles) at the end of the day, but each with a different eating pattern and outcome.

Dietary Comparisons Using Within-Day Energy Balance
Adapted from: Benardot, D. “Advanced Sports Nutrition” © 2006, pg 215

From: Deutz R, Benardot D, Martin DE, and Cody M.
Within Day Energy Balance and Body Composition in Elite Athletes. MSSE
March 2000

From: Deutz R, Benardot D, Martin DE, and Cody M.
Within Day Energy Balance and Body Composition in Elite Athletes. MSSE
March 2000
Supporting studies: advantages to eating frequently

- Maintenance of metabolic rate
- Lower body fat & lower weight on higher caloric intakes
- Lower serum lipids
- Improved glucose tolerance and lower insulin response
- Lower stress hormone production

Havelley JA and Burke LM. Br J Nutr 1997; 77:591-593.

Common Error

- Blood glucose fluxes every 3 hours
- The sensation of ‘hunger’ occurs at the same time interval
- People try to mask hunger by providing a calorie-free CNS stimulant (i.e., diet cola with caffeine)
- By the time food is provided (2 or 3 hours later), physiological hunger is severe
- Food intake at a single ‘sitting’ is too high

Sources:
Central Fatigue Theory

- Fat Requires Protein Carrier in Blood
- Tryptophan Replaced By Fat on Albumin
- Fat Intake
- Blood-Brain Barrier

Large bolus meals nearly always carry a higher fat volume, causing early fatigue or senescence and a reduction in energy expenditure.

Meeting Energy Needs

- Does the distribution of carbohydrate, protein, and fat make a difference in weight?
  - No! Weight loss has little to do with the distribution of energy substrates; Only the energy they provide is important.

- Does the distribution of carbohydrate, protein, and fat make a difference in performance?
  - Yes! Years of research suggests that a diet high in complex carbohydrates, moderate in protein, and low in fat is best.

Joint position of the ACSM, ADA, and DC. Nutrition and Athletic Performance. MSSE 2000; 32(12):2130-2145
Fat and Fat-Free Mass Change with Severe Energy Deficiency

<table>
<thead>
<tr>
<th>Optimistic View</th>
<th>Traditional View</th>
<th>Actual View</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body Fat %</td>
<td>Body Fat %</td>
<td>Body Fat %</td>
</tr>
<tr>
<td>Goes Down Much</td>
<td>Goes Down A Little</td>
<td>Goes UP</td>
</tr>
</tbody>
</table>

Change in tissue

Study Design


With Product or Placebo

Baseline → + 2 Weeks → + 6 Weeks

Measured at each assessment opportunity:
- Body composition (DEXA)
- IGF-I (Fasting)
- POMS
- Performance (Wingate)
- Diet and Energy Balance

Significantly lower Body Fat %
More vigorous
No change in calories
Significantly better power and endurance
JUMP HEIGHT STUDY COMPARING CARBOHYDRATE AND CREATINE SUPPLEMENTS

[Accepted for publication: Strength and Conditioning Research Journal, September 2007]

- No difference in first 6 of 10 jumps
- Jump 7, 250 kcal supplement significantly better than all other supplements
- Jump 8 & 9, 250 kcal and Creatine supplements better than other supplements
- Jump 10, all supplements better than placebo
- In no case did creatine monohydrate outperform 250 kcal from carbohydrate
- Creatine monohydrate group gained 1.5 kg after 6 days; 250 kcal group gained 0.0 kg after 6 days.

Blood Glucose Maintenance...

- Blood sugar peaks ~ 1 hour after a meal, and returns to pre-meal levels ~ 2 hours after that.
- Delayed eating → hypoglycemia:
  - Headache
  - Poor concentration
  - Fatigue
  - Gluconeogenesis
    - Lactate
    - Alanine
    - Glycerol
    - Pyruvate > Come mainly from working muscles

This means your muscle mass is being broken down to supply the needed energy. NOT GOOD!

After only 40 minutes of strenuous activity, free alanine can increase by 60 to 96%; even more if work occurs with low blood sugar.

HOW TO AVOID FUNCTIONAL DEPLETION OF INTERMUSCULAR GLYCOCEN AND BLOOD GLUCOSE?

- Start the race with a higher level of muscle glycogen
- Start the race with liver glycogen full, and blood glucose normal
- Have a strategy for keeping blood sugar 'normal' (sip 'n carry)
- Keeping blood glucose normal...
  - Prevents hypoglycemia
  - Prevents neuroglucopenia
  - Lowers risk for CNS fatigue
    - Large catecholamine response
    - Pale skin
    - Irritability
    - Confusion
    - Lethargy
    - Muscle fatigue
- Think about caffeine, but be careful!

Mistakes are made even in trying to resolve the higher body fat level that results from 'dieting'

Remember: The body’s adaptation to an inadequate caloric intake is to lower the mass that requires energy (muscle and organ mass).
Weight Stability

- Excellent sign that energy intake matches demand.
- Energy deficiency leads to loss of lean mass (tissue compensation).
- A rise in body fat percent results in an heightened desire to reduce energy intake further. (Makes things worse.)
- Athletes focus on doing more low-intensity ('aerobic') exercise to lose the excess fat. (Makes things worse.)

Sources:
- Dulloo AG and Girardier C. Am J Clin Nutr 1990; 52:415-420

Fuel burned at different exercise intensities

A greater proportion of fat is burned at 25% VO2max than at higher intensities, but the total calories burned from fat is less than at higher intensities.

While the proportion of fat burned to satisfy total caloric requirement is lower at higher exercise intensities (65 and 85% of VO2max), the total mass of fat burned is greater than at lower intensities (25% VO2max).

Note: Notice that as exercise intensities rise, there is an increasingly greater reliance on muscle glycogen to supply the needed fuel.

Two carbohydrate energy storage systems to consider

**Liver**
- Glycogen: About 400 kcal
- Supplies glucose to blood, brain, and muscles
- (Must keep filling me up)
- When glucose flow to brain gets low, mental fatigue results in muscle fatigue.

**Muscle**
- Glycogen: About 2,000 kcal
- Muscle broken down to supply alanine for conversion to glucose to keep blood glucose up if liver glycogen is empty.
- Muscle glycogen used almost entirely for muscle function
- (Fill me up days before)

Insulin plays a role in body composition

- **Ways to increase insulin production**
  - Large volume of simple carbohydrate
  - Large bolus meals (regardless of composition)
  - Eating following hunger (low blood sugar)
  - High body fat level
  - Low level of physical activity
  - Psychological stress?
  - Physiological stress?

> Inadequate sleep?
Vitamins and Minerals

- Concerns
  - Calcium
  - Iron
  - Folate
  - B-12 (Vegetarian concern)
  - Vitamin D (Indoor activity concern)

Healthy and Unhealthy Bone

- Normal Architecture
- Abnormal Architecture
Hemolysis in Athletes: Iron Status Is Critical

- ↑ Blood acidity
- ↑ RBC transit velocity
- Extravascular compression of major working muscles
- ↑ Plantar surface compression at footstrike
- Mean life of RBC in runners = 80 days (versus 120 days in sedentaries)

Recovery Nutrition

- Immediately (within 30-60 minutes) after workouts
  - Especially when doing > 1 workout per day
- Conditions within the body post-workout are optimal for recovery if the proper nutrients are provided
- Consuming carbohydrate & protein right after workout will:
  - Restore fuel stores in muscle (glycogen)
  - Increase synthesis of muscle protein
The Good, The Bad, & The Ugly

- **The Good**: Consumption of the right amount of the right fluid at the right time
- **The Bad**: Consumption of some fluids of questionable value at any time
- **The Ugly**: “Forget the fluids, I’m just going to skate”
Reducing Voluntary Dehydration

(Even in the presence of fluids, athletes tend to drink less than they need.)

Common Risks for Dehydration

- Vomiting
- Diarrhea
- Inadequate fluid replacement
- Induced high sweat rates (as in saunas)
- Laxatives
- Diuretics (and substances with a diuretic effect, such as high intakes of caffeine)
- Dieting
- Febrile illness
Why Water Leaves You Empty

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Beverages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flavor</strong></td>
<td><strong>Sports Drink</strong></td>
</tr>
<tr>
<td>Light flavoring that encourages people to drink more</td>
<td>Light flavoring that encourages people to drink more</td>
</tr>
<tr>
<td><strong>Carbohydrate</strong></td>
<td>Contains 14 g CHO / 8 oz to provide energy for working muscles. Absorbed quickly.</td>
</tr>
<tr>
<td><strong>Electrolytes: Sodium and Potassium</strong></td>
<td>Contains small amount of Na+ (110mg/8oz) that encourages drinking and maintains blood volume</td>
</tr>
<tr>
<td>Replaces electrolytes lost in sweat</td>
<td>Contains no sodium, encouraging urination.</td>
</tr>
<tr>
<td>Does not replace electrolytes</td>
<td></td>
</tr>
</tbody>
</table>

Fluid Intake Recommendations

- Drink as much as needed to offset sweat losses
- Humans have no idea of rate of fluid loss during exercise (‘thirst’ doesn’t work)
- It is difficult to consume and absorb sufficient fluid (1-2 Liters/hour)
- Ingestion of large volumes of fluid increases risk of GI distress and/or impairs performance
- Ingestion of large volumes of relatively dilute, low sodium fluid may increase the risk of hyponatremia
- Voluntary fluid intake commonly results in dehydration
Fluid Guidelines from ADA, ACSM and Dietitians of Canada:

- **Before**
  - Drink 12 to 20 oz (400-600 ml) 2-3 hours before

- **During**
  - Drink 6 to 12 oz (150-350 ml) every 15-20 minutes

- **After**
  - Replace 150% of sweat losses
  - Drink 3 cups (24 oz) for every 1 lb weight lost through sweat

ADA Position Paper. JADA. 100(12):1543-1556, '00

The Bottom Line

- **Never Get Hungry**
- **Never Get Thirsty**
APPLICATION

The primary nutritional goals are:

- Maintain a good state of hydration.
- Maintain blood sugar. Low blood sugar results in mental fatigue, and to muscle fatigue, even if the muscles have plenty of glycogen fuel remaining.
- Reduce the depletion of muscle glycogen stores by providing carbohydrate.
Beware!

A lot of nutrition misinformation is targeted to athletes and non-athletes of all ages.

Take home message

- Rely on food for proper nutrition and not “nutritional supplement.”
- Get enough energy by eating 3 meals a day and plan 3-4 snacks per day.
Normal Growth

Until you reach your adult height, normal growth and development only occur with adequate energy intake (calories.)

Adequate calories needed for both performance and growth!

Planning snacks

- Carbohydrates are the best fuel for athletic performance.
- Athletes should take advantage of all natural breaks in competition to consume as much carbohydrate and fluid as can be tolerated.
- Avoid getting hungry by having something to eat (even if it is a 150 to 250 between-meal snack) every 3 hours.