Managing Weight and the Role of Carbohydrates in the Diet of an Athlete

Susan M. Kleiner
PhD, RD, FACN, CNS FISSN
Disclosure

• Dr. Kleiner is the co-CEO of Vynna, LLC, a sports nutrition product company by and for active women. Vynna, LLC was launched April 1, 2014, and is a subsidiary of Vitargo Global Sciences, LLC.

• This presentation is sponsored by Vynna, LLC.
Carbohydrate Utilization During Exercise

- Endurance exercise *and performance*
- Resistance training, strength, power *and performance*
- *After all, we are talking about ATHLETES!*
Carbohydrate Utilization During Endurance Exercise

• Intensity Matters!
  – In trained cyclists, large muscle groups, van Loon et al found:
    – LIGHT INTENSITY (25-30% VO$_{2\text{max}}$)
      • CHO (Carbohydrate) contributes 10-15% of oxidized fuel substrate
    – MODERATE INTENSITY (45-55% VO$_{2\text{max}}$)
      • CHO contributes 45-51% of oxidized fuel substrate
    – HIGH INTENSITY (75% VO$_{2\text{max}}$)
      • CHO contributes 73% of oxidized fuel substrate

Endurance (trained)

Carbohydrate Utilization During Endurance Exercise

• Helge et al, J Phyiol 2007

• Graded exercise intensities with small muscle groups (knee extensions, quad); 35-45 minutes
  - Demonstrated progressive increase in carbohydrate oxidation, yet no decline in total fat oxidation rates at 25%, 65% and 85% $W_{\text{max}}$ (contrary to results with large muscle groups)
LONG-TERM LOW CARB ENDURANCE TRAINING?

THE HUMAN METABOLIC RESPONSE TO CHRONIC KETOSIS WITHOUT CALORIC RESTRICTION: PRESERVATION OF SUBMAXIMAL EXERCISE CAPACITY WITH REDUCED CARBOHYDRATE OXIDATION

Phinney et al, Metabolism 1983
LONG-TERM LOW CARB ENDURANCE TRAINING?

• 5 Professional cyclists
• Eucaloric diets (35-50 kcal/kg/d; 1.75 g pro/kg/d; vits/mins)
• 7d baseline diet; CHO (57% CHO, 29% fat, 14% pro)
• 28d ketogenic diet; KT (<2% CHO, 85% fat, ~13% pro)
• Maintain training volume and intensity during KT diet
• Cycling performance (continuous 62-64% VO_{2max} to exhaustion) assessed while on CHO and 4 weeks post KT
LONG-TERM LOW CARB ENDURANCE TRAINING?

• RESULTS:
  – TIME TO EXHAUSTION: NO SIGN DIFFERENCE (147/151 mins)
LONG-TERM LOW CARB ENDURANCE TRAINING?

• RESULTS:
  – MUSCLE GLYC CONTENT (vastus l.)
    • Pre exercise CHO: 143 ± 10 mmol glu/kg ww (1.9x KT)
    • Post exercise CHO: 53 ± 5 mmol glu/kg ww
    • Pre exercise KT: 76 ± 4 mmol glu/kg ww (30% more than CHO post; 28d later)
      – So gluconeogenesis supported some modest muscle glycogenesis
    • Glycogen utilization rate of KT: 21% of that during CHO
LONG-TERM LOW CARB ENDURANCE TRAINING?

• WHAT WAS NOT REPORTED IN THE STUDY?


• The cyclists experienced an impaired ability to perform hill climbs during training while on the KT diet. So...
LONG-TERM LOW CARB ENDURANCE TRAINING?

• WHAT WAS NOT REPORTED IN THE STUDY?

• This suggests that the near-depleted glycogen state could not adequately support higher power outputs (and possibly variable intensity work) during training.
LONG-TERM LOW CARB ENDURANCE TRAINING?


• 5 trained cyclists, lower mean VO$_{2\max}$ and lower weekly training volume vs. Phinney et al.

• Isocaloric diets, random crossover design w/2 wk washout

• 2 wk HC diet (73.6% CHO, 12% fat, 13.5% pro)

• 2 wk HF diet (7.1% CHO, 67.3% fat, 25.5% pro)
LONG-TERM LOW CARB ENDURANCE TRAINING?


• Exercise tests at the end of HC and HF diet phases
  – Series of 5s tests on cycle ergometer at max cadence/variable loads
  – Then 30s Wingate test and 30m rest; biopsy (vastus l.)
  – Cycle to exhaustion at 90% VO$_{2\text{max}}$; biopsy; 20m rest
  – Cycle to exhaustion at 60% VO$_{2\text{max}}$
LONG-TERM LOW CARB ENDURANCE TRAINING?

• RESULTS:
  – TIME TO EXHAUSTION FOR HIGH INTENSITY (HI) RIDE:
    • HC 12.5 +3.8 MINUTES
    • HF 8.3 +2.3 MINUTES
    • 51% greater time in HC; not stat sign likely due to small sample size
  – TIME TO EXHAUSTION MODERATE INTENSITY RIDE:
    • HC 42.5 + 6.8 MINUTES
    • HF 79.7 +7.6 MINUTES
    • 88% greater time in HF
LONG-TERM LOW CARB ENDURANCE TRAINING?

• RESULTS:
  – MUSCLE GLYC CONTENT (vastus l.)
    • Pre HI Ride HC: 77% greater vs HF
    • Post HI Ride HC: same as pre-HI ride in HF
    • Glycogen utilization rates were similar between treatments
    • Nearly 2-fold higher fat and 42% lower CHO oxidation rates in HF vs. HC explains better performance in Moderate event, when glycogen stores already depleted and HC cyclists more dependent on CHO
LONG-TERM LOW CARB ENDURANCE TRAINING?

• WHAT DOES THIS MEAN?

• Submaximal/moderate exercise intensity can be sustained with reduced muscle glycogen concentrations without performance deficits

• However...
LONG-TERM LOW CARB ENDURANCE TRAINING?

• WHAT DOES THIS MEAN?

• HOWEVER, NEAR MAXIMAL/HIGH INTENSITY AND PERHAPS VARIABLE LOAD EXERCISE MAY BE COMPROMISED EVEN AFTER ONLY 1 DAY OF DEPLETION.

LONG-TERM LOW CARB ENDURANCE TRAINING?

• “Fat adaptation” for athletic performance: the nail in the coffin? – Louise M. Burke, Bente Kiens. Journal of Applied Physiology January 2006 vol. 100 no. 1 7-8

  – Low CHO, Hi Fat = Greater RPE; Greater race deficits

  – Lower rate of glycogen utilization with HF diet in submax exercise may actually demonstrate impaired ability to oxidize CHO vs energetic efficiency of fat oxidation.
LONG-TERM LOW CARB ENDURANCE TRAINING?

• “Fat adaptation” for athletic performance: the nail in the coffin? – Louise M. Burke, Bente Kiens. Journal of Applied Physiology January 2006 vol. 100 no. 1 7-8

  – “those at the coal-face of sports nutrition can delete fat loading and high-fat diets from their list of genuine ergogenic aids for conventional endurance and ultra-endurance sports.”
Carbohydrate Utilization During Resistance Exercise

• Churchley et al., J Appl Physiol, 2007

• 7 male experienced resistance trainers

• Acute diet and exercise regimen to achieve 1 leg with “normal” (nl) glycogen state, contralateral leg in “low” glycogen state.

• 8 sets, 5 reps, single leg press at 80% 1 RM, for each leg.

• 60 seconds rest between each leg sets
Carbohydrate Utilization During Resistance Exercise

• Churchley et al., J Appl Physiol, 2007

• LOW LEG COULD NOT COMPLETE 5 REPS

• WORK CAPACITY WAS LESS IN LOW LEG VS NL LEG

• Resting glycogen on low leg significantly less than nl leg

• Net glycogen utilization was similar between legs

• Relative glycogen utilization was 47% of baseline in nl leg; 28% of baseline in low leg (quad/vastus l.)
Strength

(trained)

LONG-TERM LOW CARB RESISTANCE TRAINING?

• “The subjects couldn’t maintain the intense training demands so we had to stop the study...”
  
  - Dr. John Hawley
CARB AND WEIGHT CONTROL IN ATHLETES

• Excess Post-exercise Oxygen Consumption (EPOC)

• You know the data...
  – EPOC is greatest after resistance exercise and HIIT
  – Numerous studies have shown that despite lower caloric requirements during exercise, resistance exercise and HIIT result in higher EPOC, significantly greater total body fat (and abdominal fat) loss and significantly less muscle loss vs. endurance exercise over time in men and women.
CARB AND WEIGHT CONTROL IN ATHLETES

• Excess Post-exercise Oxygen Consumption (EPOC)
  – Resistance exercise and HIIT require optimal glycogen stores
  – *To maintain training and sculpt an athlete, carbohydrate is absolutely essential!*
  – Low-carb dieting will ultimately cause muscle loss and training deficits.
CARBS, CALORIES, FASTING AND METABOLIC CONTROL

• PERIPHERAL METABOLIC PATHWAY
  – Travel from the body to the brain
  – Influence metabolism, weight and appetite
CARBS, CALORIES, FASTING AND METABOLIC CONTROL

• PERIPHERAL METABOLIC PATHWAY

• Chemical messengers from:
  - Fat mass
  - Muscle mass
  - Bone
  - GI tract
  - Pancreas
  - Liver
  - Endocrine glands
  - Blood
CARBS, CALORIES, FASTING AND METABOLIC CONTROL

• PERIPHERAL METABOLIC PATHWAY

• Chemical messengers:
  – Major hormones:
    • Insulin
    • Glucagon
    • Leptin
    • Adiponectin

- Cooper Emily. The Metabolic Storm. Emily Cooper, M.D., 2013
CARBS, CALORIES, FASTING AND METABOLIC CONTROL

• PERIPHERAL METABOLIC PATHWAY

• Chemical messengers:
  – Gut Hormones:
    • Incretins
      – GIP and GLP-1
    • Other gut hormones:
      – Ghrelin
      – PYY
      – Oxyntomodulin
      – And more

- Cooper Emily. The Metabolic Storm. Emily Cooper, M.D., 2013
CARBS, CALORIES, FASTING AND METABOLIC CONTROL

• BEFORE THE BRAIN AND BODY FEEL SAFE ENOUGH TO CARRY OUT ROBUST ENERGY METABOLISM, THEY MUST BE CONVINCED THAT THE BODY HAS ENOUGH FUEL AND FAT TO SURVIVE A FOOD EMERGENCY

• This is the complex role of the metabolic messengers
CARBS, CALORIES, FASTING AND METABOLIC CONTROL

• FOOD EMERGENCY - STARVATION ADAPTATION

– At any single point along the peripheral metabolic pathway, if a messenger is disturbed too much or too often, the feedback loop of the pathway will shift away from robust energy metabolism to starvation adaption.

– Starvation adaptation results in diminished function of non-essential systems including thyroid function, lower metabolic rate, halting use of circulating fuel and shuttling fuel into storage as fat, increasing appetite, decreasing availability of fuel for energy resulting in fatigue and lethargy...

... all with the goal of fat gain!
CARBS, CALORIES, FASTING AND METABOLIC CONTROL

• INSULIN
  – Primary roles
    • Inform the brain that we have adequate fuel on board
    • Transport glucose and protein into body cells for use as energy
    • Gives the brain a green light to burn fuel in current circulation
    • Produced in response to a meal or snack
    • Also produced in smaller amounts when the liver releases glucose stores to keep the blood supply steady

• GLUCAGON
  – Primary roles
    • As blood glucose concentrations drop, glucagon signals the liver to release a small amount of glucose into the bloodstream to maintain levels between meals. Once liver releases stored glucose, the pancreas secretes just enough insulin to transport glucose to cells for energy.
    • Influences the brain to regulate blood glucose and metabolism.
CARBS, CALORIES, FASTING AND METABOLIC CHAOS!

• As one example, insulin and glucagon are a tag team to maintain normal metabolic function, cognition, mood, focus, and energy.

• Without adequate calories and carbohydrate to meet the demand for fuel, insulin is not secreted in adequate amounts and the feedback loop of the peripheral metabolic pathway is disturbed, shifting the drive from robust energy metabolism to starvation adaptation.
CARBS, CALORIES, FASTING AND METABOLIC CHAOS!

- Skipping breakfast, too long between meals, fasting before training, very low calorie and/or very low carbohydrate diets negatively impact the feedback loop somewhere along the peripheral metabolic pathway, placing the athlete at risk of **metabolic chaos**.
CARBS, CALORIES, FASTING AND METABOLIC CHAOS!

• Metabolic chaos is particularly profound in female athletes.

• Reproductive hormones play a role in the feedback loops of the metabolic pathway. With inadequate calories and carbohydrates, these hormone secretions may be altered, further disturbing the pathway and setting the stage for chronic inhibition of energy metabolism.
CARBS, CALORIES, FASTING AND METABOLIC CHAOS!

• In general, athletes are at risk of metabolic chaos due to chronic systemic inflammation.

• Inflammatory markers can disrupt the peripheral metabolic pathway.

• A diet robust in anti-inflammatory factors decreases inflammation and supports the metabolic energy pathway.

• Low-calorie, low carbohydrate diets are typically also low in essential nutrients and anti-inflammatory factors

  - Cooper Emily. The Metabolic Storm. Emily Cooper, M.D., 2013
FUELING FOR TRAINING & WEIGHT LOSS

• WHAT IS THE ENERGY COST OF EXERCISE?
CARBOHYDRATE UTILIZATION
- ACTUAL RACE (very trained)

<table>
<thead>
<tr>
<th></th>
<th>Time</th>
<th>Speed (m·s⁻¹)</th>
<th>TEE (Ind. Cal.), MJ (kcal)</th>
<th>TEE (DLW), MJ (kcal)</th>
<th>CHO (g)</th>
<th>Fat (g)</th>
<th>BW (kg)</th>
<th>CHO Intake (g)</th>
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<tbody>
<tr>
<td>Pre</td>
<td>36:00</td>
<td></td>
<td>0.5 (121)</td>
<td>Initial collection</td>
<td></td>
<td></td>
<td>78.6</td>
<td></td>
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<tr>
<td>Swim</td>
<td>1:15:51</td>
<td>0.8</td>
<td>3.4 (805)</td>
<td>↓</td>
<td>141</td>
<td>27</td>
<td>↓</td>
<td>0</td>
</tr>
<tr>
<td>T1</td>
<td>4:29</td>
<td></td>
<td>0.2 (45)</td>
<td></td>
<td>8</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cycle</td>
<td>5:19:40</td>
<td>9.4</td>
<td>21.4 (5,123)</td>
<td>↓</td>
<td>925</td>
<td>156</td>
<td>↓</td>
<td>404</td>
</tr>
<tr>
<td>T2</td>
<td>4:47</td>
<td></td>
<td>0.2 (48)</td>
<td></td>
<td>8</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Run</td>
<td>3:55:29</td>
<td>3.0</td>
<td>10.9 (2,596)</td>
<td>↓</td>
<td>288</td>
<td>161</td>
<td>↓</td>
<td>228</td>
</tr>
<tr>
<td>Post</td>
<td>1:12:44</td>
<td></td>
<td>1.2 (291)</td>
<td>Postcollection</td>
<td></td>
<td></td>
<td></td>
<td>72.7</td>
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<tr>
<td>Total</td>
<td>12:29:00</td>
<td></td>
<td>37.8 (9,029)</td>
<td>37.3 (8,926)</td>
<td>1,370</td>
<td>348</td>
<td></td>
<td>632</td>
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Doing the math, **D2O** style

- **Grams of carbohydrates**

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<tr>
<th>Activity</th>
<th>Time</th>
<th>Calories</th>
</tr>
</thead>
<tbody>
<tr>
<td>SWIM</td>
<td>1:16</td>
<td>500</td>
</tr>
<tr>
<td>BIKE</td>
<td>5:20</td>
<td>1000</td>
</tr>
<tr>
<td>RUN</td>
<td>3:55</td>
<td>1500</td>
</tr>
<tr>
<td>RACE TOTAL</td>
<td></td>
<td>12:29</td>
</tr>
</tbody>
</table>

Cuddy et al., *Int J Physiol Perf*, 2010
FUELING FOR TRAINING & WEIGHT LOSS

• EAT BREAKFAST

• EAT EVERY 3-4 HOURS THROUGHOUT THE DAY

• FUEL BEFORE, DURING AND AFTER EXERCISE BASED ON THE ENERGY COST AND INTENSITY OF EXERCISE
FUELING FOR TRAINING & WEIGHT LOSS

• THROUGHOUT THE DAY CHOOSE NUTRIENT-DENSE CARBOHYDRATE SOURCES
  – Watery vegetables
  – Starchy vegetables
  – Fruit
  – Whole grains
  – Beans
  – Dairy
FUELING FOR TRAINING & WEIGHT LOSS

• THE METABOLIC WINDOW

  – < 300 kcal within day and total daily energy deficit will not disrupt the feedback loop of the metabolic pathway (Benardot, 2000)

• FUEL TRAINING WITH ADEQUATE CARBOHYDRATE TO OPTIMIZE INTENSITY FOR GREATEST TRAINING EFFECT AND EPOC
FUELING FOR TRAINING & WEIGHT LOSS

• WHAT CARBOHYDRATE AROUND EXERCISE?

• GLYCEMIC INDEX
  – Describes the increment in blood glucose concentration over a period of time (2-hr) relative to an indexed food (dextrose or white bread)
  – It DOES NOT describe the glucose kinetics (Ra, rate of appearance; Rd, rate of disappearance) derived from a food, beverage or nutritional supplement.
FUELING FOR TRAINING & WEIGHT LOSS

• WHAT CARBOHYDRATE AROUND EXERCISE?

• GLYCEMIC INDEX

• In fact, studies have shown that the Ra is virtually identical for High GI and Low GI foods (Schenk et al, 2003; Eelderink et al, 2012)

• It is the significantly greater Rd and glucose clearance rate over the 30-60 min postprandial period from greater insulin concentration and action that lowers the glucose concentration for Low GI foods, beverages and supplements
FUELING FOR TRAINING & WEIGHT LOSS

• **WHAT CARBOHYDRATE AROUND EXERCISE?**

• GLYCEMIC INDEX

• Does not tell us where the glucose goes or when it enters the liver or muscle after disappearance.

• Only studies on muscle glycogen repletion and appearance in the muscle cell give us the data on rate of glycogen replenishment from foods, beverages and supplements
FUELING FOR TRAINING & WEIGHT LOSS

• WHAT CARBOHYDRATE AROUND EXERCISE?

• GLYCEMIC INDEX

• Product comparison studies on rates of muscle glycogen repletion and performance in repeated bouts of high intensity/variable exercise are the most reliable for application in real athletic events (Stephens et al., J Sports Sci 2008)
FUELING FOR TRAINING & WEIGHT LOSS

• ADD MORE PROTEIN TO A CALORIE &/OR CARB DEFICIENT DIET TO ENHANCE GLYCOGEN REPLENISHMENT AND RECOVERY

• EAT EVERY 3-4 HOURS: A COMBINATION OF CARB-PROTEIN-HIGH PERFORMANCE FATS FOR METABOLIC CONTROL

• AVOID FAT AROUND EXERCISE TO SPEED STOMACH EMPTYING AND NUTRIENT ABSORPTION

• PUT YOUR FOOD TO WORK FOR YOU!
Feed Your Muscles!

Don’t Let Your Muscles Feed You!
THANK YOU