LOW CARBOHYDRATE DIETS FOR ATHLETES

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OVERVIEW

- When and why an athlete may use a low-carb intake strategy
- Benefits and limitations of “Train Low”
- Altering carbohydrate availability
- Ketone supplements

Carbohydrate is the predominant fuel source for most exercise

But…

POPULAR TRENDS

Low Carb, Keto and Paleo diet plans have become popular amongst the general population.

It is often confusing for athletes to understand the difference between meeting their energy demands and messages from the popular media.

RECOMMENDATIONS

In general, team-sport athletes should eat a carbohydrate-rich diet during their competitive season to maintain glycogen stores and support performance.

If an athlete is interested in one of the low-carb eating styles, the appropriate time is during the off-season, or when injured.

The ideal scenario is to work with a sports dietitian to personalize carbohydrate intake through a training cycle to adequately meet energy demands and goals.

If you're an endurance athlete looking to improve performance, why might you consider trying a low carbohydrate diet?

BENEFITS

Endurance athletes may benefit from *periods* of lower carbohydrate intake during their training, still focusing on higher carbohydrate intakes to support performance.

This concept is often referred to as “train low”.

Altering amounts of carbohydrate intake should be individualized based on the training cycle and goals.

TRADITIONAL APPROACH: CHO & ENDURANCE

Promotion of high CHO availability for performance and recovery

- Before, during, after training sessions
- Ensure adequate muscle glycogen storage
- Amount based on activity, intensity, & duration
- Associated with "carbohydrate loading", or a period of greater carbohydrate intake leading up to a competition

Bartlett, Hawley, Morton. EJSP. 2015;15(1):3-12

METABOLIC ADAPTATIONS

Metabolic Adaptations to Endurance Training

- Increased fat oxidation (lower RER)
- Slower utilization of CHO substrate
- Less lactate production
- Increased muscle glycogen storage
- Higher maximal rates of CHO oxidation

How can you manipulate nutrients to further enhance endurance performance?

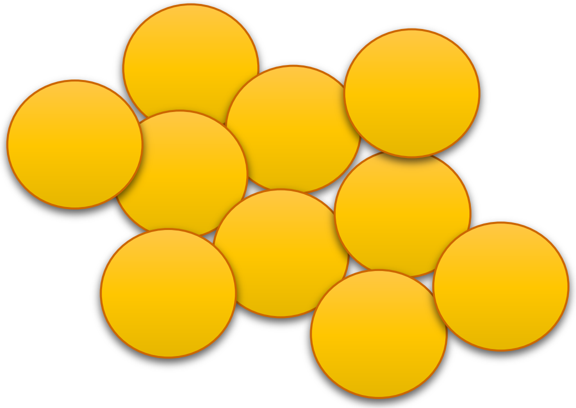
- ‘Spare” CHO substrates
- Further enhance rates of fat oxidation

Leckey & Hawley. *Sport Science Exchange.* 2018;29(184):1-6

METABOLIC ADAPTATIONS

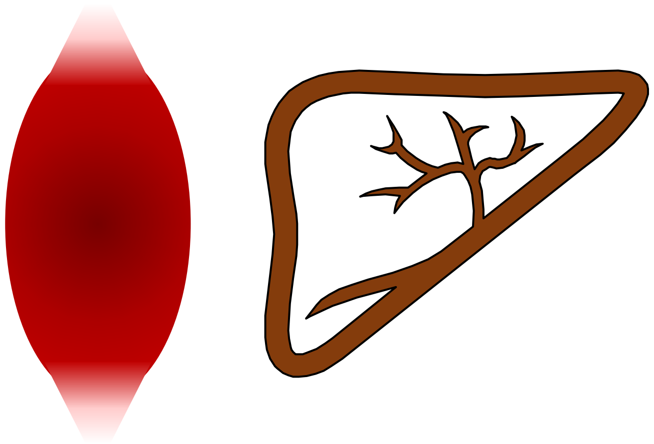
Is there a way to alter the availability and utilization of fuels to improve endurance performance?

Fat Stores



>30,000 kcal
(even in a very lean athlete)

Carbohydrate Stores



~2 ,000 kcal

What Do You Think?

Could training on a low carbohydrate diet promote adaptations to improve fat utilization?

"Train low, compete high": By providing carbohydrate for competition, can the combination of improved fat oxidation and carbohydrate substrate for competition improve endurance performance?

What could be some of the drawbacks of this approach?

TRAIN LOW

Area of research was developed by Dr. Louise Burke at the Australian Institute of Sport.

In collaboration with Dr. John Hawley and several others, the concept has been studied over the past couple of decades.

The strategy of training with low carbohydrate availability and providing carbohydrate for competition does not improve performance, in fact in many cases performance is impaired.

Burke, LM. *Sports Med. 2015;*45(1):S33-49

TRAIN LOW

However, this area of research along with trial by practitioners working with athletes, has evolved to incorporation of periods of low carbohydrate availability during training.

Sports nutrition guidelines are not "one size fits all", including the use of a train low strategy!

Hear Dr. Burke speak

Link to Video https://www.youtube.com/watch?v=Fh0EqE8zUOI

Burke, LM. *Sports Med. 2015;*45(1):S33-49

RATIONALE

Training in conditions of reduced CHO availability does promote training-induced adaptations in the skeletal muscle:

- Increased rates of fat oxidation
- Enhanced activation of cell signaling pathways
- Increased mitochondrial enzyme activities
- Increased mitochondrial content

LIMITATIONS

- Inability to maintain the desired training intensity
- Lower overall training impulse (volume x intensity)
- Increased susceptibility to illness
- Increased muscle protein breakdown
- Loss of skeletal mass

Exercising without regular exogenous CHO provision impairs ability to oxidize exogenous CHO.

This means carbohydrate consumed during competition will not be effectively used and performance is likely impaired.

Bartlett, Hawley, Morton. *EJSP*. 2015;15(1):3-12

RESEARCH

International Journal of Sport Nutrition and Exercise Metabolism, 2018, 28, 451-463
https://doi.org/10.1123/ijsnem.2018-0289

Human Kinetics
COMMENTARY

Toward a Common Understanding of Diet–Exercise Strategies to Manipulate Fuel Availability for Training and Competition Preparation in Endurance Sport

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"From the breakthrough studies of dietary carbohydrate and exercise capacity in the 1960s through to the more recent studies of cellular signaling and the adaptive response to exercise in muscle, it has become apparent that manipulations of dietary fat and carbohydrate **within training phases**, or in the immediate preparation for competition, can profoundly alter the availability and utilization of these major fuels and, subsequently, the performance of endurance sport (events >30min up to ~24 hr)."

What does it mean to alter carbohydrate availability?

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METHODS TO ALTER CHO AVAILABILITY

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Exercise-diet strategy	Main Effects
Athletes consume a chronically low CHO diet CHO intake less than fuel requirements for daily training sessions.	Low CHO availability (endogenous and potentially exogenous sources) for all training sessions, depending on degree of fuel mismatch. Possible negative effects on immune system and central nervous system (CNS).
Multiple daily training sessions Low exercise-induced muscle glycogen availability for the second/third session attained by limiting CHO intake during recovery from the first session.	Reduction in endogenous and exogenous CHO availability for contracting muscles during the second training session. Acute reduction in CHO availability for immune and CNS depending on duration of CHO restriction and muscle fuel requirements of second session.
Commencing training after an overnight fast	Reduction in exogenous CHO availability for the muscle for the specific session. Potential reduction in endogenous CHO availability if there is inadequate glycogen restoration from previous day's training. Acute reduction in CHO availability for immune and CNS depending on duration of CHO restriction and fuel requirements of the session.
Prolonged training with or without an overnight fast and/or restricting/withholding CHO intake during the session	Reduction in exogenous CHO sources for contracting muscles for the specific session. Acute reduction in CHO availability for immune and CNS depending on duration of CHO restriction and fuel requirements of the session.
Withholding carbohydrate during the first hours of recovery	Could provide adequate fuel availability for the session but restrict availability for post-exercise signalling activities.
"Train-high"-"Sleep-low" Undertaking intense glycogen-lowering training session in the evening, go to bed in fasted state (i.e., with low exogenous CHO availability).	Reduction in exogenous CHO availability for the muscle for next day's training session, resulting in lower-intensity workout. Effects on CNS (i.e., hypoglycaemia).

Adapted from Hawley and Burke (2010).

Hawley J. *Sport Science Exchange.* 2014;27(134):1-7

PRACTICAL APPLICATIONS

- Train in the fasted state or twice per day
  - Fasted = 6-10 h after meal
  - 2nd session performed with
    - Reduced glycogen stores &/or
    - Restricting CHO intake in the recovery period post exercise
  - Incorporate when training duration & intensity are not overly compromised
- Do not undertake during uncustomary training loads (supramaximal, prolonged, or intense sessions)
- To offset reduced training intensity athletes may ingest caffeine
- Ingest protein (20-25g) before, during, or immediately after exercise
  - Attenuate muscle protein breakdown & promote synthesis
  - AAs do not downregulate beneficial adaptations
- Undertaken along deliberate sessions of training high CHO
  - Competition fueling schedule
  - Simulate the demands of competition

REMAINING QUESTIONS

- How can you maintain exercise intensity?
- Should sessions be focused on achieving a set training load or completing as much work as possible?
- Who benefits most? Elite? Sub-elite? Recreationally active?
- Is there a glycogen threshold that needs to be met to activate?
- Does this strategy result in enhanced exercise performance?

Bartlett, Hawley, Morton. *EJSP*. 2015;15(1):3-12

A Method of Low Carbohydrate Availability: High Fat Diets

REMEMBER

Prolonged endurance exercise (> 90 min) relies on oxidative metabolism of carbohydrate and fat, requiring high rates of carbohydrate oxidation.

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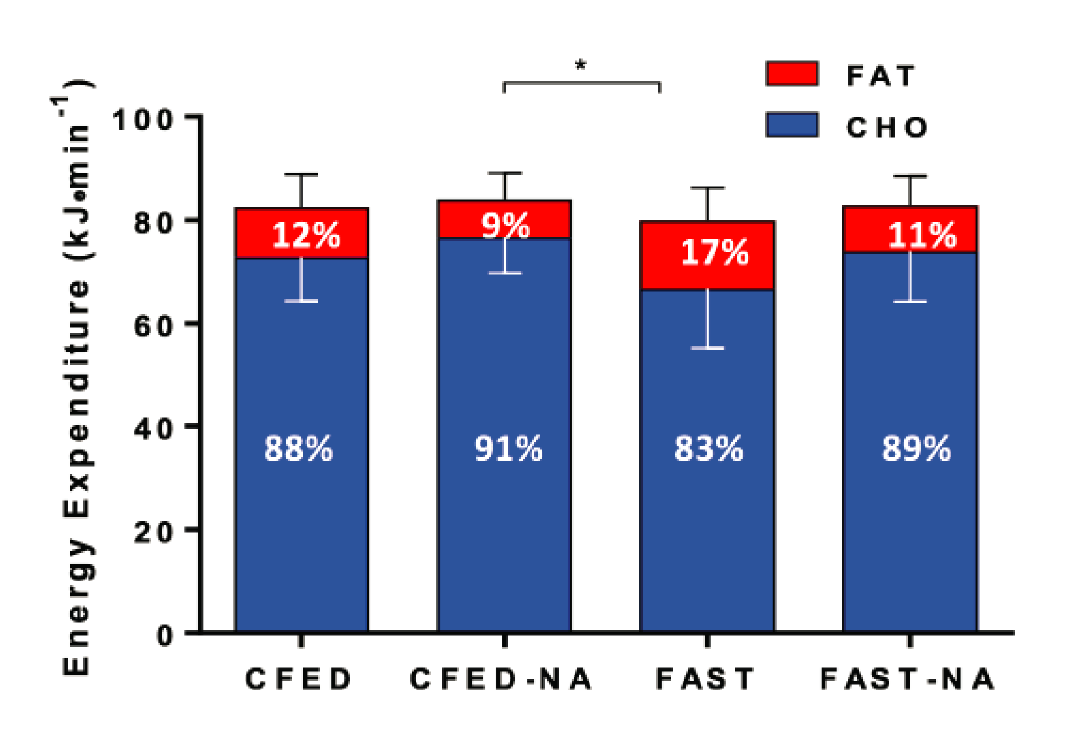

Figure 1. Estimated energy expenditure during half-marathon running for all experiemental trials. CFED carbohydrate trial; CFED-NA, carbohydrate with nicotinic acid trial; FAST, fasted trial; FAST-NA, fasted with nicotinic acid trial. Values are means ± SD. *CFED-NA significantly different than FAST, $P < 0.05$. Adapted from Leckey et al. (2016)

Can we maximize the contribution of fat to fuel muscular work via the ingestion of a high fat diet?

Increase utilization of fat stores

“Spare” limited CHO

HIGH FAT DIET (HFD) EXAMPLES

Example 1:

65% of energy intake from fat (~4 g/kg)

<20% energy from CHO (~2.5 g/kg)

Example 2:

Chronic ketogenic diet consists of

- <20 g/d CHO
- 80% energy intake from fat
  - ≈4.5-5 g/kg

HFD studies have demonstrated that transport, uptake, and oxidation of fat-based fuels can be increased further than training adaptations alone.

KETOGENIC DIETS & EXERCISE PERFORMANCE

29

World-Class Race Walkers, given one of the following diets during 3 weeks of intensified training:

HCHO
High Carb
8.6 g/d CHO
2.1 g/d PRO
1.2 g/d Fat

Periodized Diet
Timing of macronutrient content was altered around training to ensure specific sessions were performed in a low-CHO state

LCHF
Low Carb/High Fat
< 5.0 g/d CHO
2.2 g/d PRO
4.7 g/d Fat

Measured before and after the intervention:

1) Graded exercise test to measure walking economy
2) 25 km standardized walk (i.e., 20 km race pace) to incorporate both laboratory and field testing to assess changes to substrate utilization
3) 10 km International Association of Athletics Federation sanctioned race to measure performance

Burke, L. et al. (2017) *J. Physiol.* 595:2785-2807.

Leckey & Hawley. *Sport Science Exchange.* 2018;29(184):1-6

OUTCOMES

Graded Exercise Test

LCHF: RER reduced, greater O_2 cost during all 4 stages.

25 km Standardized Walk

LCHF: increased whole-body rates of fat oxidation from ~0.6 g/min to ~1.6 g/min when walking at 80% $\dot{V}O_2$peak, with the latter being the highest rates of fat oxidation ever to be reported in the literature.

10 km Race Walk Time

Only the HCHO and PCHO conditions improved their 10 km race-walk time, with no improvement measured in the LCHF condition.

This lack of performance improvement measured in the LCHF condition was associated in part with the greater O_2 consumption required to sustain the same speed as prior to the intervention.

Burke, L. et al. (2017) *J. Physiol.* 595:2785-2807.

Leckey & Hawley. *Sport Science Exchange.* 2018;29(184):1-6

CARBOHYDRATE RESTORATION

Goal: maximize the capacity for fat utilization while also optimizing glycogen stores.

HFD 5-6 days w/ training (60-70% energy intake from fat)

Followed by:

24-36 h of high CHO intake (70-80% energy intake from CHO)

Several different research studies have shown that this strategy:

- ✓ Increases fat oxidation
- ✗ Impairs carbohydrate metabolism
- ✗ Impairs exercise economy
- ✗ Does not improve performance

Leckey & Hawley. *Sport Science Exchange.* 2018;29(184):1-6

HFD SUMMARY

Longer periods of HFD consumption followed by quick carbohydrate restoration do not improve performance.

BUT short periods of HFD consumption do promote metabolic adaptations for fat metabolism.

Given the current research, athletes should periodize their CHO intake based on the goal, intensity and duration of a particular training session in order to maximize skeletal muscle adaptations.

Leckey & Hawley. *Sport Science Exchange.* 2018;29(184):1-6

GUIDELINES

- No longer recommend high CHO for **all** training sessions and competitions.
- Focus on matching CHO availability to the energy demands of training, considering duration & intensity of exercise.
- CHO intake should be individualized to raining and competition requirements.
- Athletes may train with low endogenous or exogenous CHO availability or delay the replenishment of CHO post training to promote skeletal muscle adaptation & improve performance.

KETONE SUPPLEMENTATION

While adaptations to a high fat diet for short-term or chronic periods has been well investigated, the effects of the resulting low carbohydrate intake have been researched less.

Ketone bodies can be used as an alternative fuel by the skeletal muscle and brain.

Production of ketone bodies is stimulated after periods of low carbohydrate, high fat intake.

KETONES

Ketone bodies:

- β-hydroxybutyrate (βHB)
- Acetoacetate (AcAC)
- Acetone (mostly lost through breath and urine)

βHB and AcAC

- Used by heart, brain, and skeletal muscle
- Can be measured in the circulation

Circulating ketones are usually low, increase with:

- Overnight fasting
- Fasted exercise
- Prolonged fasting/ starvation (5d)
- Ketogenic diet

Will supplementing with ketones improve exercise performance?

Hot topic with endurance athletes.

KETONE SUPPLEMENTATION?

In research conducted in a fed state to simulate real world race-day conditions:

- ✓ Ketone monoester supplementation *may improve* cycling time trial performance
- ✓ Ketone diester supplementation *may impair* time trial performance and lead to gut discomfort

More research is needed to fully understand the potential benefit of ketone supplementation on performance and how tolerable the supplements are for athletes on race day.

Leckey & Hawley. *Sport Science Exchange.* 2018;29(184):1-6

KEY TAKEAWAYS

- ✓ Prolonged HFDs:
  - No improvement in exercise capacity or performance.
  - Impaired muscle glycogen utilization.
- ✓ Ketone drinks (exogenous ketone esters):
  - Increase circulating ketones.
  - Reduce the reliance on CHO based fuels during. submaximal exercise
  - Further research required, some promise with ketone monoesters.
- ✓ Periodization of CHO intake should be based on goal, intensity, & duration to maximize skeletal muscle adaptations.
- ✓ CHO should be ingested before and during competition.

Leckey & Hawley. *Sport Science Exchange.* 2018;29(184):1-6

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