High Fat v High Carbs – Which diet is best for athletes?

Dr Justin Roberts
Anglia Ruskin University, Cambridge, Sport & Exercise Sciences Research Group

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Nutrition Issues

- “2-weeks to go” syndrome
- Neuro-Endocrine
  - Fatigue, low energy, dysglycemia
  - Anxiety/nervous/insomnia
- Metabolic
  - Dehydration
  - Cravings
  - Fueling/negative balance
- Immuno-suppression
  - ‘Run down’, colds, sore throats
- Digestive
  - Gastrointestinal complaints
  - ‘Endotoxin like symptoms’
  - Cramps
- Muscular
  - Soreness, tightness, recovery

Metabolic fuelling

Defence & Recovery
Fuelling repeated performance

How does this relate to performance?
Well established that high carb diets linked to endurance
Pre loading linked to depletion
Muscle overload reduced
Importance of ‘recovery nutrients’


Metabolic Demands

N=14

Muscle glycogen \( \rho \) at 449±23 mmol.kg\(^{-1} \) dw
42±5% lower after game (P<0.05)

Pre game: 73±6% fully repleted (all fibres)
Post game: only 19±4% left (P<0.05, all fibres)
ST reduction: 54±10% (completely / almost empty)
FTa reduction: 46±11%
FTx reduction: 26±10%


Pre Race Carb Loading

- 3 d of moderate-CHO diet (50% of energy from CHO) and hard training, ending with exercise to exhaustion at 75% \( V_{O2 max} \), then...
- 3 d of low-CHO diet (10% CHO) and heavy training, ending with another bout of exhaustive exercise to further deplete glycogen stores, then...
- 3 d of high-CHO diet (90% CHO) and reduced training

**Effect on sustained performance**

![Graph showing exercise time (min) for mixed, low, and high carbohydrate diets](image)

**Figure 3:** Time to exhaustion during prolonged cycling (~70% VO2 max) after a mixed diet followed by 3 d on a low-carbohydrate diet and then 3 d on a high-carbohydrate diet (Bergström et al., 1967).

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**Pre marathon loading**

![Graph showing split speeds for runners consuming <7 g/kg and >7 g/kg of carbohydrate](image)

**Fig. 2:** Within-race split speeds for the runners who consumed <7 g/kg and >7 g/kg of carbohydrate during the day before the race. Also shown is the split speeds for the matched sample of 30 runners who consumed <7 g/kg of carbohydrate.


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**Carbohydrate Density**

**Comparison with ancestral diets suggests dense scallular carbohydrates promote an inflammatory microbiota, and may be the primary dietary cause of leptin resistance and obesity**

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**Diabetes, Metabolic Syndrome and Obesity: Targets & Therapy. (2012); 5 : 175-189**
**Macronutrient Intakes: Subject 1 (Club Recreational)**

- **Macronutrient Intake (% of total kcal d⁻¹)**
- **Macronutrient Intake (g d⁻¹)**

- **Carbohydrate**
- **Fats**
- **Proteins**

- TOTAL Energy intake: 2736.7 kcal/d average
- Relatively good CHO intake: 4.20g/kg/d – moderate GI load (31.6%)”
- PUFA (inc. MUFA) = 84.3 g/d
- Saturated fat content = 48.3 g/d moderate (33.1% of total fats)
- Protein intake 1.73 g/kg/d – high
- Water intake: 1.89 L/d

**Micronutrient Intakes: Subject 1 (Club Recreational)**

<table>
<thead>
<tr>
<th>Food Item</th>
<th>Vitamin / Mineral</th>
<th>S1</th>
<th>RNI</th>
<th>SPL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cinnamon &amp; Relish Baked &amp; Butter and Honey</td>
<td>Vitamin</td>
<td>666.6</td>
<td>700-800</td>
<td>1000-1500</td>
</tr>
<tr>
<td>Rice Cakes (3) and Peanut Butter</td>
<td>Vitamin</td>
<td>101</td>
<td>40-60</td>
<td>500-1000</td>
</tr>
<tr>
<td>Chicken, Avocado, Lettuce, Tomatoes &amp; Olives</td>
<td>Vitamin</td>
<td>24.76</td>
<td>4-10</td>
<td>150-400</td>
</tr>
<tr>
<td>Greek Yoghurt with honey, Blueberries and Almonds/Cinnamon</td>
<td>Vitamin</td>
<td>2.39</td>
<td>1-4</td>
<td>25-75</td>
</tr>
<tr>
<td>Baked Potato with Butter and Cheese</td>
<td>Vitamin</td>
<td>2.20</td>
<td>1-3.5</td>
<td>10-20+</td>
</tr>
<tr>
<td>400ml Hot Water with Lemon and Money, 450 ml Black Coffee</td>
<td>Vitamin</td>
<td>2.06</td>
<td>1-10</td>
<td>10-50</td>
</tr>
<tr>
<td></td>
<td>Mineral</td>
<td>423</td>
<td>300</td>
<td>300-500</td>
</tr>
<tr>
<td></td>
<td>Mineral</td>
<td>877</td>
<td>700-800</td>
<td>1000-1500</td>
</tr>
<tr>
<td></td>
<td>Mineral</td>
<td>10.14</td>
<td>9.5-15</td>
<td>15-25</td>
</tr>
<tr>
<td></td>
<td>Mineral</td>
<td>43.6</td>
<td>75</td>
<td>100-200</td>
</tr>
<tr>
<td></td>
<td>Mineral</td>
<td>12.90</td>
<td>8.7-14</td>
<td>10-15</td>
</tr>
</tbody>
</table>
Nutritional Periodisation

Review
Fueling strategies to optimize performance: training high or training low?

L. M. Burke
Department of Sports Nutrition, Australian Institute of Sport, Belconnen ACT, Australia
Corresponding author: Louise M. Burke, PhD. Department of Sports Nutrition, Australian Institute of Sport, PO Box 176, Belconnen ACT 2616, Australia. Tel: +61 2 6214 1351, Fax: +61 2 6214 1003. Email: Louise.Burke@ausport.gov.au
Accepted for publication 15 June 2010

Availability of carbohydrate as a substrate for the muscle and central nervous system is critical for the performance of both intermittent high-intensity work and prolonged aerobic exercise. Therefore, strategies that promote carbohydrate availability, such as ingesting carbohydrate before, during and after exercise, are critical for the performance of many sports and a key component of current sports nutrition guidelines. Guidelines for daily carbohydrate intakes have evolved from the “one size fits all” recommendation for a availability for competition (“train low, compete high”), based on observations that the intracellular signaling pathways underpinning adaptations to training are enhanced when exercise is undertaken with low glycogen stores. The present literature is limited to studies of “twice a day” training (low glycogen for the second session) or withholding carbohydrate intake during training sessions. Despite increasing the muscle adaptive response and reducing the reliance on carbohydrate utilization during exercise, there


Train low, perform high

Is it a lack or surplus of CHO that triggers adaptations?

Adaptation is related to accumulation of specific proteins
Gene expression for changes in protein concentration critical factor

Glycogen (low) training
- Transcription of IL-6, pyruvate dehydrogenase, hexokinase, HSP72


Training ‘high’ or ‘low’

Training ‘high’ or ‘low’

Training twice every second day:
1) Increased CS activity
2) Amplified overall

Enhanced oxidative metabolism
Could this support diet?


Fuelling during exercise

Maintain euglycemia for longer at 70% VO\textsubscript{2\text{max}}.

But PL maintained until 1.5hrs constant!

High CHO\textsubscript{TOT}
Possible GLYCOGEN\textsubscript{(LIVER)} sparing

Improved motor skills/ CNS activity

Beware GI distress


Fluid availability

Figure 4: Influence of Beverage Ingestion on Plasma Deuterium Enrichment

* = significantly different from placebo (P<0.05)
# = significantly different from placebo (P<0.01)
$ = significant difference between MD and MD+F (P<0.05)
# Nutritional "Trainability"

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>TOTAL Carbohydrate Oxidation (g/min)</th>
<th>TOTAL Exogenous Carbohydrate Oxidation (g/min)</th>
<th>TOTAL Fat Oxidation (g/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2.94</td>
<td>1.71</td>
<td>0.81</td>
</tr>
<tr>
<td>20</td>
<td>3.50</td>
<td>1.64</td>
<td>0.67</td>
</tr>
<tr>
<td>40</td>
<td>3.57</td>
<td>1.66</td>
<td>0.65</td>
</tr>
<tr>
<td>60</td>
<td>3.32</td>
<td>1.67</td>
<td>0.79</td>
</tr>
<tr>
<td>80</td>
<td>3.59</td>
<td>1.89</td>
<td>0.71</td>
</tr>
<tr>
<td>100</td>
<td>3.89</td>
<td>2.09</td>
<td>0.62</td>
</tr>
</tbody>
</table>


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# Nutritional Periodisation

## Case Study: Nutrition and Training Periodization in Three Elite Marathon Runners

**Trent Stellingwerff**

Laboratory-based studies demonstrate that fueling (carbohydrate, CHO) and fluid strategies can enhance training adaptations and race-day performance in endurance athletes. Thus, the aim of this case study was to characterise several periodized training and nutrition approaches leading to individualized race-day fluid and fuelling plans for 3 elite male marathoners. The athletes kept detailed training logs on training volume, pace, and subjective ratings of perceived exertion (RPE) for each training session over 16 wk before race day. Training intensity and load calculations (TRIMP: min x RPE x load [arbitrary units; AU]) and 2 central nutritional techniques were implemented: periodic low-CHO-availability training and individualized CHO- and fluid-intake assessments. Athletes averaged ~13 training sessions per week for a total average training volume of 182 km/wk and peak volume of 231 km/wk. Weekly TRIMP peaked at 4,487 AU (Wk 9), with a low of 1,887 AU (Wk 16) and an average of 3,026 ± 446 AU. Of the 606 total training sessions, ~74%, 11%, and 15% were completed at an intensity in Zone 1 (very easy to somewhat hard), Zone 2 (at lactate threshold) and Zone 3 (very hard to maximal), respectively. There were 2.5 ± 2.3 low-CHO availability training bouts per week. On race-day athletes consumed 61 ± 15 g CHO in 400 ± 156 mL/hr (80% ± 80% CHO solution) in the following format: 15 g CHO in 150 mL every ~15 min of racing. Their resultant marathon times were 2:11:23, 2:12:39 (both personal bests), and 2:16:17 (a marathon debut). Taken together, these periodized training and nutrition approaches were successfully applied to elite marathoners in training and competition.


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# Nutritional Periodisation

- **Low CHO Availability Training**
- **CHO Fueling Practice**

*Haile Gebrselassie 2:06:35 – no water; 2008 – 2:03:59 – 60-70g/hr*

Macronutrient Intakes: Subject 2 (Elite)

- TOTAL Energy intake: 2164 kcal/d average
- Relatively good CHO intake: 3.00g/kg/d – low GI load (25.8%)  
- PUFA (inc. MUFA) = 24.7g/d
- Saturated fat content = 17.6 g/d moderate (29.2% of total fats)
- Protein intake 2.06g/kg/d – high
- Water intake: 4.15 L/d

Micronutrient Intakes: Subject 2 (Elite)

<table>
<thead>
<tr>
<th>Food</th>
<th>VITAMINS</th>
<th>MINERALS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S2</td>
<td>RNI</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Egg scrambled, egg on a</td>
<td>A (µg/d)</td>
<td>Magnesium (mg/d)</td>
</tr>
<tr>
<td>wholesome baget</td>
<td>1473.3</td>
<td>355</td>
</tr>
<tr>
<td>Banana</td>
<td>C (mg/d)</td>
<td>143</td>
</tr>
<tr>
<td>Jacket potato with tuna</td>
<td>E (µg/d)</td>
<td>9.00</td>
</tr>
<tr>
<td>mayonnaise</td>
<td>4.12</td>
<td></td>
</tr>
<tr>
<td>Apple</td>
<td>B6 (mg/d)</td>
<td>3.48</td>
</tr>
<tr>
<td>Roast chicken, green</td>
<td>B12 (µg/d)</td>
<td>3.60</td>
</tr>
<tr>
<td>potatoes, broccoli,</td>
<td>1.5-2</td>
<td></td>
</tr>
<tr>
<td>carrots, peas</td>
<td>D (µg/d)</td>
<td>3.56</td>
</tr>
<tr>
<td>2500 - 3000ml of water</td>
<td>1.10</td>
<td></td>
</tr>
<tr>
<td>throughout the day</td>
<td>10-50</td>
<td></td>
</tr>
</tbody>
</table>

1. Generally consuming close to or above the RNI
2. Increased training demand for antioxidants, zinc, selenium, B vitamins, vitamin D, vitamin C and E as example
3. Note calcium intake lower

Performance & Observations

Marathon Performance

- 2010 - 2:52.54
- 2012 - 2:41:49 (~6.4% since 2010)
- 2014 - 2:34:30 (~4.5% since 2012)
- **2015 – 2:29:47 (PB)**

Increased mileage in training routines
Improved structure to training
Improved P:W

Lower calories?
Less reliance of carbohydrate generally
More reliance on protein
Long term fat adaptation

Table 1. The dietary content of the prescribed diets and the daily habitual and experimental dietary energy and nutrient intake

<table>
<thead>
<tr>
<th></th>
<th>Habitual diet</th>
<th>Experimental diet</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FAT</td>
<td>CHO</td>
</tr>
<tr>
<td>Energy (MJ)</td>
<td>13.3 ± 0.8</td>
<td>13.9 ± 0.9</td>
</tr>
<tr>
<td>Protein (%)</td>
<td>14.0 ± 0.4</td>
<td>13.0 ± 0.7</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>109 ± 7</td>
<td>105 ± 7</td>
</tr>
<tr>
<td>Carbohydrate (%)</td>
<td>54.2 ± 3.6</td>
<td>52.4 ± 3.7</td>
</tr>
<tr>
<td>Carbohydrate (g)</td>
<td>424 ± 33</td>
<td>429 ± 33</td>
</tr>
<tr>
<td>Fat (%)</td>
<td>29.1 ± 5.0</td>
<td>29.9 ± 5.0</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>102 ± 12</td>
<td>111 ± 15</td>
</tr>
<tr>
<td>P:S ratio</td>
<td>0.50 ± 0.12</td>
<td>0.24 ± 0.07</td>
</tr>
</tbody>
</table>

But not ketogenic (<50g)


Figure 4: Effect of a high-fat or high-carbohydrate (CHO) diet on endurance capacity in athletes who were engaged in a training program. Data from Helge et al., 1998a, 1996.


Long term fat adaptation

62% fat
21% carb
7 weeks

Substrate oxidation (% of energy)

Keto-adaptation

Figure 1. The rate of fat use during exercise at 65% VO_{2max} is reduced overall (Phinney et al., 1983) compared to peak fat oxidation rates recorded in 350 people that included regularly trained individuals (Volek et al., 2005).


Table II. Endurance capacity and fuel use before and after keto-adaptation in athletes

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Four-week ketosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>VO_{2max} (L/min)</td>
<td>5.1</td>
<td>5.0</td>
</tr>
<tr>
<td>Endurance @65% VO_{2max} (min)</td>
<td>147</td>
<td>151</td>
</tr>
<tr>
<td>Exercise RQ (VCO_{2}/VO_{2})</td>
<td>0.83</td>
<td>0.72</td>
</tr>
<tr>
<td>Pre-exercise muscle glycogen (mmol/kg w.w.)</td>
<td>143</td>
<td>76</td>
</tr>
<tr>
<td>Post-exercise muscle glycogen (mmol/kg w.w.)</td>
<td>56</td>
<td>53</td>
</tr>
<tr>
<td>Change muscle glycogen (mmol/kg)</td>
<td>87</td>
<td>23</td>
</tr>
</tbody>
</table>

Source: Adapted from Phinney, Bistrian, Evans, et al. (1983).


Histone deacetylase (HDAC) enzymes
Gene-silencing when active
Reduced antioxidant protection

Regulation of CPT1 by AMPK thought to be a primary mediator of up-regulation of FA oxidation, even after CHO restoration.


Nutritional modulation

General Preparation
Specific Preparation
Competitive Preparation

Adaptive
Nutritional needs
Metabolic regulation
Low CHO
Ketogenic?
Immunostimulating
Maximising recovery

Tolerance
Increased nutritional needs
High LOW days
Nutrient modulation
Antioxidant and GI protection
Immunostimulating
Managing recovery

Refine
Competitive preparation
GI tolerance
Low residual diet
Antioxidant loading?
Absolute strategies

“Nutritional Hormesis”


Nutrient Modulation

Caloric restriction mimetics: towards a molecular definition
Frank Mifsud, Federico Petracca, Istvan Eisenberg and Guido Kroemer
Abstract (Caloric restriction, be it constant or intermittent, is required to have health-promoting and lifespan-extending effects. Caloric restriction mimetics (CRMs) are compounds that mirror the biochemical and functional effects of caloric restriction. In this Opinion article, we propose a unifying definition of CRMs, as compounds that stimulate autophagy by favouring the deacetylation of signalling proteins. This deacetylation process can be achieved by three classes of compounds that deplete acetyl coenzyme A (AcCoA): the sole donor of acetyl group, that inhibit acetyl transferases (e.g.- group of enzymes that acetylate lysine residues in an array of proteins) or that stimulate the activity of deacetylases and hence reverse the action of acetyl transferases. A unifying definition of CRMs will be important for the continued development of this class of therapeutic agents.

Antioxidant Support

- MicroCell® Curcumin Plus
  - High potency, bioavailable antioxidant support
  - Curcumin, ginger, ursolic acid & oligopin™ (pine bark)
  - 90 size/3 caps daily

- Flavonoid Complex
  - Very high potency flavonoid complex
  - With grapeseed, green tea, quercetin, bilberry, hesperidin, rutin, naringin, gingko and acerola cherry
  - 60 size/2 caps daily

- Antioxidant Complex
  - All round antioxidant
  - Turmeric, quercetin, green tea, lycopene, lutein & vitaflavan™
  - 90 size/1-3 caps daily

Adaptive nutrients/ botanicals

- Thermogenesis
  - Bitter orange (citrus aurantium)
  - Guarana (paullinia cupana)
  - HCA (garcinia cambogia)
  - Glycosides (Naringin – grapefruit; Hesperidin – oranges, lemons)

- Cell signalling/AMPK activation
  - Polyphenols: catechins (green tea), quercitin, resveratrol (red grapes)
  - Capsaicin, curcumin

Bitter orange (citrus aurantium)

- Protoalkaloid (p-synephrine)
  - On WADA 2015 monitoring programme!

- B3-adrenoreceptors

- Stohs1 et al (2011) (50mg bitter orange + 600mg naringin + 100mg hesperidin = 183kcal increased in BMR)

- Higher dose of hesperidin reduced BMR improvement

Guarana (Paullinia cupana)

- Caffeine/polyphenols
- Stimulant effect
- Often used in combination
  1. Ma-Huang – Guarana herbal for 8 weeks
  2. Combination: 6mg synephrine, 150mg caffeine, 150mg catechins
- Increased CHOox!


(-)-hydroxycitrate

- Garcinia cambogia
- Competitive inhibitor of ATP-citrate lyase
  - Reduces malonyl-CoA
  - 18±0.4g HCA
- Good bioavailability
  - In trained subjects no effect on fat oxidation
  - Yet 500mg HCA for 5 days in untrained influenced RER²
- Kriketos³ – no effect in fasting state (3g/d HCA for 3 days)


Garcinia Cambogia Plus

Garcinia Cambogia Plus 1.5g
(40% hydroxycitric acid) with manganese, chromium, vitamins B5 and C
90 size/3 caps daily
Flavonoids – catechins
Epigallocatechin gallate (EGCG) suggested to inhibit catechol-O-methyltransferase (COMT)
Noradrenaline effects more sustained
Increased fat oxidation

Increased EE at rest (90mg)\(^1\)
Increased TEE 17% (366mg + 890mg polyphenols)\(^2\)
Enhanced bioavailability with vitamin C
Possible combination with caffeine
Performance: 3-9mg/kg caffeine offers better potential\(^3\)

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Current Supplementation: Green Tea
EGCG not caffeine?
High dose?
Increased fat gene expression

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Quercetin
Quercetin increases brain and muscle mitochondrial biogenesis and exercise tolerance.

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Quercetin Plus
Quercetin, bromelain, nettle & green tea
90 size/3 caps daily

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Informed Sport Range

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