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Evolution of carbohydrate guidelines for sports performance

ILSI SEA
Carbohydrate Intakes – high , low or irrelevant?
19th March 2013

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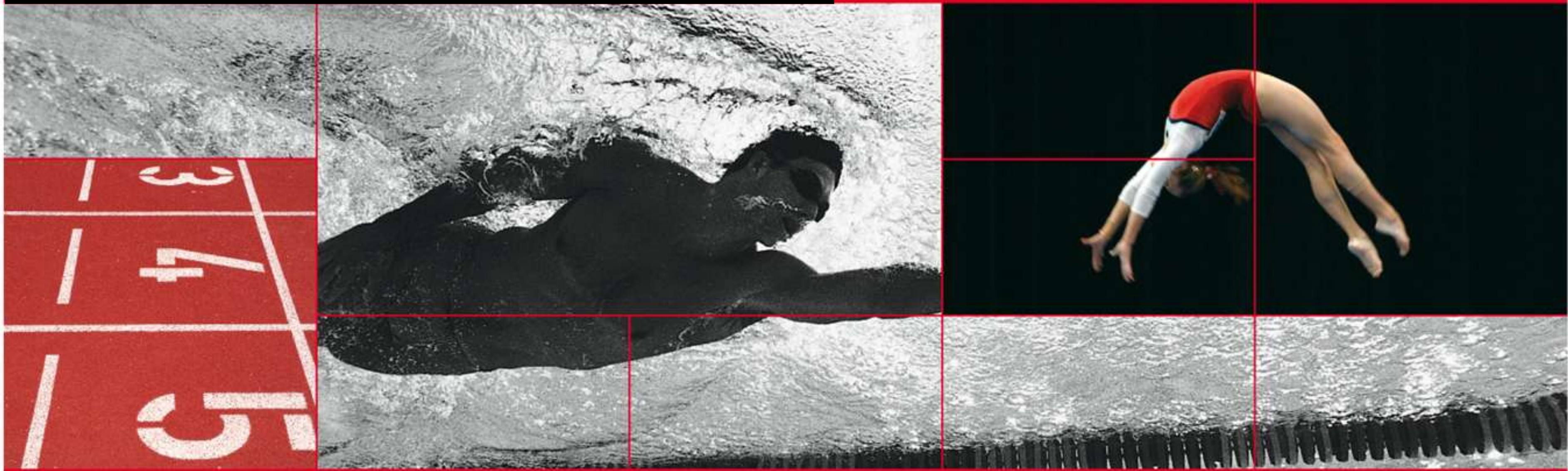
Dept of Sports Nutrition
Australian Institute of Sport



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1990s sports nutrition:
everyday diet/recovery

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Former Guidelines: 1991

- In the optimum diet for most sports, carbohydrate is likely to contribute about 60-70% of total energy intake.
- Carbohydrate intake after exhaustive exercise should average 50 g per 2 hours of mostly moderate and high glycaemic carbohydrate foods. The aim should be to ingest a total of about 600 g in 24 hours.

~~Athletes should eat **60-70%** of their energy intake from carbohydrates~~

Coyle. J Sports Sci 1991;9:29-52.

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Amount of CHO intake and muscle glycogen storage

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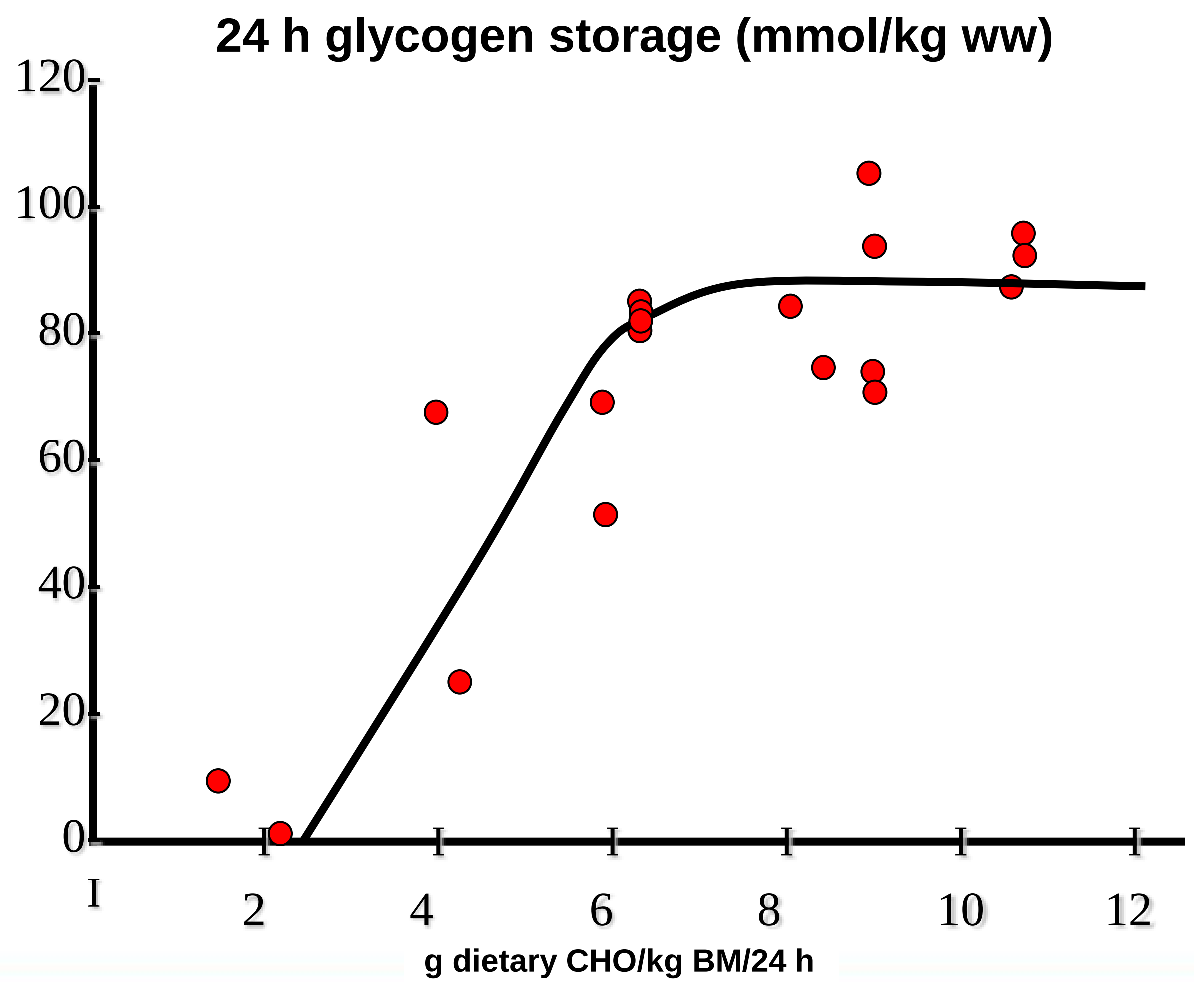
- *Costill et al. Am J Clin Nutr 1981; 34: 1831-6*
- *Burke et al. J Appl Physiol 1993; 75: 1019-23*
- *Burke et al. J Appl Physiol 1995; 78: 2187-92*
- *Burke et al. Am J Clin Nutr 1996; 64: 115-9*
- *Parkin et al. Med Sci Sports Exerc 1997; 29: 220-4*
- *Starling et al. J Appl Physiol 1997; 82: 1185-1189.*

Burke et al. J Appl Physiol 2005; 95:983-990



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2003 Guidelines for carbohydrate intakes in the everyday training diet

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"Athletes should aim to achieve carbohydrate intakes to meet the fuel requirements of their training program and to optimise restoration of muscle glycogen stores between workouts"

International Olympic Committee
2003 Consensus conference on Nutrition for Sport

- **Light training schedule or moderate training schedule for athletes with large BM or energy restriction: 3-5 g/kg/d**
- **Moderate training schedule: 5-7 g/kg/d**
- **Heavy training schedule: 7-10 g/kg/d**
- **Extreme training: 10-12** g/kg/d

Optimising fuel support for training

= training better, training harder

Burke et al. J Sports Sci 2004; 22: 15-30

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Terminology

= g/kg rather than % energy

Burke et al. J Sports Sci 2004; 22: 15-30

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Guidelines are "ball park" figures

- **fine tune with individual consideration of total energy needs, specific training needs and feedback from training performance**

Burke et al. J Sports Sci 2004; 22: 15-30

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2010 Guidelines for carbohydrate intakes in the everyday training diet

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"When it is important to train hard or with high intensity, daily carbohydrate intakes should match the fuel needs of training and glycogen restoration."

Low intensity or skill-based activities: Moderate training program for athletes with large BM or energy restriction	3-5 g/kg of athlete's body mass (BM)/d
Moderate exercise program (i.e. ~1 hr per day)	5-7 g/kg/d
Endurance program (e.g. 1-3 h/d mod-high intensity exercise)	6-10 g/kg/d
Extreme commitment (i.e., >4-5 h/d mod-high intensity exercise	8-12 g/kg/d

Terminology change

- **high carbohydrate availability rather than high carbohydrate *per se***

(a diet with high carbohydrate availability may not contain large amounts of carbohydrate)

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2010 Strategies to promote muscle glycogen storage

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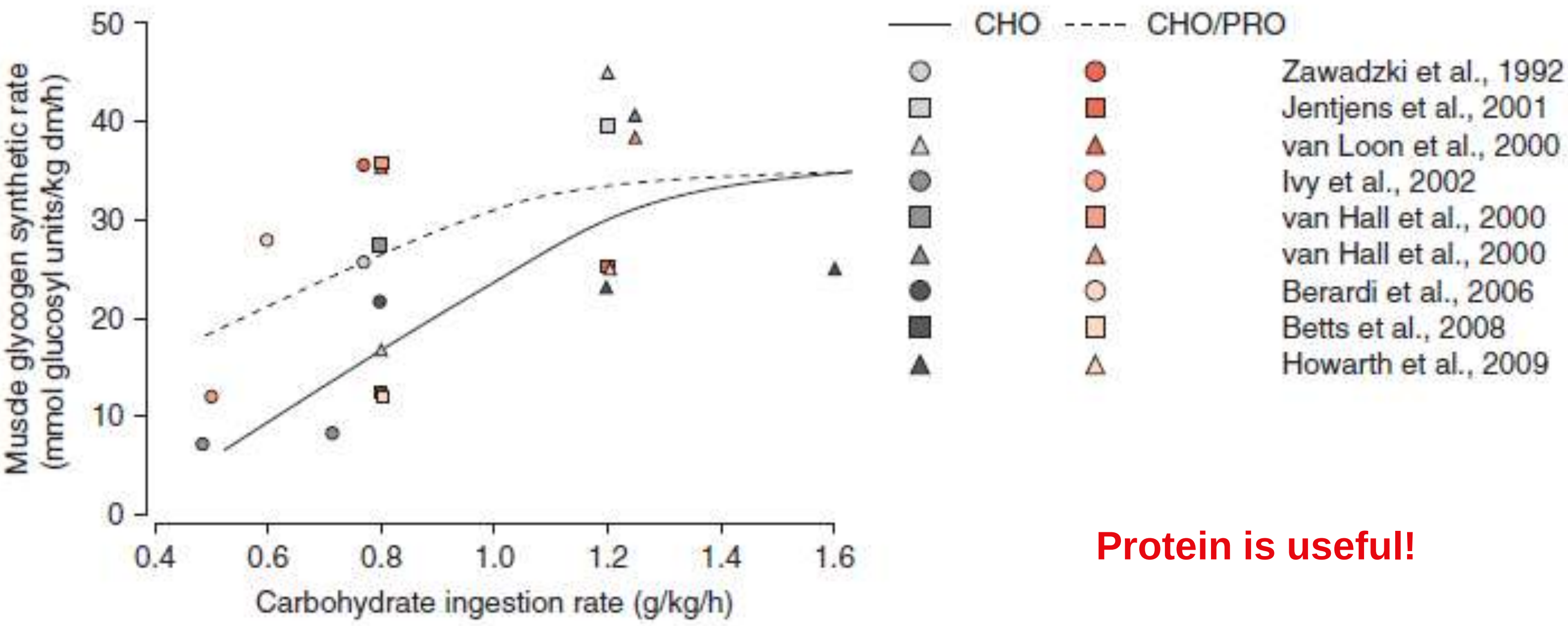
- **There may be some ways to enhance glycogen storage from same carbohydrate intake. This could be important if total intake is sub-optimal (energy restrictions, poor appetite, poor access to food)**



Protein is useful!

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2010 Recognition of acute fuelling strategies

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These strategies promote high carbohydrate availability for optimal performance in competition or key training sessions		
Carbohydrate loading	• Before important exercise > 90 min	8-10 g/kg/d for 24-48 h
Pre-event fuelling	• Before exercise > 60 min	1-4 g/kg consumed 1-4 hr before exercise
Fuelling during exercise		
Speedy refuelling	• < 8 h recovery between 2 fuel demanding sessions	1-1.2 g/kg/h for first 4 h then resume daily fuel needs

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2003 guidelines for carbohydrate intake during exercise

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- During exercise > 60 min that would otherwise cause fatigue
- 30-60 g/h
- Experiment to find a personalised plan

International Olympic Committee
2003 Consensus conference on Nutrition for Sport

- Variety of mechanisms by which carbohydrate intake can enhance performance
- Sports and individuals vary with their needs and opportunities to refuel
- No evidence of a dose response
- Carbohydrate oxidation capped at 1 g/min

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2010 guidelines for carbohydrate intake during exercise

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Type of exercise		Carbohydrate guideline	Comments
Brief events	**< 45 min**	Not needed	
Sustained high intensity events	**45-75 min**	Small amounts provided regularly (including mouth rinse)	• Effects on the CNS
Endurance events including "stop and start" sports	**1-2.5 h**	30-60 g/h	• Opportunities to consume foods and drinks vary according to the rules and nature of each sport
Ultra-endurance events	**> 2.5-3 h**	Up to 90 g/h	• Higher intakes associated with better performance • "Multiple transportable carbohydrates" (Glucose:fructose mixtures) achieve high rates of carbohydrate oxidation • Gut is trainable

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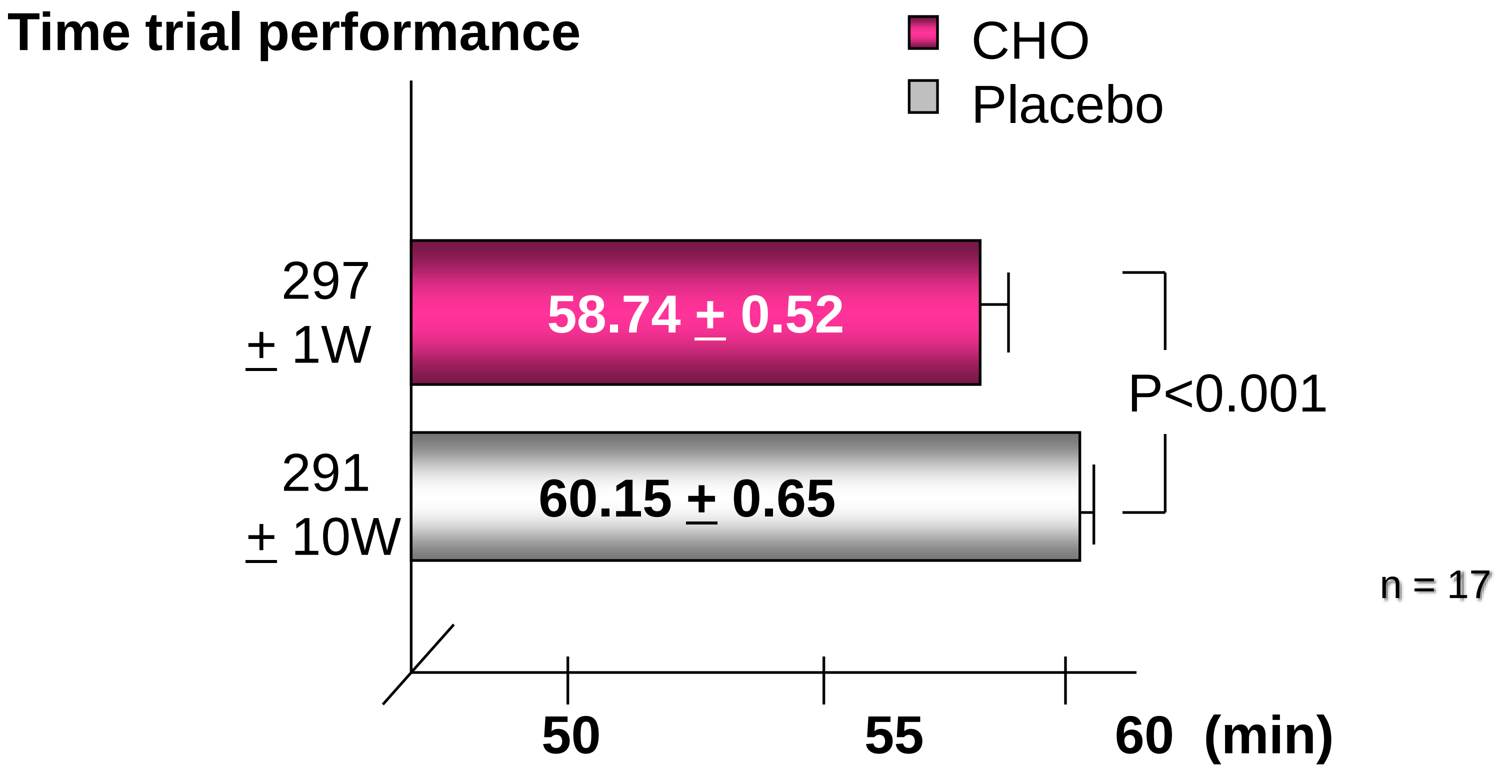
Carbohydrate intake during events NOT limited by muscle fuel



Jeukendrup et al. Int. J. Sports Med 18: 125-129, 1997

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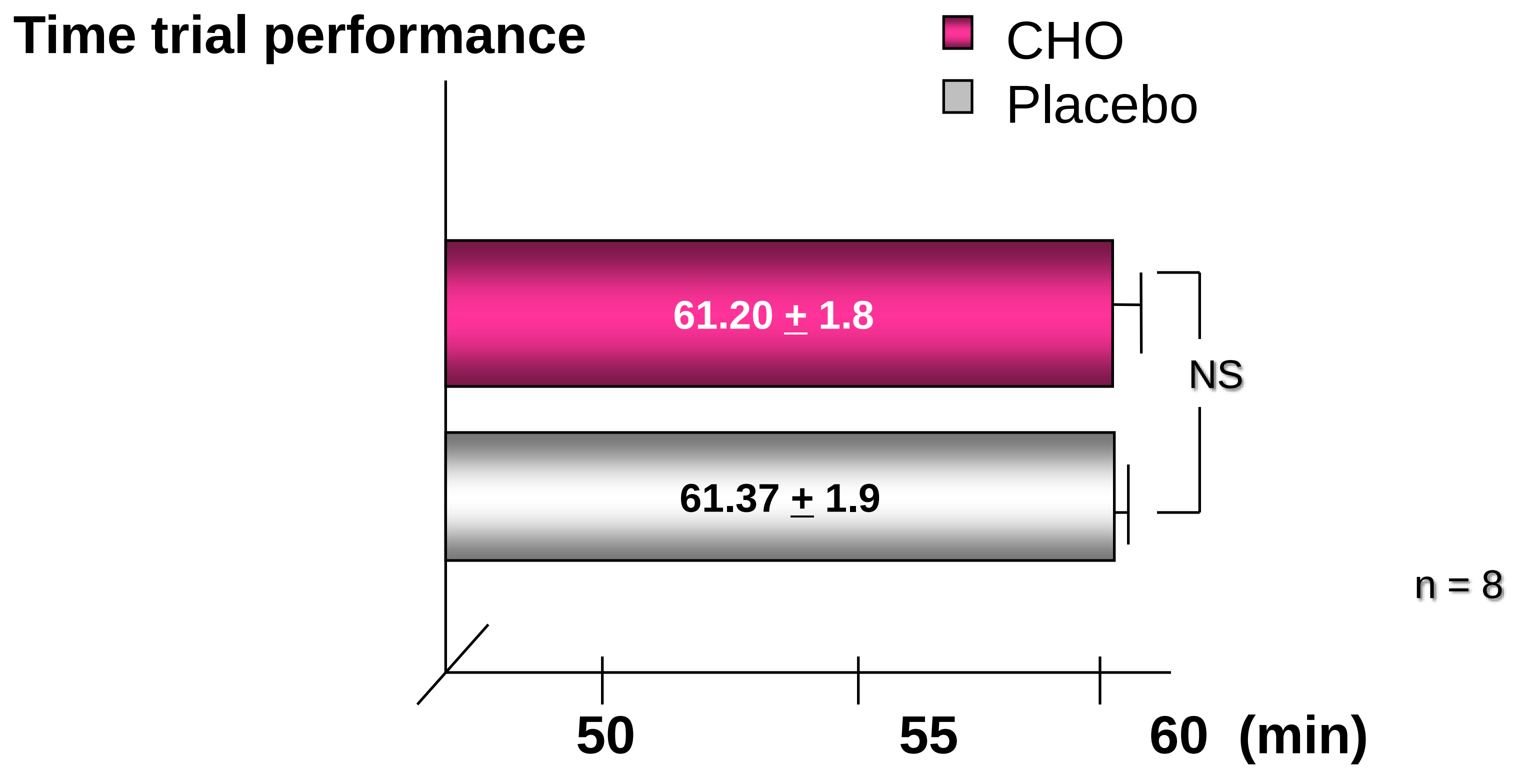
Carbohydrate infusion doesn't aid events not limited by muscle fuel



Carter et al. Med Sci Sports Exerc 2004; 36:1543-1550.

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Carbohydrate "sensing" by CNS during events not limited by muscle fuel

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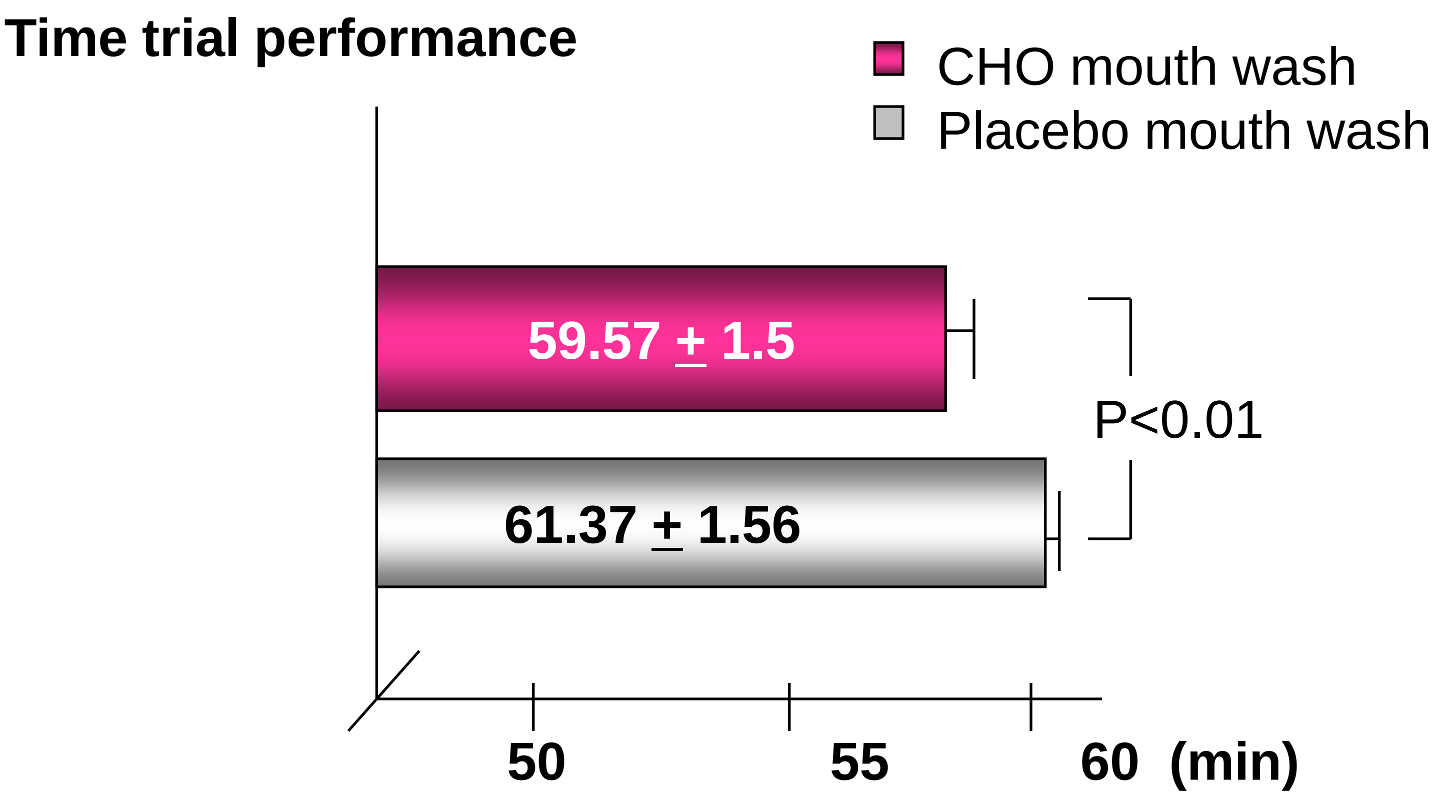

Carter et al Med Sci Sports Exerc 2004; 36 : 2107-2111

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Carbohydrate mouth rinse studies

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Study	Performance	outcome
Carter et al 2004	1 h cycling	2.8% improvement
Pottier et al. 2008	1 h cycling	3.7% improvement
Rollo et al. 2008	30 min running	2.0% improvement
Rollo et al. 2009	1 h running	2.0% improvement
Chambers et al. 2009	1 h cycling	1.9% improvement
Beelen et al. 2009	1 h cycling	NS
Witham & McKinney 2007	1 h running	NS

Undertaken after pre-event CHO meal

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Chambers et al. 2009	1 h cycling	1.9% improvement
Beelen et al. 2009	1 h cycling	NS
Witham & McKinney 2007	1 h running	NS
Lane et al 2013	1 h cycling	1% fed 3% fasted

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Carbohydrate mouthwash during exercise and the brain

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- Performance of 1 h cycling with mouth rinse
- fMRI study at rest
  - Activation of “reward” centres of brain
- Glucose ≠ Saccharin
- Glucose = Maltodextrin

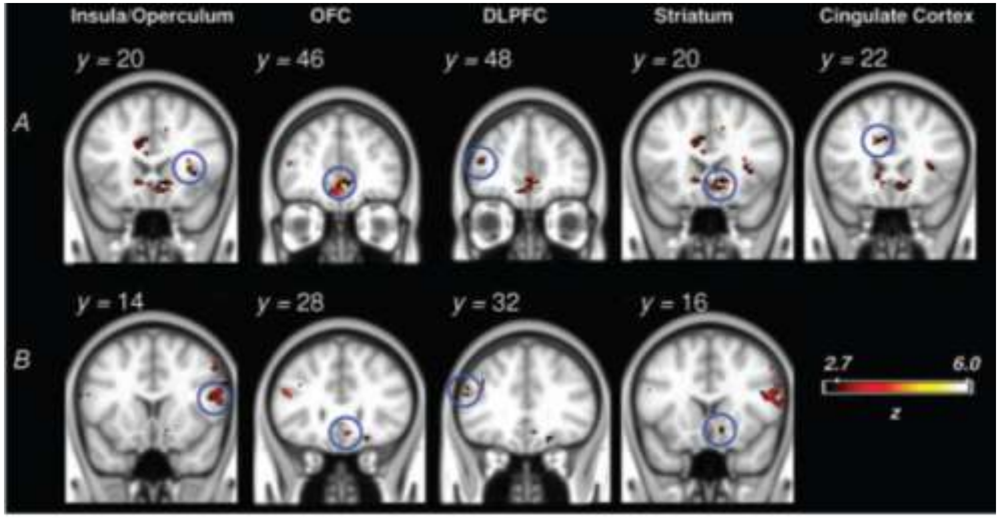

Figure 6. Activations in the insula/frontal operculum, the orbitofrontal cortex (OFC), the dorsolateral prefrontal cortex (DLPFC), the striatum, and the cingulate cortex by the contrasts *A*, [Glucose – Control] and *B*, [Maltodextrin – Control]

Chambers et al. J Physiol 2009; 587: 1779-1794

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Role of substrate availability in training adaptation

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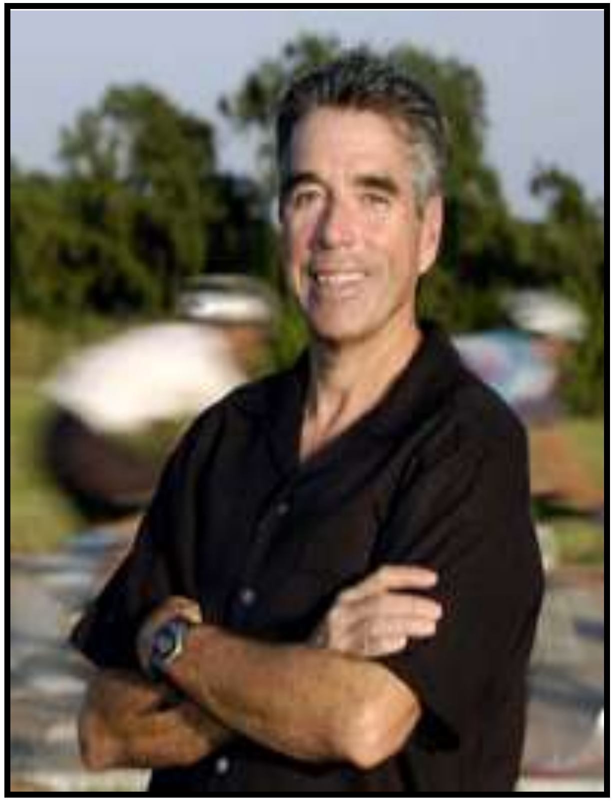
Although it is generally assumed that optimal adaptation to the demands of repeated training sessions requires a diet that can sustain muscle energy reserves, this premise does not consider the unsolved longstanding question of whether it is a lack or surplus of a substrate that triggers the training adaptation."



Coyle. Am J Clin Nutr 72: 512S-520S, 2000.

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Strategies to promote low carbohydrate availability

- Low carbohydrate/high fat diet
- Scheduling training sessions to leave little time for refuelling between sessions (Twice a day training)
- Training after overnight fast
- Training without carbohydrate intake during session
- Withholding carbohydrate during first phase of recovery

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New paradigms for training: Promoting greater adaptation

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1. Fat adaptation and carbohydrate restoration

5 d high fat diet + 1 d glycogen restoration + event fuelling strategies

- enhanced fat oxidation
- No performance improvement
- Carbohydrate impairing rather than carbohydrate sparing

  (loss of "top gear" for event defining activities)

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New paradigms for training: Promoting greater adaptation

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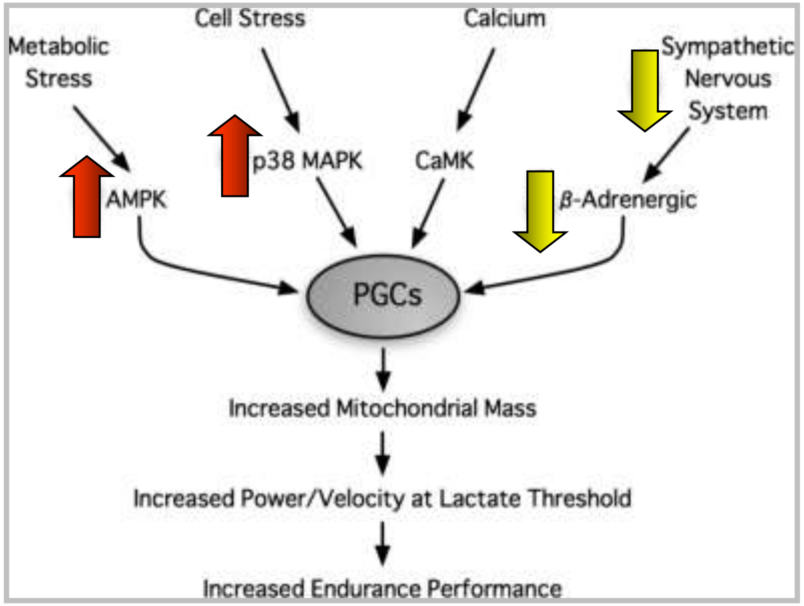
2. "Train Low" (carbohydrates)

Twice a day training (train 50% low)

Train overnight fasted

- Increase in cell signalling
- Increase in cellular adaptations (fat oxidation, glycogen storage)
- No effect on performance gains in already trained individuals
- Impairment of training intensity
- Periodisation into training program?



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New paradigms for training: Promoting greater adaptation

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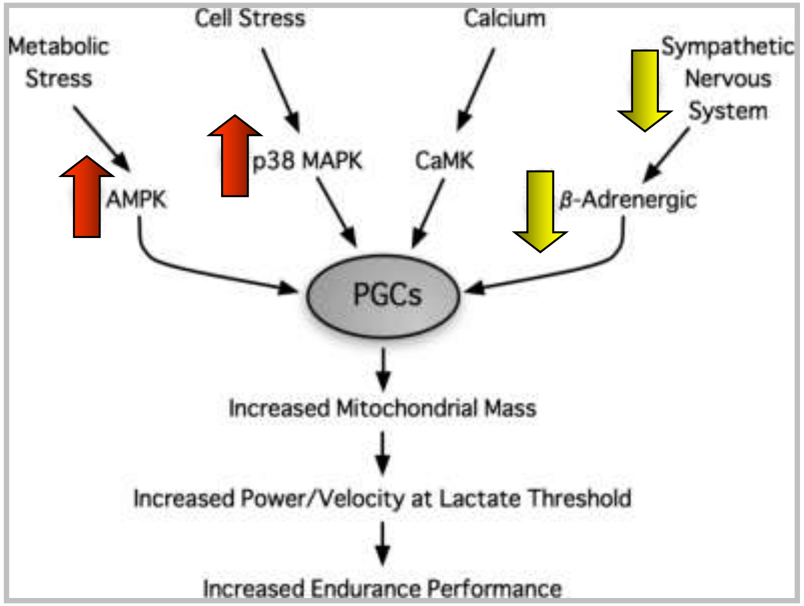
3. "Sleep low" (carbohydrates)

Key training session at night

Delay glycogen restoration

- Prolongation of elevated cell signalling
- Increase in cellular adaptations (fat oxidation, glycogen storage)
- No effect on training intensity?
- Performance gains?
- Periodised into training program?



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Summary

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1. Carbohydrate plays a key role in exercise capacity and sports performance
2. Carbohydrate has played a key role in the development of sports nutrition
3. Terminology of carbohydrate guidelines is important
4. There is always something new!

Research milestones

1900-1930s: RER, exercise capacity
1960s Muscle biopsies – glycogen supercompensation
1980s Tracer technology – exogenous carbohydrate oxidation
2000s Cell signalling – train low with carbohydrates
2020s? "Brain scans"

Practice milestones

1920s Carbohydrate intake during Boston marathon
1960s Carbohydrate loading
1980s Sports drinks
2010 New sports products with multiple transportable CHOs