DETERMINING THE EFFICACY OF LOW-CARBOHYDRATE DIET MODELS FOR ATHLETIC POPULATIONS
WHY LOW-CARB?

- Depend less on sugar
- Enhance fat oxidation
- Weight loss

http://dietabadop.atspace.co.uk/what-can-i-eat-on-a-no-carb-diet.html
WHAT DOES THIS HAVE TO DO WITH ATHLETES?

- Improve physical performance
- Get lean
CONCERNS

- Excessive/unnecessary weight loss
- Reduced muscle glycogen
- Dehydration
- Hormone function
- Cardiovascular disease risk
PURPOSE

- LC diets are widely followed but poorly understood & explained in most cases
  - Explain what is currently known about the biochemistry behind LC diets.

- LC diets are highly variable
  - Review popular LC diets to determine efficacy & considerations

- Research with athletes or healthy people following LC diets is scarce
  - ID possible considerations based on the information available & needs for future research
METHODS

- Literature search using Science Direct, Medline Plus, PubMed, & Web of Science

- Inclusion criteria: written in English, using human subjects
ENERGY SUBSTRATES

- **Fat** – 98% of energy stores
  - Adipose tissue
  - IMTGs
  - Plasma fatty acids
- **Carbohydrates**
  - Blood glucose
  - Glycogen (liver & muscle)
- **Protein**
# PATHWAYS

<table>
<thead>
<tr>
<th>ATP-CP</th>
<th>Glycolysis</th>
<th>Aerobic Metabolism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rapid</td>
<td>Rapid</td>
<td>Slower</td>
</tr>
<tr>
<td>Small amount of energy</td>
<td>Small amount of energy</td>
<td>Large amount of energy</td>
</tr>
<tr>
<td>Creatine in muscle</td>
<td>Blood glucose &amp; glycogen</td>
<td>Blood glucose, glycogen &amp; fat</td>
</tr>
</tbody>
</table>

---

*Energy system use during exercise* ¹
As exercise intensity increases, the body relies more on CHO for fuel.

Energy substrate use relative to exercise intensity²
## CONTROLLING BLOOD GLUCOSE

<table>
<thead>
<tr>
<th>Insulin</th>
<th>Glucagon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pancreatic α-cells</td>
<td>Pancreatic β-cells</td>
</tr>
<tr>
<td>High blood glucose levels</td>
<td>Low blood glucose levels</td>
</tr>
<tr>
<td>Blood glucose target tissue</td>
<td>Stored glucose blood</td>
</tr>
<tr>
<td>Blood glucose</td>
<td>Blood glucose</td>
</tr>
</tbody>
</table>
## Glycemic Index/Load

<table>
<thead>
<tr>
<th>Food</th>
<th>GI</th>
<th>GL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baked potato</td>
<td>85</td>
<td>26</td>
</tr>
<tr>
<td>Whole wheat bread</td>
<td>77</td>
<td>9</td>
</tr>
<tr>
<td>White bread</td>
<td>70</td>
<td>10</td>
</tr>
<tr>
<td>Sweet potato</td>
<td>61</td>
<td>17</td>
</tr>
<tr>
<td>Oatmeal</td>
<td>55</td>
<td>12</td>
</tr>
<tr>
<td>Brown rice</td>
<td>50</td>
<td>16</td>
</tr>
<tr>
<td>Chocolate cake, frosted</td>
<td>38</td>
<td>20</td>
</tr>
<tr>
<td>Spaghetti</td>
<td>38</td>
<td>18</td>
</tr>
<tr>
<td>Apple</td>
<td>38</td>
<td>6</td>
</tr>
</tbody>
</table>

Adapted from Krause appendix 43 (GI/GL of selected foods)

Glycemic effect of high GI and low GI foods³
What happens when CHO supply is low?
KETOSIS

< 10% CHO (or up to 30g)
50-80% fat
≥ 7 days

Fuel utilization for a low-carbohydrate ketogenic diet

Figure 1. Projected fuel utilization for a low-carbohydrate ketogenic diet. (ATP—adenosine triphosphate.)
WHICH LC DIETS ARE KETOGENIC?

Atkins
South Beach
FDA definition?

Grams vs. %

Low-carbohydrate diet: (For our purposes) less than 40% of daily calories from carbohydrates
POPULAR LOW-CARBOHYDRATE DIETS
THE ATKINS DIET (1972)

- Too much carb leads to hyperinsulemia
  - No more than 20g carb (Induction)

- 4 phases:
  1. Induction (ketosis)
  2. Ongoing Weight Loss
  3. Pre-Maintenance
  4. Lifetime Maintenance

- Regular exercisers: 60-90g CHO/day
<table>
<thead>
<tr>
<th>Rung 1</th>
<th>Foundation vegetables: leafy greens and other low-carb vegetables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rung 2</td>
<td>Dairy foods high in fat and low in carbs: cream, sour cream, and most hard cheeses</td>
</tr>
<tr>
<td>Rung 3</td>
<td>Nuts and seeds (but not chestnuts)</td>
</tr>
<tr>
<td>Rung 4</td>
<td>Berries, cherries, and melon (but not watermelon)</td>
</tr>
<tr>
<td>Rung 5</td>
<td>Whole milk yogurt and fresh cheeses, such as cottage cheese and ricotta</td>
</tr>
<tr>
<td>Rung 6</td>
<td>Legumes, including chickpeas, lentils, and the like.</td>
</tr>
<tr>
<td>Rung 7</td>
<td>Tomato and vegetable juice “cocktail” (plus more lemon and lime juice)</td>
</tr>
<tr>
<td>Rung 8</td>
<td>Other fruits (but not fruit juices or dried fruits)</td>
</tr>
<tr>
<td>Rung 9</td>
<td>Higher-carb vegetables, such as winter squash, carrots, and peas</td>
</tr>
<tr>
<td>Rung 10</td>
<td>Whole grains</td>
</tr>
</tbody>
</table>

Atkins Carbohydrate Ladder⁶
<table>
<thead>
<tr>
<th>PROS</th>
<th>CONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>• No calorie counting</td>
<td>• Requires supplements</td>
</tr>
<tr>
<td>• Can result in significant, rapid weight loss</td>
<td>• Easy to misinterpret</td>
</tr>
<tr>
<td>• Allows dieter to eat foods that feel decadent</td>
<td>• Restricts CHO to lower levels than many athletes need (initiation)</td>
</tr>
<tr>
<td>• May improve endurance performance</td>
<td>• Restricts some nutrient-dense foods, may cause deficiencies</td>
</tr>
</tbody>
</table>
THE SOUTH BEACH DIET (2003)

“Good carbs & good fats”

✗ (bread, rice, potatoes, pasta, baked goods, fruit, sugar, or alcohol (Phase 1))

3 phases:
1. Phase 1 (Ketosis, 2 weeks)
2. Phase 2 (Slowly add CHO)
3. Phase 3 (Maintenance)
<table>
<thead>
<tr>
<th>PROS</th>
<th>CONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Can result in rapid weight loss</td>
<td></td>
</tr>
<tr>
<td>- Promotes variety of nutrient-dense foods</td>
<td></td>
</tr>
<tr>
<td>- Lower fat than Atkins</td>
<td></td>
</tr>
<tr>
<td>- Wider variety of carbs than Atkins</td>
<td></td>
</tr>
<tr>
<td>- Restricts CHO to lower levels than many athletes need (initiation)</td>
<td></td>
</tr>
<tr>
<td>- Too low in calories for athletes</td>
<td></td>
</tr>
</tbody>
</table>
Humans are best adapted to eat foods resembling what ancient humans ate before modern agriculture

- dairy, grains, alcohol, salty foods, refined sugars, or processed foods

*The Paleo Diet for Athletes*

- Rigorous training 10+ hours/week?
  - Modify by eating certain “non-Paleo” foods
**PROS**

- Eliminates nutrient-poor foods
- Emphasizes nutrient-dense foods

**CONS**

- Extremely restrictive
- Restricts many nutrient-dense foods, may cause deficiencies
- On average, the diet is lower in calories than South Beach, which is too low for athletes
- Requires significant knowledge & planning to execute correctly
THE ZONE DIET (1995)

- “The Zone”- controlled range of insulin that optimizes weight control, satiety, & metabolic function
- “protein-adequate, moderate carbohydrate & low fat”

3 meals + 2 snacks

- Base: protein prescription based on lean body mass
  - 1 block = 7g PRO
- Match carb blocks
  - 1 block = 9g digestible CHO
- Match fat blocks
  - 1 block = 1.5g fat\textsuperscript{9,10}
1 carrot + 2 tomatoes + 1 apple = 4 blocks of carbohydrates

8 egg whites = 4 blocks of protein

12 almonds = 4 blocks of fats

**PROS**

- Meets AMDRs when followed correctly
- Effective for fat loss
- Close measurements promote moderation
- More liberal than other LC diets

**CONS**

- Restrictions
- Hypocaloric for most dieters
- Measurement & planning may decrease adherence
- Restricts some nutrient-dense foods, may cause deficiencies
**Macronutrient Distribution**

- **Atkins**
  - CHO: 9%
  - PRO: 29%
  - Fat: 62%

- **Paleo**
  - CHO: 22.6%
  - PRO: 37.9%
  - Fat: 39.5%

- **South Beach**
  - CHO: 33%
  - PRO: 26%
  - Fat: 40%

- **Zone**
  - CHO: 37%
  - PRO: 35%
  - Fat: 27%

*Macronutrient distribution of LC diets*  

---

**6-11**
DISCUSSION

Findings & Implications
WEIGHT LOSS

- Significant weight loss from fat consistently reported
  - Other factors may cause weight loss
    - LC diets usually lower in calories than control diets\(^\text{12}\)
    - Increased protein (26%) promotes satiety\(^\text{12}\)
    - Water loss

- Can the athlete safely lose weight?
  - Relative Energy Deficiency in Sport/Female Athlete Triad

- How does weight loss impact performance?
Can training with low levels of pre-exercise glycogen enhance muscle glycogen stores & lessen reliance on carbohydrates?

- Not proven effective, may be deleterious to the health and performance of athletes involved in high-intensity activities.\(^\text{13}\)
- Negatively affects the intensity and duration of endurance training\(^\text{14}\)
- Higher levels of body protein breakdown after exercise have been shown while performing endurance training on a LC diet\(^\text{15}\)
With every 1g of glycogen storage, 2.6g of water is stored
- Loss of glycogen stores = loss of water

Consequences of dehydration:
- 3-4% dehydration decreases muscular endurance performance \(^{16-20}\)
- 3% dehydration decreases aerobic power
- Increases rate of perceived exertion, decreases time to exhaustion \(^{21-23}\)
Are GI/GL valid measures for the basis of dietary requirements?

- GI and GL have not been shown to affect insulin response to meals in people with healthy BMIs.¹²,²²-²⁶
- Variability makes these measures unreliable¹²
- No effect on performance or metabolic function in athletes⁴¹

High protein diets (30-40% of calories, Paleo & Zone) may result in an increase in cortisol²⁷,²⁸
Relationship between LC diets & CVD risk still unclear

- Ketogenic diets
  - Some studies: LDL-cholesterol, free FAs, no change to HDL\(^{29}\)
  - Other studies: no negative impact on CVD risk profile\(^{46}\)

- Limitations of these results
  - Subjects
  - Variability
  - Length
### PROS
- Rapid weight loss
- Increased fat oxidation
- Maintenance of lean tissue
- May have a positive effect on endurance performance

### CONS
- Excessive/Unnecessary weight loss
- Reduced glycogen stores to power high-intensity activity
- Curtailed muscle growth
- Dehydration
- Increased cortisol
CONSIDERATIONS FOR ATHLETES

- Do you need to lose weight?
- LC diets maintain muscle, they don’t build it\(^{22}\)
- LC diets may be useful for endurance athletes
  - Mostly aerobic (fueled by fat)
- LC diets are inappropriate for strength & power athletes\(^{30}\)
  - High intensity exercise is fueled by blood glucose & glycogen

- Are you able to afford diminishing your exercise capacity during training?
NEEDS FOR FUTURE RESEARCH

- Studies with strength & power athletes following LC diets
- Studies to determine the extent of dehydration in athletes following a LC diet
- More long-term studies need to be conducted with a variety of participants, including healthy people & athletes to determine effect of LC diets on CVD risk profile
REFERENCES


Serfass RC, et al. The effects of rapid weight loss and attempted rehydration on strength and endurance of the handgripping muscles in college wrestlers.
REFERENCES


THANK YOU