From Walking to Marathons: The Role of Nutrition in Exercise

Liz Lane and Adam Brown
DayCon 2016
Roadmap

Background:
• Metabolism and Exercise

Vignettes
• Endurance Athletes and Carb Loading
• Diabetes and Walking
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Why do we need to eat?

Uses for nutrients
1. Broken down for energy
2. Stored for later use
3. Used as building blocks for biomolecules (ex. building new muscle)
The body requires energy to function

BMR is dependent on 3 variables
- Weight
- Height
- Age

For a 25 year old man
6 feet 175 pounds
BMR=1,651 Calories

http://www.calculator.net/bmr-calculator.html
The energy requirement of the body increases with exercise.
Three types of nutrients in foods

- **High Protein Foods**: Amino acids
- **High Carb Foods**: Sugars
- **High Fat Foods**: Fatty acids
Three types of nutrients in foods

- **High Protein Foods**: Amino acids
- **High Carb Foods**: Sugars
  - Monosaccharides (one sugar)
    - Glucose
    - Fructose
    - Galactose
  - Disaccharides (table sugar)
    - Glucose
    - Fructose
  - Complex carbs (starch)
- **High Fat Foods**: Fatty acids
Three types of nutrients in foods

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- **High Carb Foods**: Sugars
  - Monosaccharides: Glucose, Fructose, Galactose
  - Disaccharides (table sugar): Glucose, Fructose
  - Complex carbs (starch)
- **High Fat Foods**: Fatty acids
  - Triglycerides
Three types of nutrients in foods

**High Protein Foods**
- Amino acids

**High Carb Foods**
- Sugars
  - Glucose
  - Fructose
  - Galactose
  - Monosaccharides
- Disaccharides (table sugar)
  - Glucose
  - Fructose
- Complex carbs (starch)
- Triglycerides

**High Fat Foods**
- Fatty acids
How do we get energy from nutrients (the importance of oxygen)?

- **Aerobic Metabolism:** Requires Oxygen
  - Glucose
  - ATP (Energy) = 36

- **Anaerobic Metabolism:** No Oxygen
  - Glucose
  - ATP (Energy) = 2

- Triglycerides
  - Oxygen
## Carbohydrates vs. fats as an energy source

<table>
<thead>
<tr>
<th>ATP Produced Per Oxygen</th>
<th>Glucose</th>
<th>Fatty Acids</th>
</tr>
</thead>
<tbody>
<tr>
<td>~6 ATPs</td>
<td>~4.5 ATP</td>
<td></td>
</tr>
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</table>

**ATP** = The main energy source of the cell
Carbohydrates are the preferred energy source during intense workouts.
Medium intensity workouts burn the most fat.
What happens when blood glucose isn’t enough?

Data from http://www.medbio.info/
After using up glucose, the body switches to glycogen

Data from [http://www.medbio.info/](http://www.medbio.info/)
What is Glycogen?

Glycogen is the storage form of carbs and made in liver and muscle when blood glucose is high.

Protein core: anchor for glucose chains

Glucose monomers linked together
Glycogen is an excellent source of energy but stores are limited.

Data from http://www.medbio.info/
The body has large energy reserves in fat

Data from http://www.medbio.info/
During endurance exercise the body begins to use more fat for energy.
Questions?
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“Hitting the wall” during prolonged exercise

• An athlete “hits the wall” when they use up all their glycogen stores, causing blood glucose to drop

• To avoid ‘hitting the wall’
  – Maximize glycogen stores
  – Replenish carbohydrates during exercise (using energy gels, etc.)
Carb loading isn’t just eating pasta the night before a race
Does carb loading improve performance for endurance exercise?

8 endurance trained cyclists

3 days prior to test participants were assigned to either

High Carb Diet - with potato starch supplement

Normal diet

Measure glycogen

Performance test:
1. 2 hour ride at 65% max work with 60 sec sprints at 6 intervals
2. Max intensity ride for 1 hour

Repeat with participants in other diet group

Rauch et al, 1995
Carb loading for 3 days increases muscle glycogen content

Rauch et al, 1995
Carb loading for 3 days increases performance in cycling test

- Increased power output in performance ride after carb loading
- Increased distance traveled in performance ride after carb loading

Rauch et al, 1995
Fact and fiction of carbohydrate loading

• Carb loading is a multi-day process

• The purpose of carb loading is to increase glycogen stores

• A word of caution
  – Carb loading can cause gastrointestinal distress
  – Carb loading can increase the risk of diabetes
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Glucose: a double-edged sword

Glucose is **necessary** for your body during rest and exercise alike, but diabetics have **too much** blood sugar.

Too much blood sugar **can hurt many organs**, including the heart, kidneys and eyes.
Diabetes and Exercise

- Daily monitoring combined with physical activity improves long-term health\(^1\)
- Many diabetics aren’t mobile enough for strenuous exercise, so walking is often suggested as an alternative

[Left, Right] Images from Wikimedia Commons, under a CC license
Walking as Exercise

Walking is often recommended by doctors to improve diabetes and general health\(^1\)
What’s the right number of steps to take each day?

“Use a pedometer to count how many steps you take each day. Each week aim to increase your daily step count by 1,000 steps until you reach 10,000 steps a day.”

- American Heart Association

- Governments and Companies most often suggest 10,000 steps/day
- Numbers are the same for diabetics
Where does 10,000 steps per day come from?

• 10,000 steps a day (manpo-kei) was coined by Y. Hatano in the mid 1960’s as a tool to sell pedometers\(^1\)

[Left] Image from Mi Community, under CC license, [Right] Image from Yamasa-Tokei, under CC license

Two Open Questions

1. Does walking directly impact blood glucose in diabetics? If so, at what time scales?

2. Are population-level trends applicable to individual diabetics? Will walking help everyone equally?
The GlucoSuccess iPhone App

Welcome to GlucoSuccess
A Diabetes Research Study

Dashboard

Activity Completion
Today, March 3

Activity Tracker

Sleep 60%
Sedentary 7%
Light 9%
Moderate 31%
Vigorous 31%

Data Gathering
Collected data may reveal patterns of how health behaviors affect your blood glucose, and also advance clinical research into type 2 diabetes.

Learn more
Does Walking Lower Blood Glucose?

- Probably. Among 2,496 diabetics, walking 1K more steps per day was associated with 1 point (mg/dL) lower fasting blood glucose (measured over 9 months)
What about in the short-term?

- We looked at day-to-day impact of walking on glucose and found a significant, but small and very noisy relationship.
Lessons from GlucoSuccess

1. Overall, blood glucose in diabetics is probably tied to daily step count.

2. BUT, the relationship is complex and not generalizable from person to person.

3. 10K a day is nice, but we need more personalized recommendations.
Walking
Endurance Exercise

Hitting the Wall

Low Glucose

High Glucose

Diabetes

Carbo Loading
Lifestyle
Disease
Questions?
Thank you!

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The Harvard/MIT COOP
Aerobic vs anaerobic metabolism

**Pros of aerobic metabolism**
1. Produces a lot of energy
2. Long lasting

**Cons of aerobic metabolism**
1. Requires oxygen
2. Slower than anaerobic metabolism

**Pros of anaerobic metabolism**
1. Fast
2. Does not require oxygen

**Cons of anaerobic metabolism**
1. Inefficient
2. Produces toxic by-product
3. Lasts only a couple of minutes

**ATP: Main source of energy for the cell**

36 ATP

2 ATP
Anaerobic metabolism is brief during exercise.
Is 10,000 steps per day supported by science?

“most of the benefit is achieved by **8000 steps per day**”
  - Ewald et al., 2014 (J Phys Act Health)

“The findings suggest that **10,000 to 11,000 and 7700 to 8000 steps/d represent the optimal thresholds** [depending on which activity goal you choose]”
  - Cao et al., 2014 (J Phys Act Health)

- The verdict is still out, but the evidence suggests that 10K/day isn’t a “magic number” of steps
Aerobic metabolism can use both glucose and fats.

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**Aerobic Metabolism**
- Requires oxygen
  - Glucose $+ O_2$ → Pyruvate → Lactate → $O_2$ → $CO_2$
  - Produces 36 ATP

**ATP**: Main source of energy for the cell

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