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Nutritional Considerations for Training and Racing

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This Evening's Session

1. Energy metabolism: The basics
2. Carbohydrates for training and competition
3. Protein recommendations
4. Fat as a fuel
5. Periodized nutrition
6. Ergogenic aids *(nutritional/performance supplements)*
    i. General overview
    ii. Creatine
    iii. Buffers (sodium bicarbonate, beta-alanine)
    iv. Caffeine
    v. Nitrate
    vi. Combining ergogenic aids

”Information overload”

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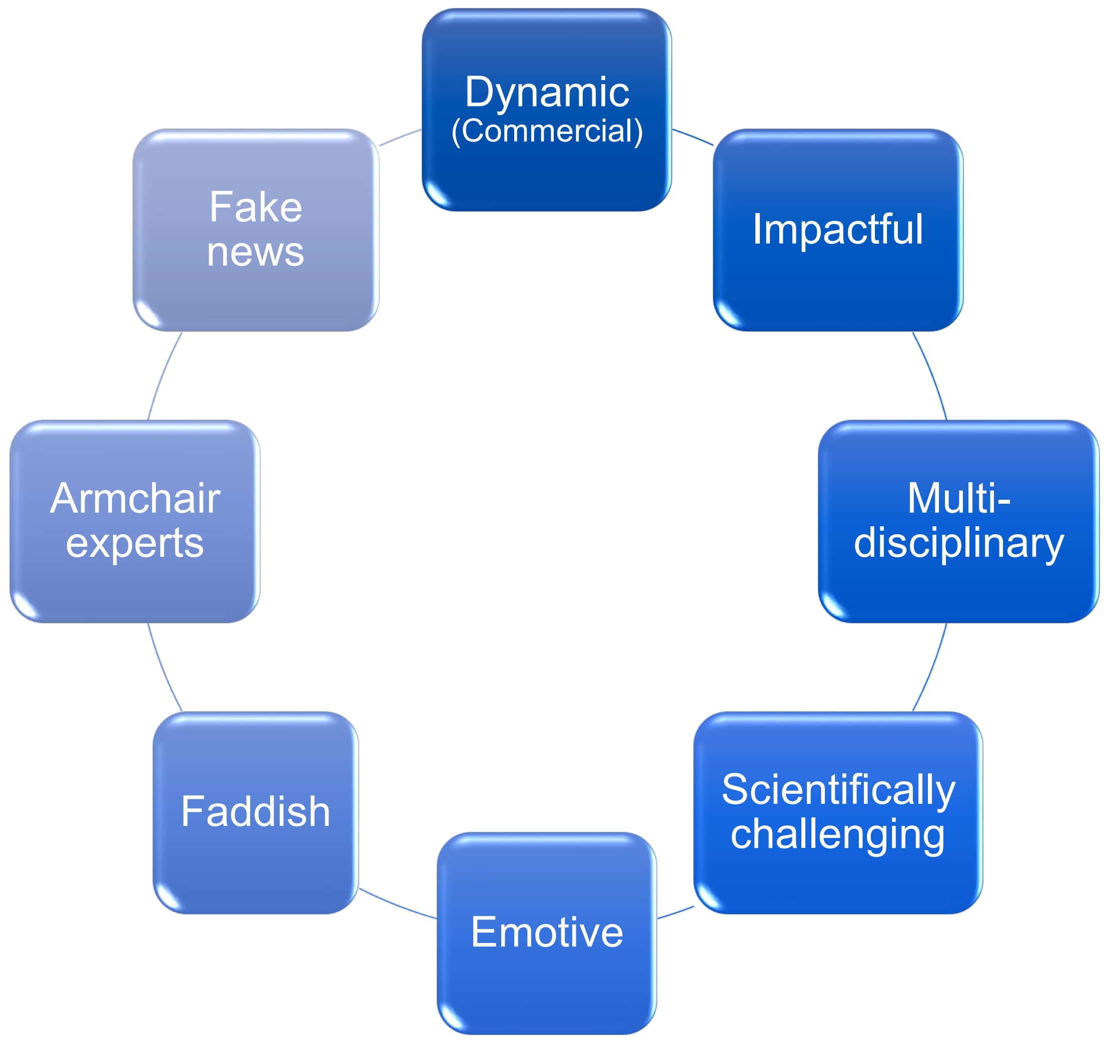


Macronutrients

Where all of our energy comes from...

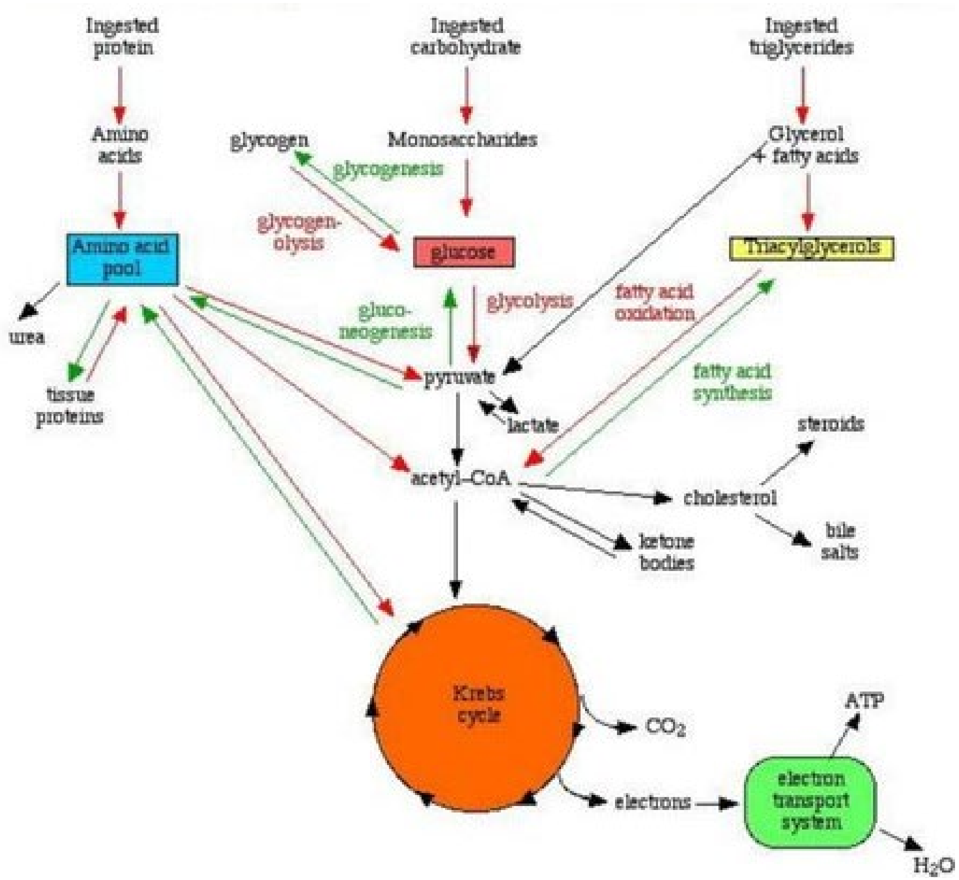
Carbohydrates (CHO)

Fats (FAT)

Protein (PRO)

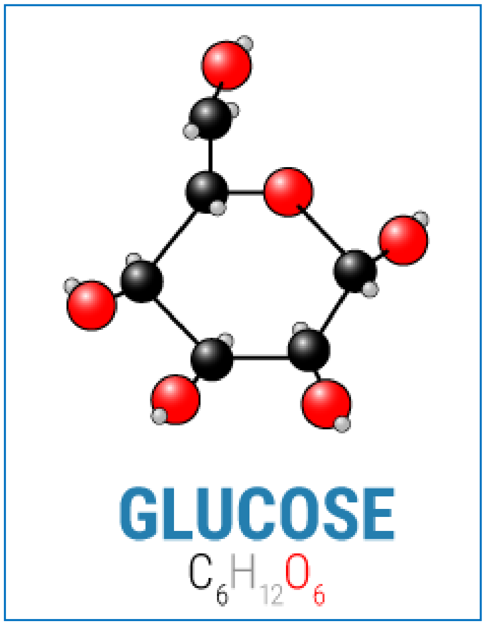
Energy metabolism

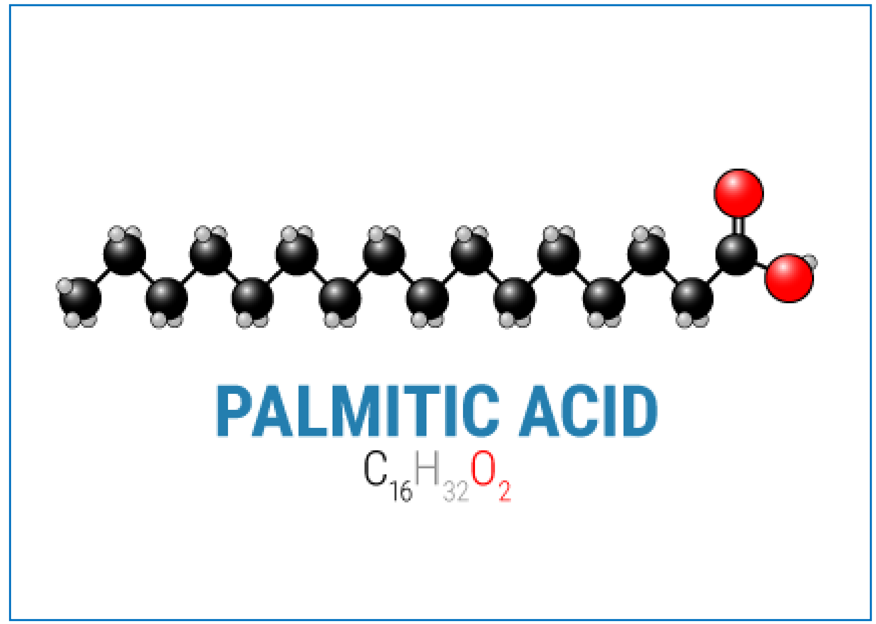
Converting stored food energy into useable energy for muscle contraction (i.e., movement)



Energy metabolism

Carbohydrates require less oxygen to metabolize aerobically than fat, giving carbohydrates a “per-unit-of-oxygen energy bonus”

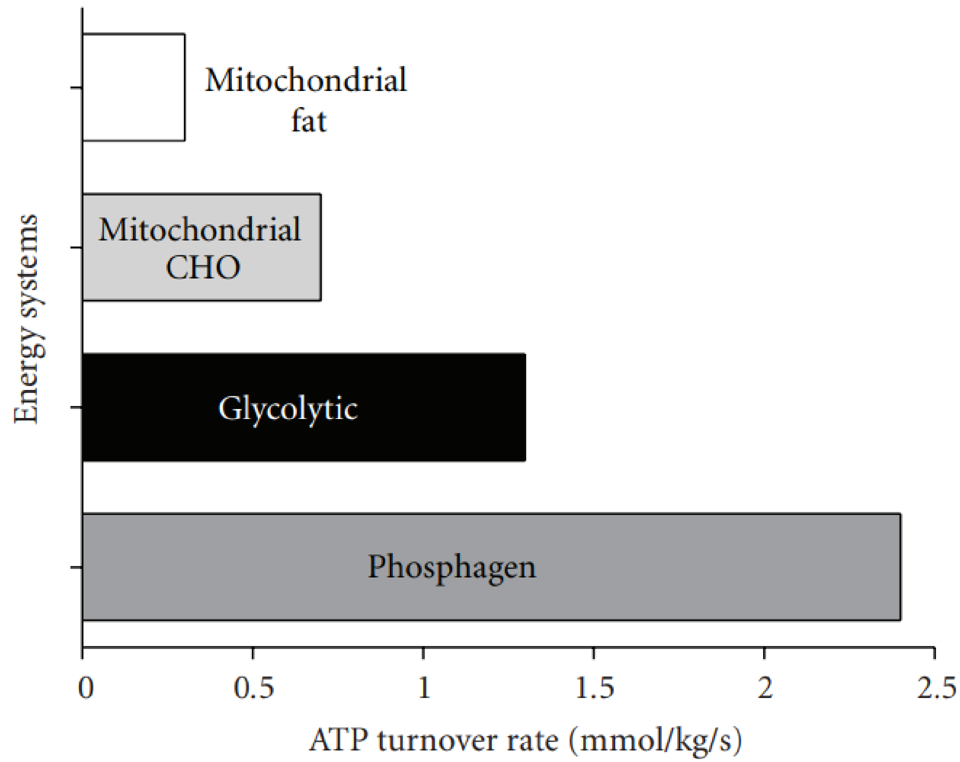




To produce CO_2, which yields energy (ATP), carbohydrate (simple sugar) needs 6 O_2 while fat (basic structure) needs 32 O_2

Energy metabolism

A higher rate of ATP production =
faster muscle contraction/speed of movement



Nutritional Intake in Elite Cross-Country Skiers During Two Days of Training and Competition

Amelia Carr
Mid Sweden University and Deakin University

Kerry McGawley, Andrew Govus, and Erik P. Andersson
Mid Sweden University

Oliver M. Shannon
Newcastle University

Stig Mattsson
Örebro University

Anna Melin
University of Copenhagen

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Carbohydrates for Training and Competition: Daily Needs

Activity Level	Situation	CHO Target
Low	Low intensity or skill based activities	3-5 $g.kg^{-1}d^{-1}$
Moderate	Moderate exercise programme (~ 60 min/d)	5-7 $g.kg.^{-1}d^{-1}$
High	Endurance programme (1-3 h/d mod-high intensity exercise)	6-10 $g.kg.^{-1}d^{-1}$
Very High	Elite endurance athlete/Ultra-endurance (>4-5 h/d mod-high intensity)	8-12 $g.kg.^{-1}d^{-1}$

Burke et al. (2011) J Sports Sci 29:S17-S27

Carbohydrates: Daily Needs

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How much ”food” (e.g., pasta, rice, potatoes, bread) do ***you*** need to reach your daily CHO target?

Activity Level	Situation	CHO Target
Low	Low intensity or skill based activities	3-5 g.kg^{-1}d^{-1}
Moderate	Moderate exercise programme (~ 60 min/d)	5-7 g.kg.$^{-1}$d^{-1}
High	Endurance programme (1-3 h/d mod-high intensity exercise)	6-10 g.kg.$^{-1}$d^{-1}
Very High	Elite endurance athlete/Ultra-endurance (>4-5 h/d mod-high intensity)	8-12 g.kg.$^{-1}$d^{-1}

Burke et al. (2011) J Sports Sci 29:S17-S27

Carbohydrates for Training and Competition: During ex.

ACUTE FUELLING STRATEGIES: *these guidelines promote high carbohydrate availability to promote optimal performance in competition or key training sessions*

During brief exercise	• < 45 min
During sustained high-intensity exercise	• 45–75 min
During endurance exercise including "stop and start" sports	• 1.0–2.5 h
During ultra-endurance exercise	• > 2.5–3.0 h

Burke et al. (2011) J Sports Sci 29:S17-S27

Carbohydrates for Training and Competition: ”Loading”

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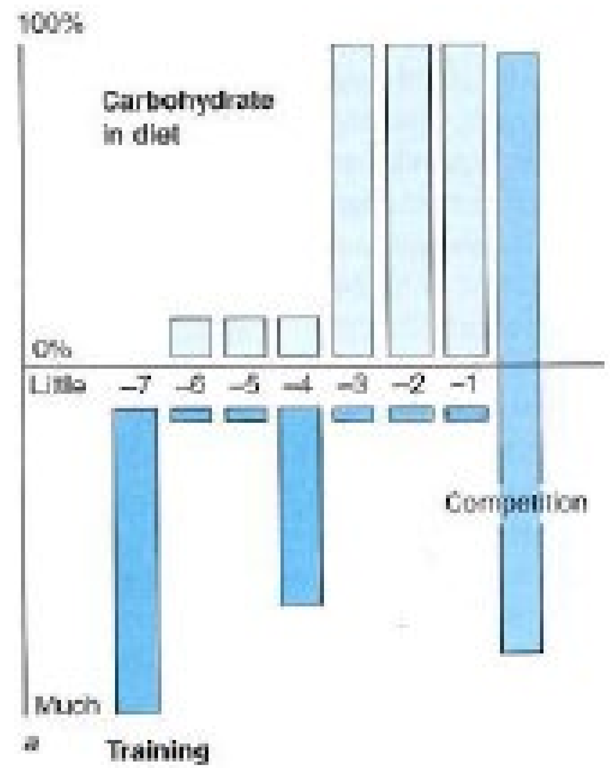
Burke et al. (2011). **Carbohydrates for training and competition,** S19-21

Early protocols:

Depletion (3 days low carbohydrate + training)
→ **Loading** (3 days high carbohydrate + taper)



Burke et al. (2011) J Sports Sci 29:S17-S27

Carbohydrates for Training and Competition: ”Loading”

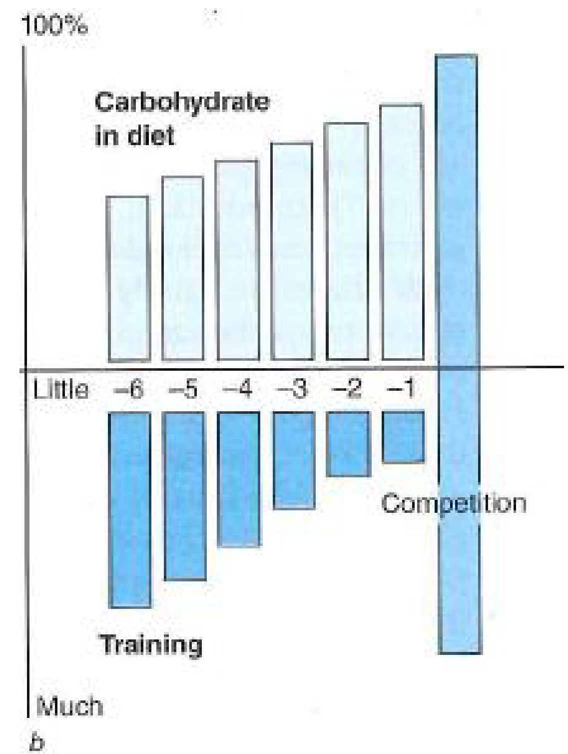
Burke et al. (2011). **Carbohydrates for training and competition,** S19-21

Early protocols:

Depletion (3 days low carbohydrate + training)
→ **Loading** (3 days high carbohydrate + taper)

More recent protocols:

- **Depletion** NOT NEEDED
→ **Loading** (1 – 1.5 days high carbohydrate + rest)



Nutrition and Athletic Performance

ACSM, AND & DC Joint Position Statement, 2016

SPECIAL COMMUNICATIONS

AMERICAN COLLEGE of SPORTS MEDICINE®

ACADEMY OF NUTRITION AND DIETETICS
DIETITIANS OF CANADA

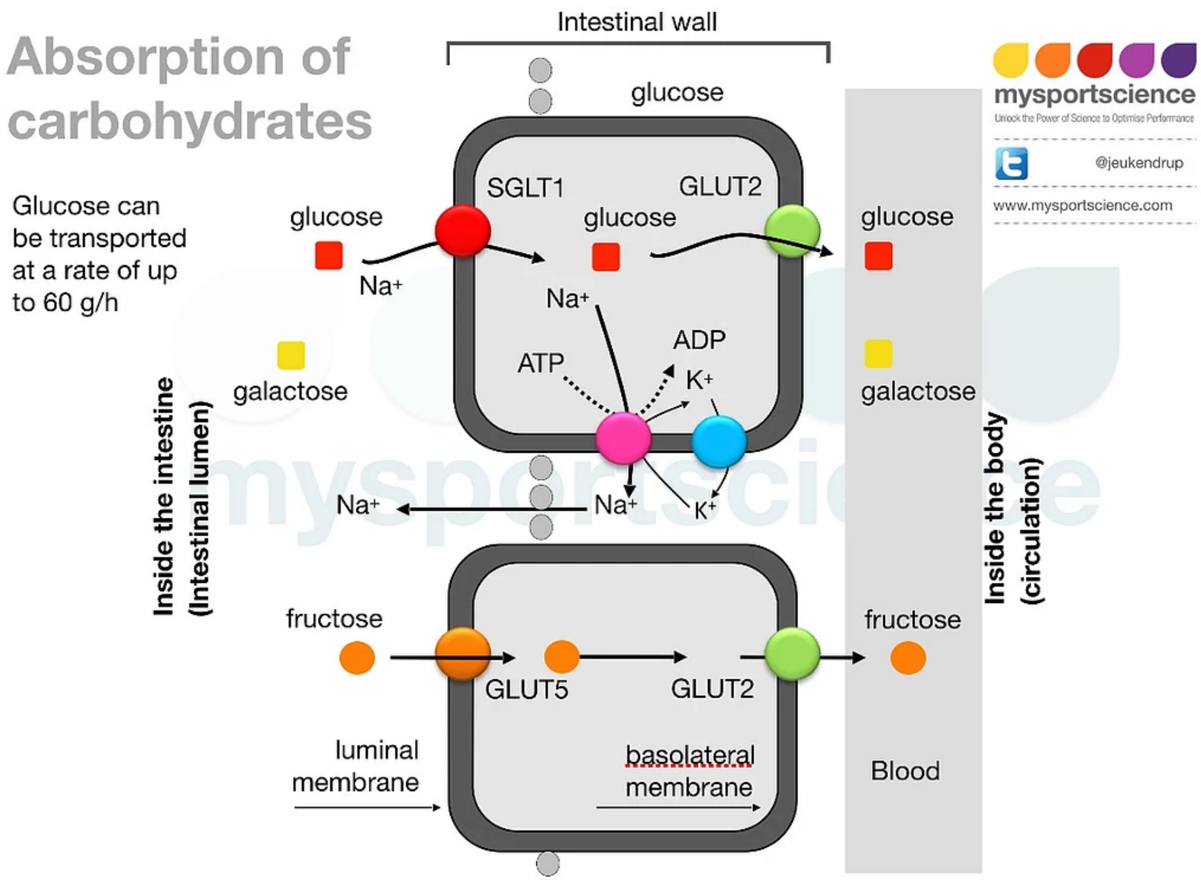
Nutrition and Athletic Performance

JOINT POSITION STATEMENT

Thomas et al. (2016) Med Sci Sports Exerc 48: 543–568

Multiple Transportable CHOs

Carbohydrates for Training and Competition



Carbohydrates for Training and Competition

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Duration of exercise	Amount of carbohydrate needed	Recommended type of carbohydrate	Additional recommendation
30–75 minutes	Small amounts or mouth rinse	Single or multiple transportable carbohydrates	Nutritional training recommended
1–2 hours	30 g/hour	Single or multiple transportable carbohydrates	Nutritional training recommended
2–3 hours	60 g/hour	Single or multiple transportable carbohydrates	Nutritional training highly recommended
> 2.5 hours	90 g/hour	**ONLY multiple transportable** carbohydrates	Nutritional training essential

Jeukendrup (2014) Sports Med 44:S25-S33

Multiple Transportable CHOs

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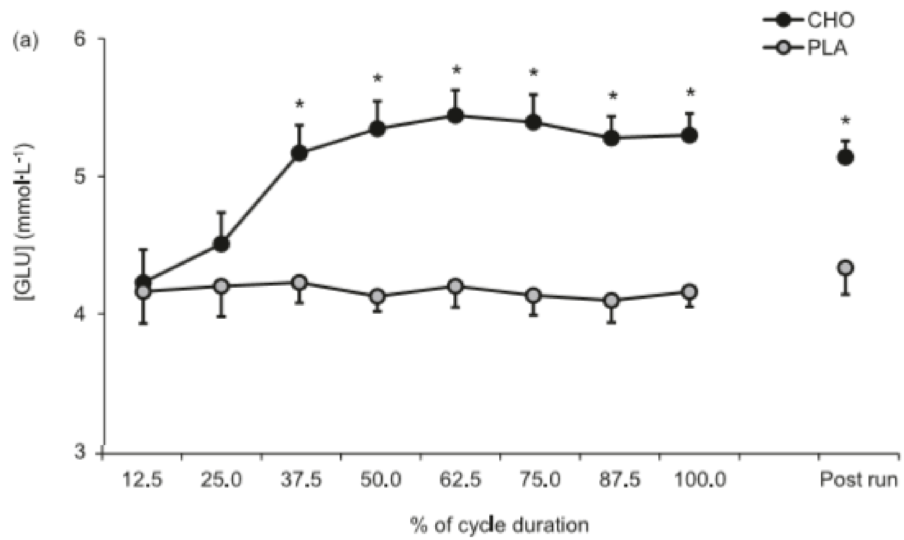
Ingesting a high-dose carbohydrate solution during the cycle section of a simulated Olympic-distance triathlon improves subsequent run performance

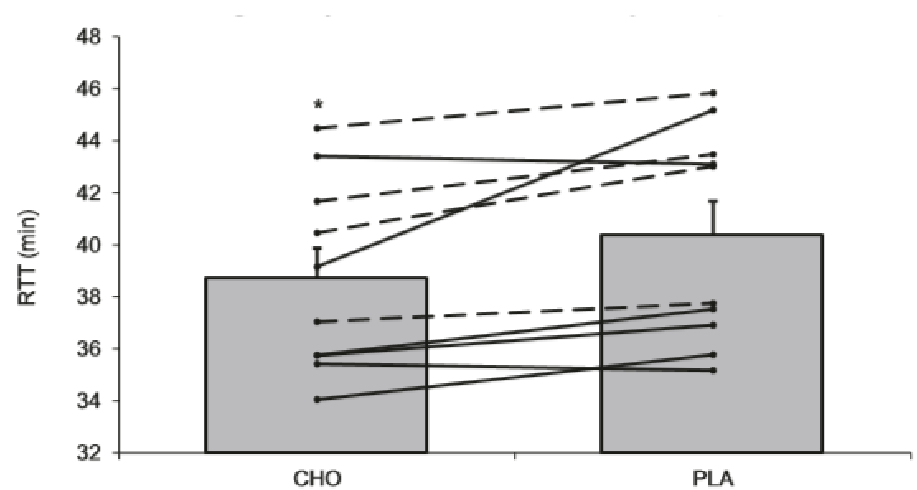
Kerry McGawley, Oliver Shannon, and James Betts

Abstract: The well-established ergogenic benefit of ingesting carbohydrates during single-discipline endurance sports has only been tested once within an Olympic-distance (OD) triathlon. The aim of the present study was to compare the effect of ingesting a 2:1 maltodextrin/fructose solution with a placebo on simulated OD triathlon performance. Six male and 4 female amateur triathletes (age, 25 ± 7 years; body mass, 66.8 ± 9.2 kg; peak oxygen uptake, 4.2 ± 0.6 $L{\cdot}min^{-1}$) completed a 1500-m swim time-trial and an incremental cycle test to determine peak oxygen uptake before performing 2 simulated OD triathlons. The swim and cycle sections of the main trials were of fixed intensities, while the run section was completed as a time-trial. Two minutes prior to completing every quarter of the cycle participants consumed 202 ± 20 mL of either a solution containing 1.2 $g{\cdot}min^{-1}$ of maltodextrin plus 0.6 $g{\cdot}min^{-1}$ of fructose at 14.4% concentration (CHO) or a sugar-free, fruit-flavored drink (PLA). The time-trial was 4.0% ± 1.3% faster during the CHO versus PLA trial, with run times of 38:43 ± 1:10 min:s and 40:22 ± 1:18 min:s, respectively ($p = 0.010$). Blood glucose concentrations were higher in the CHO versus PLA trial ($p < 0.001$), while perceived stomach upset did not differ between trials ($p = 0.555$). The current findings show that a 2:1 maltodextrin/fructose solution (1.8 $g{\cdot}min^{-1}$ at 14.4%) ingested throughout the cycle section of a simulated OD triathlon enhances subsequent 10-km run performance in triathletes.

McGawley et al. (2012) Appl Physiol Nutr Metab 37:664-671

Multiple Transportable CHOs





McGawley et al. (2012) Appl Physiol Nutr Metab 37:664-671

Multiple Transportable CHOs

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Superior Endurance Performance with Ingestion of Multiple Transportable Carbohydrates

ABSTRACT

CURRELL, K., and A. E. JEUKENDRUP. Superior Endurance Performance with Ingestion of Multiple Transportable Carbohydrates. *Med. Sci. Sports Exerc.*, Vol. 40, No. 2, pp. 275–281, 2008. **Introduction:** The aim of the present study was to investigate the effect of ingesting a glucose plus fructose drink compared with a glucose-only drink (both delivering carbohydrate at a rate of 1.8 g·min^{-1}) and a water placebo on endurance performance. **Methods:** Eight male trained cyclists were recruited (age 32 ± 7 yr, weight 84.4 ± 6.9 kg, $\dot{V}O_{2max}$ 64.7 ± 3.9 mL·kg^{-1}·min^{-1}, Wmax 364 ± 31 W). Subjects ingested either a water placebo (*P*), a glucose (*G*)-only beverage (1.8 g·min^{-1}), or a glucose and fructose (GF) beverage in a 2:1 ratio (1.8 g·min^{-1}) during 120 min of cycling exercise at 55% Wmax followed by a time trial in which subjects had to complete a set amount of work as quickly as possible (~1 h). Every 15 min, expired gases were analyzed and blood samples were collected. **Results:** Ingestion of GF resulted in an 8% quicker time to completion during the time trial (4022 s) compared with *G* (3641 s) and a 19% improvement compared with *W* (3367 s). Total carbohydrate (CHO) oxidation was not different between GF (2.54 ± 0.25 g·min^{-1}) and *G* (2.50 g·min^{-1}), suggesting that GF led to a sparing of endogenous CHO stores, because GF has been shown to have a greater exogenous CHO oxidation than *G*. **Conclusion:** Ingestion of GF led to an 8% improvement in cycling time-trial performance compared with ingestion of *G*. **Key Words:** GLUCOSE, FRUCTOSE, ERGOGENIC AID, CYCLING, EXOGENOUS CARBOHYDRATE, TIME TRIAL

Multiple Transportable CHOs

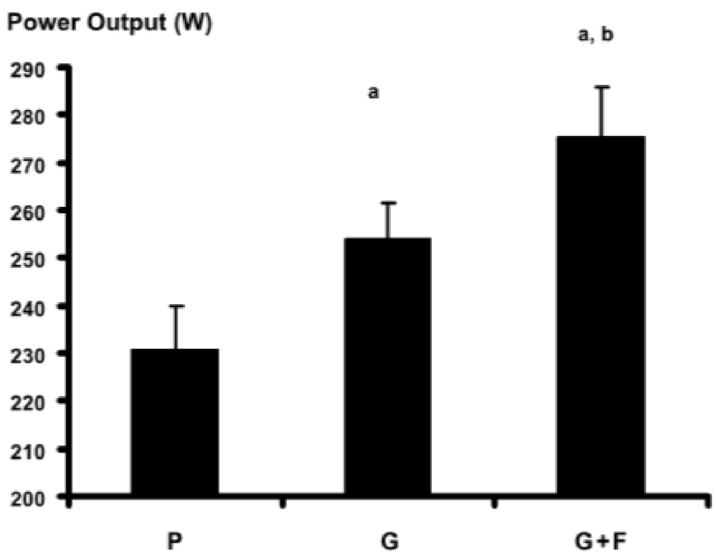

FIGURE 1—Power output during the time trial, where *P* is the water placebo trial, *G* is glucose fed at 1.8 g·min^{-1}, and *G* + *F* is glucose fed at 1.2 g·min^{-1} plus fructose fed at 0.6 g·min^{-1}. *a*, significantly different from *P*; *b*, significantly different from *G*. Data are presented as means ± SE.

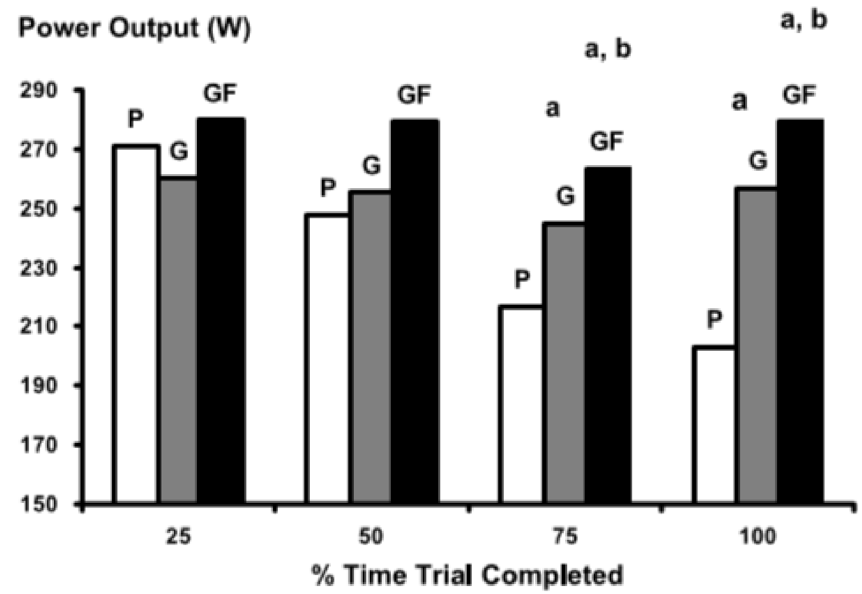

FIGURE 2—Power output during each quarter of the time trial. *P*, water placebo trial; *G*, glucose fed at 1.8 g·min^{-1}; GF, glucose at 1.2 g·min^{-1} and fructose at 0.6 g·min^{-1}. *a*, significantly different from *P*; *b*, significantly different from *G*. Data are presented as means ± SE.

Currell & Jeukendrup (2008) Med Sci Sports Exerc 40(2):275-281

CHO Hydrogel Products

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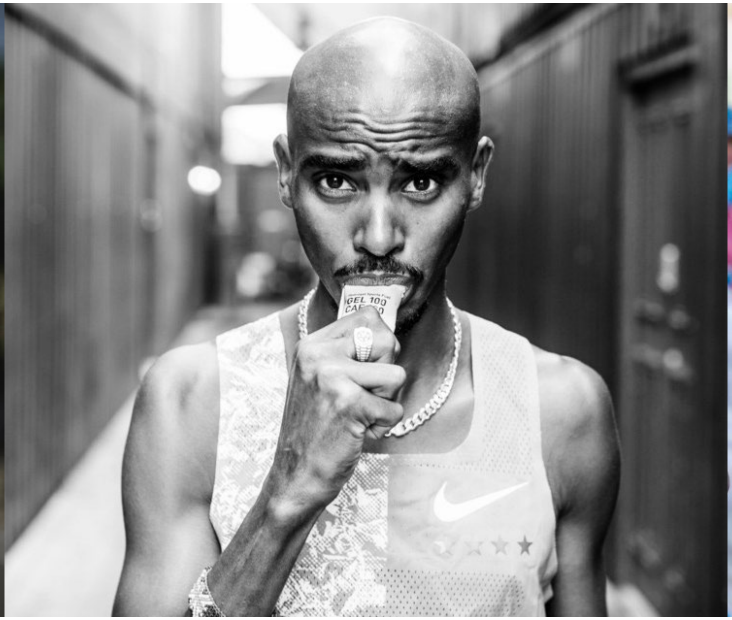

CHO Hydrogel Products

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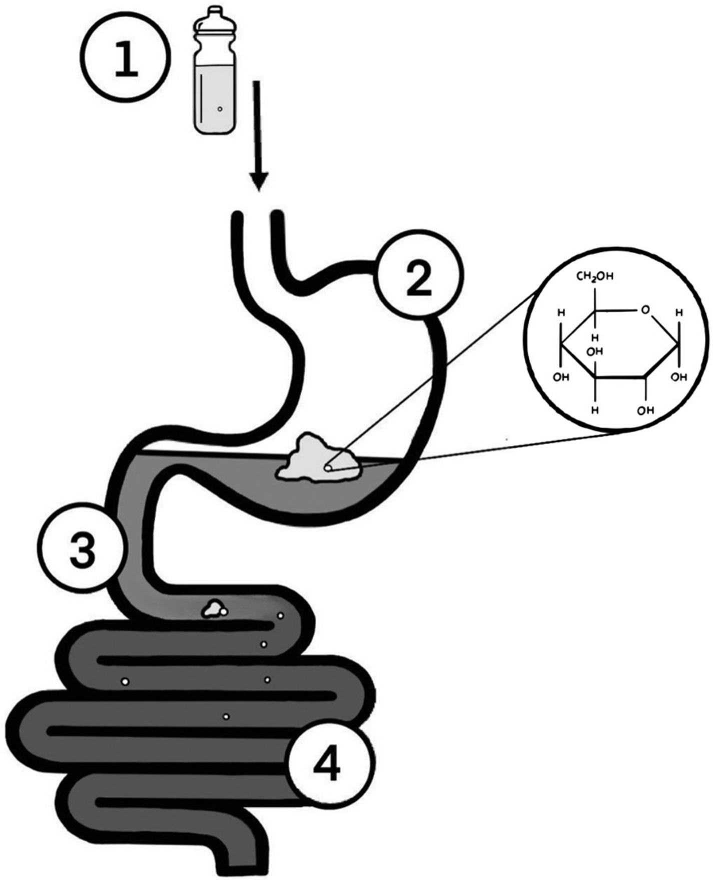

1

Gelling agents such as alginate and pectin are added to typical CHO (e.g., glucose, fructose, sucrose) in solution.

2

On contact with gastric fluid, CHO-alginate mixtures form a hydrogel, encapsulating the CHO in the solution.

3

The encapsulated CHO passes into the duodenum, without activating glucagon-like peptide 1 secretion in the enteroendocrine cells of the gastrointestinal mucosa. Gastric emptying is therefore not reduced as with typical high CHO drinks.

4

In the duodenum, the higher pH environment dissolves the hydrogel allowing intestinal CHO transport proteins to deliver the ingested CHO to the systemic circulation.

Figure — Mechanisms of CHO hydrogel formation and delivery to the small intestine. Despite benefits to gastric emptying with hydrogelencapsulated CHO, the rate-limiting step of exogenous CHO oxidation lies in the intestinal transport of monosaccharides. CHO = carbohydrate

King et al. (2020) Int J Sport Nutr Ex Metabol 30:305-314

CHO Hydrogel Products

Glucose and Fructose Hydrogel Enhances Running Performance, Exogenous Carbohydrate Oxidation, and Gastrointestinal Tolerance

ABSTRACT

ROWE, J. T., R. F. G. J. KING, A. J. KING, D. J. MORRISON, T. PRESTON, O. J. WILSON, and J. P. O'HARA. Glucose and Fructose Hydrogel Enhances Running Performance, Exogenous Carbohydrate Oxidation, and Gastrointestinal Tolerance. *Med. Sci. Sports Exerc.*, Vol. 54, No. 1, pp. 129–140, 2022. **Purpose:** Beneficial effects of carbohydrate (CHO) ingestion on exogenous CHO oxidation and endurance performance require a well-functioning gastrointestinal (GI) tract. However, GI complaints are common during endurance running. This study investigated the effect of a CHO solution-containing sodium alginate and pectin (hydrogel) on endurance running performance, exogenous and endogenous CHO oxidation, and GI symptoms. **Methods:** Eleven trained male runners, using a randomized, double-blind design, completed three 120-min steady-state runs at 68% $\dot{V}O_{2max}$, followed by a 5-km time-trial. Participants ingested 90 $g \cdot h^{-1}$ of 2:1 glucose–fructose (^{13}C enriched) as a CHO hydrogel, a standard CHO solution (nonhydrogel), or a CHO-free placebo during the 120 min. Fat oxidation, total and exogenous CHO oxidation, plasma glucose oxidation, and endogenous glucose oxidation from liver and muscle glycogen were calculated using indirect calorimetry and isotope ratio mass spectrometry. GI symptoms were recorded throughout the trial. **Results:** Time-trial performance was 7.6% and 5.6% faster after hydrogel ([min:s] 19:29 ± 2:24, $P < 0.001$) and nonhydrogel (19:54 ± 2:23, $P = 0.002$), respectively, versus placebo (21:05 ± 2:34). Time-trial performance after hydrogel was 2.1% faster ($P = 0.033$) than nonhydrogel. Absolute and relative exogenous CHO oxidation was greater with hydrogel (68.6 ± 10.8 g, 31.9% ± 2.7%; $P = 0.01$) versus nonhydrogel (63.4 ± 8.1 g, 29.3% ± 2.0%; $P = 0.003$). Absolute and relative endogenous CHO oxidation was lower in both CHO conditions compared with placebo ($P < 0.001$), with no difference between CHO conditions. Absolute and relative liver glucose oxidation and muscle glycogen oxidation were not different between CHO conditions. Total GI symptoms were not different between hydrogel and placebo, but GI symptoms were higher in nonhydrogel compared with placebo and hydrogel ($P < 0.001$). **Conclusion:** The ingestion of glucose and fructose in hydrogel form during running benefited endurance performance, exogenous CHO oxidation, and GI symptoms compared with a standard CHO solution. **Key Words:** ^{13}C TRACER, TIME TRIAL, ENCAPSULATION, METABOLISM, ENDURANCE

CHO Hydrogel Products

Carbohydrate Hydrogel Products Do Not Improve Performance or Gastrointestinal Distress During Moderate-Intensity Endurance Exercise

Andy J. King
Australian Catholic University

Joshua T. Rowe
University of Leeds

Louise M. Burke
Australian Catholic University and
Australian Institute of Sport

The benefits of ingesting exogenous carbohydrate (CHO) during prolonged exercise performance are well established. A recent food technology innovation has seen sodium alginate and pectin included in solutions of multiple transportable CHO, to encapsulate them at pH levels found in the stomach. Marketing claims include enhanced gastric emptying and delivery of CHO to the muscle with less gastrointestinal distress, leading to better sports performance. Emerging literature around such claims was identified by searching electronic databases; inclusion criteria were randomized controlled trials investigating metabolic and/or exercise performance parameters during endurance exercise >1 hr, with CHO hydrogels versus traditional CHO fluids and/or noncaloric hydrogels. Limitations associated with the heterogeneity of exercise protocols and control comparisons are noted. To date, improvements in exercise performance/capacity have not been clearly demonstrated with ingestion of CHO hydrogels above traditional CHO fluids. Studies utilizing isotopic tracers demonstrate similar rates of exogenous CHO oxidation, and subjective ratings of gastrointestinal distress do not appear to be different. Overall, data do not support any metabolic or performance advantages to exogenous CHO delivery in hydrogel form over traditional CHO preparations; although, one study demonstrates a possible glycogen sparing effect. The authors note that the current literature has largely failed to investigate the conditions under which maximal CHO availability is needed; high-performance athletes undertaking prolonged events at high relative and absolute exercise intensities. Although investigations are needed to better target the testimonials provided about CHO hydrogels, current evidence suggests that they are similar in outcome and a benefit to traditional CHO sources.

King et al. (2020) Int J Sport Nutr Ex Metabol 30:305-314

CHO Hydrogel Products

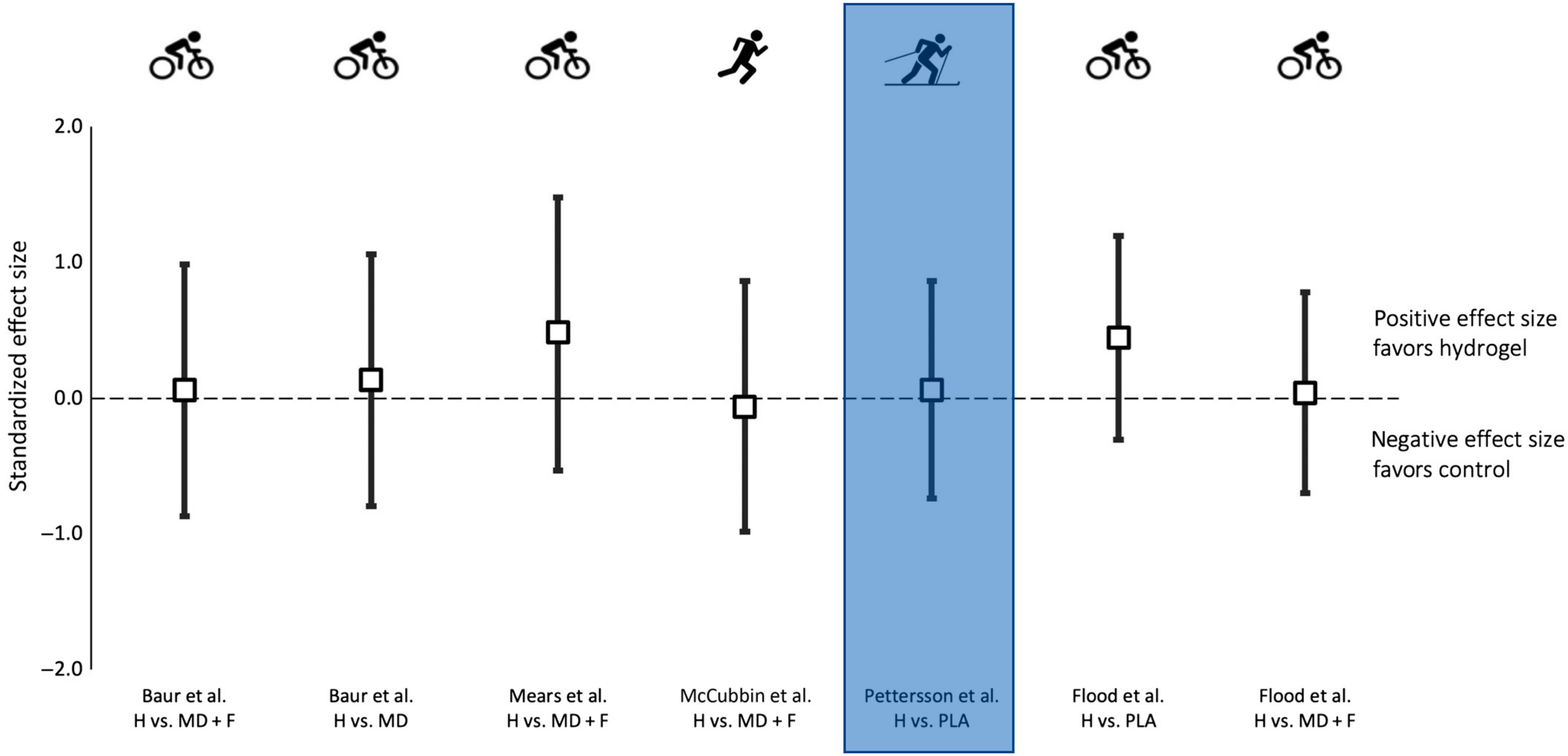

Figure — Forest plot of standardized effects sizes and 95% confidence intervals for exercise performance in studies comparing CHO hydrogel formulations with isocaloric CHO or noncaloric placebo solutions. H = hydrogel; MD= maltodextrin; MD+ F = maltodextrin + fructose; PLA = placebo; H (MD + F) = hydrogel of MD+ F; CHO = carbohydrate.

King et al. (2020) Int J Sport Nutr Ex Metabol 30:305-314

CHO Hydrogel Products

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Pettersson et al. (2019) J Int Soc Sports Nutr 16:46

Effects of supplementing with an 18% carbohydrate-hydrogel drink versus a placebo during whole-body exercise in −5 °C with elite cross-country ski athletes: a crossover study

Stefan Pettersson[1,2*], Fredrik Edin[1], Linda Bakkman[2] and Kerry McGawley[3]

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Abstract

Background: Whilst the ergogenic effects of carbohydrate intake during prolonged exercise are well-documented, few investigations have studied the effects of carbohydrate ingestion during cross-country skiing, a mode of exercise that presents unique metabolic demands on athletes due to the combined use of large upper- and lower-body muscle masses. Moreover, no previous studies have investigated exogenous carbohydrate oxidation rates during cross-country skiing. The current study investigated the effects of a ^{13}C-enriched 18% multiple-transportable carbohydrate solution (1:0.8 maltodextrin:fructose) with additional gelling polysaccharides (CHO-HG) on substrate utilization and gastrointestinal symptoms during prolonged cross-country skiing exercise in the cold, and subsequent double-poling time-trial performance in ~ 20 °C.

Methods: Twelve elite cross-country ski athletes (6 females, 6 males) performed 120-min of submaximal roller-skiing (69.3 ± 2.9% of $\dot{V}O_2$peak) in −5 °C while receiving either 2.2 g CHO-HG·min^{-1} or a non-caloric placebo administered in a double-blind, randomized manner. Whole-body substrate utilization and exogenous carbohydrate oxidation was calculated for the last 60 min of the submaximal exercise. The maximal time-trial (2000 m for females, 2400 m for males) immediately followed the 120-min submaximal bout. Repeated-measures ANOVAs with univariate follow-ups were conducted, as well as independent and paired t-tests, and significance was set at $P < 0.05$. Data are presented as mean ± SD.

Results: Exogenous carbohydrate oxidation contributed 27.6 ± 6.6% to the total energy yield with CHO-HG and the peak exogenous carbohydrate oxidation rate reached 1.33 ± 0.27 g·min^{-1}. Compared to placebo, fat oxidation decreased by 9.5 ± 4.8% with CHO-HG, total carbohydrate oxidation increased by 9.5 ± 4.8% and endogenous carbohydrate utilization decreased by 18.1 ± 6.4% (all $P < 0.05$). No severe gastrointestinal symptoms were reported in either trial and euhydration was maintained in both trials. Time-trial performance (8.4 ± 0.4 min) was not improved following CHO-HG compared to placebo (− 0.8 ± 3.5 s; 95% confidence interval − 3.0 to 1.5 s; $P = 0.46$). No sex differences were identified in substrate utilization or relative performance.

Conclusions: Ingestion of an 18% multiple-transportable carbohydrate solution with gelling polysaccharides was found to be well-tolerated during 120 min of submaximal whole-body exercise, but did not improve subsequent maximal double-poling performance.

Keywords: Biathlete, Cold, Double-poling, Endurance, Roller-skiing, Sex differences, Stabile isotopes, Substrate utilization, World-class

Pettersson et al. (2019) J Int Soc Sports Nutr 16:46

DIY CHO Hydrogel

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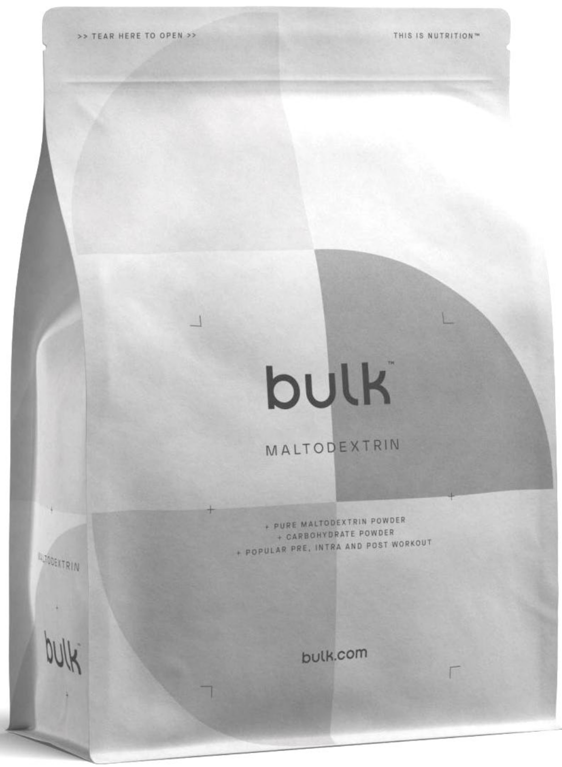

+

+

50 g MD + 50 g S + ¼ teaspoon SA blended in 150 mL H_2O

CHO Dose and Frequency

CHO Dose and Frequency

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Effects of carbohydrate dose and frequency on metabolism, gastrointestinal discomfort, and cross-country skiing performance

B. Stocks[1,2], J. A. Betts[2], K. McGawley[1]

[1]Swedish Winter Sports Research Centre, Department of Health Sciences, Mid Sweden University, Östersund, Sweden, [2]Human Physiology Research Group, Department for Health, University of Bath, Bath, UK
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Accepted for publication 23 July 2015

This study investigated carbohydrate ingestion of varied doses and frequencies during a simulated cross-country skiing time trial. Ten men and three women (age: 30 ± 7 years; $\dot{V}O_{2max}$: 59.6 ± 5.7 mL/kg/min) completed four, 30-km classic technique roller skiing time trials on a treadmill. A 1:1 maltodextrin-fructose carbohydrate solution was provided at high (2.4 g/min; HC) and moderate (1.2 g/min; MC) ingestion rates, each at high (six feeds; HF) and low (two feeds; LF) frequencies. In the LF trials, blood glucose was elevated following carbohydrate ingestion (at 4 and 19 km) but was reduced at 14 and 29 km compared with HF strategies ($P \leq 0.05$). Gastrointestinal discomfort was higher in HC-LF compared with all other trials ($P \leq 0.05$). Whole-body lipid oxidation was lower and carbohydrate oxidation was higher in LF compared with HF trials ($P \leq 0.05$). While performance time was not significantly different between trials (140:11 ± 15:31, 140:43 ± 17:40, 139:12 ± 15:32 and 140:33 ± 17:46 min:s in HC-HF, HC-LF, MC-HF, and MC-LF, respectively; $P > 0.05$), it was improved with trial order ($P < 0.001$). There was no effect of order on any other variable ($P > 0.05$). Altering carbohydrate dose or frequency does not affect cross-country ski performance. However, low-frequency carbohydrate ingestion resulted in poorer maintenance of euglycemia, reduced lipid oxidation, and increased gastrointestinal discomfort.

Stocks et al. (2016) Scand J Med Sci Sports 26:1100-1108

CHO Mouth Rinse

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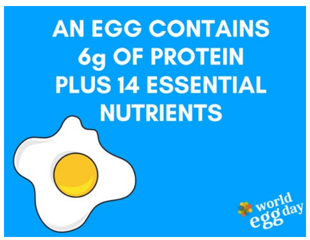
Rodrigues Oliveira-Silva et al. (2022) ” Effect of carbohydrate mouth rinse on muscle strength and muscular endurance: A systematic review with meta-analysis”. Crit Rev Food Sci Nutr

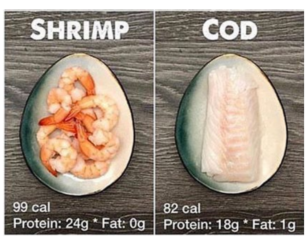
Painelli et al. (2022) ” A Narrative Review of Current Concerns and Future Perspectives of the Carbohydrate Mouth Rinse Effects on Exercise Performance”. SAGE Open Med

Protein and Training

International Society of Sports Nutrition Position Stand

Ralf Jäger[1], Chad M. Kerksick[2], Bill I. Campbell[3], Paul J. Cribb[4], Shawn D. Wells[5], Tim M. Skwiat[5], Martin Purpura[1], Tim N. Ziegenfuss[6], Arny A. Ferrando[7], Shawn M. Arent[8], Abbie E. Smith-Ryan[9], Jeffrey R. Stout[10], Paul J. Arciero[11], Michael J. Ormsbee[12,13], Lem W. Taylor[14], Colin D. Wilborn[14], Doug S. Kalman[15], Richard B. Kreider[16], Darryn S. Willoughby[17], Jay R. Hoffman[10], Jamie L. Krzykowski[18] and Jose Antonio[19*]





Abstract

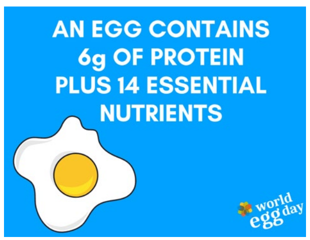
Position statement: The International Society of Sports Nutrition (ISSN) provides an objective and critical review related to the intake of protein for healthy, exercising individuals. Based on the current available literature, the position of the Society is as follows:

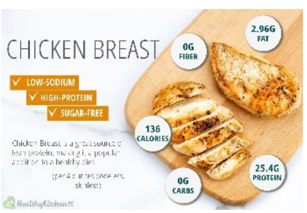
1) An acute exercise stimulus, particularly resistance exercise, and protein ingestion both stimulate muscle protein synthesis (MPS) and are synergistic when protein consumption occurs before or after resistance exercise.
2) For building muscle mass and for maintaining muscle mass through a positive muscle protein balance, an overall daily protein intake in the range of 1.4–2.0 g protein/kg body weight/day (g/kg/d) is sufficient for most exercising individuals, a value that falls in line within the Acceptable Macronutrient Distribution Range published by the Institute of Medicine for protein.
3) There is novel evidence that suggests higher protein intakes (>3.0 g/kg/d) may have positive effects on body composition in resistance-trained individuals (i.e., promote loss of fat mass).
4) Recommendations regarding the optimal protein intake per serving for athletes to maximize MPS are mixed and are dependent upon age and recent resistance exercise stimuli. General recommendations are 0.25 g of a high-quality protein per kg of body weight, or an absolute dose of 20–40 g.
5) Acute protein doses should strive to contain 700–3000 mg of leucine and/or a higher relative leucine content, in addition to a balanced array of the essential amino acids (EAAs).
6) These protein doses should ideally be evenly distributed, every 3–4 h, across the day.
7) The optimal time period during which to ingest protein is likely a matter of individual tolerance, since benefits are derived from pre- or post-workout ingestion; however, the anabolic effect of exercise is long-lasting (at least 24 h), but likely diminishes with increasing time post-exercise.

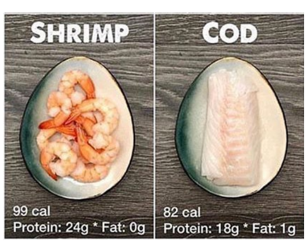
(Continued on next page)

Protein as ”Food”

International Society of Sports Nutrition Position Stand

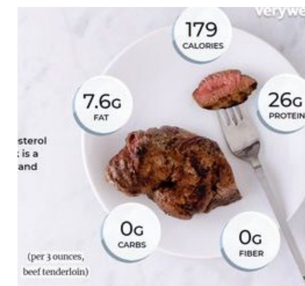






What do these guidelines translate to in terms of “food” (see some examples in the pictures) over a whole day and per serving:

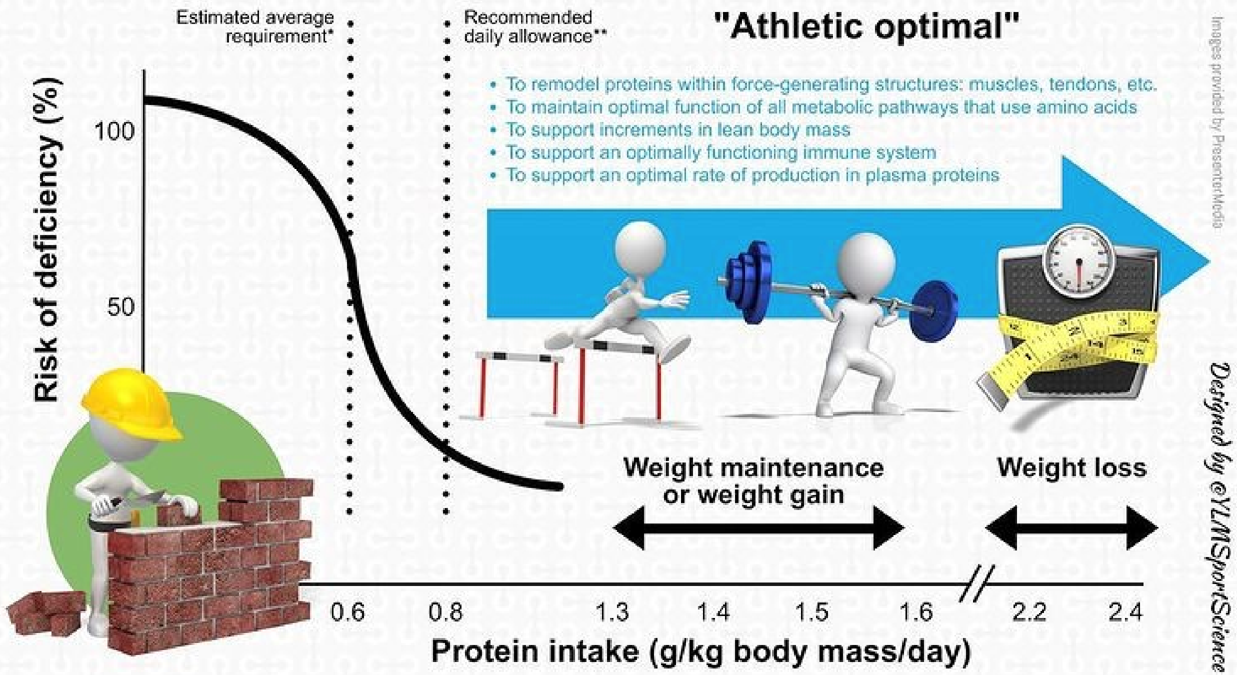
- Daily PRO intake: 1.4–2.0 g/kg BM/day
- Evenly distributed every 3–4 h
- Per serving: 0.25 g/kg BM or 20–40 g *high quality* PRO (e.g., ≥ 700–3000 mg leucine and other EAAs)



Jäger et al. (2017)) J Int Soc Sports Nutr 14:20

DIETARY PROTEIN

for Training Adaptation and Body Composition



*Intake level at which the needs of 50 percent of the population will be met; ** Intake level per day considered necessary for the maintenance of good health

1 Consume ~0.4–0.5 g/kg body mass per serving/meal for maximal stimulation of muscle protein synthesis when real food is ingested (vs ~0.3–0.4 g/kg body mass for isolated proteins)

2 Select leucine-rich rapidly digested protein sources, such as whey protein, to elicit a greater stimulation of muscle protein synthesis during training recovery

3 Distribute your daily protein intake in 4–5 equally spaced servings throughout the day and include a slow-releasing, protein-rich, snack at bedtime

Reference: Witard, Garthe, and Phillips IJSNEM 2019

Designed by @YLMSportScience

Fat as a Fuel

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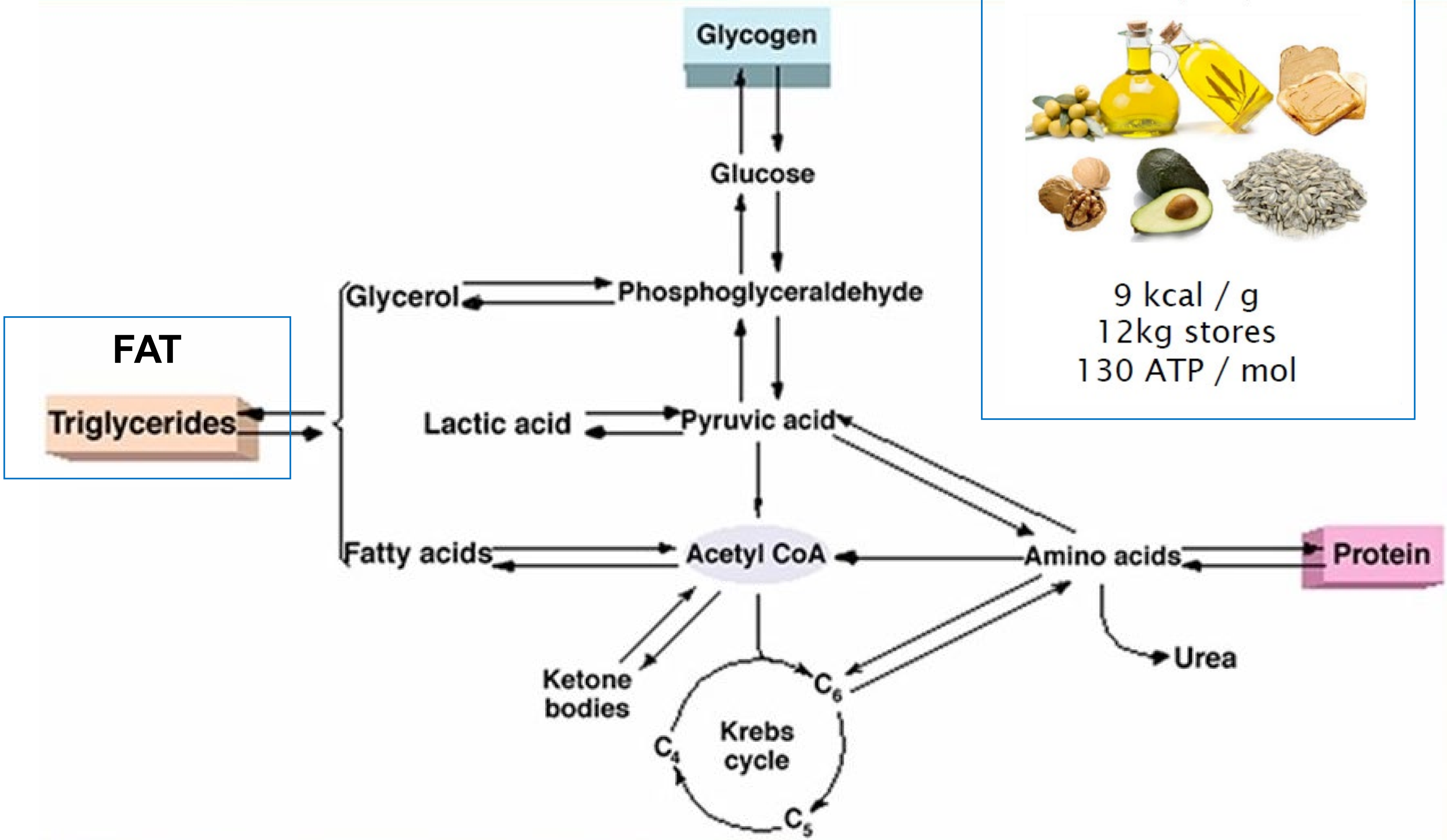

Fats (FAT)

9 kcal / g
12kg stores
130 ATP / mol

Fat as a Fuel... in Triathlon

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Fat as a Fuel

- **Volek** et al. (2015) ”Rethinking fat as a fuel for endurance exercise”. Eur J Sport Sci 15:13-20
- **Burke** et al. (2017) ”Low carbohydrate, high fat diet impairs exercise economy and negates the performacne benefit from intensified training in elite race walkers”. J Physiol 595:2785-2807
- **McSwiney** et al. (2019) ”Impact of ketogenic diet on athletes: Current insights”. OA J Sports Med 10:171-183
- **Burke** (2021) ”Ketogenic low-CHO, high-fat diet: The future of elite endurance sport”. J Physiol 599:819-843

Periodized Nutrition

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”The planned, purposeful, and strategic use of specific nutritional interventions to enhance the adaptations targeted by individual exercise sessions or periodic training plans, or to obtain other effects that will enhance performance longer term.”

- **Training low** (e.g., twice a day, fasted, without sport drink, high-fat/ketogenic diet, CHO restriction, sleep low)
- **Training high** (e.g., high muscle/liver glycogen, high CHO diet)
- **Training the gut** (e.g., stomach comfort, gastric emptying, absorption)
- **Training race nutrition**
- **Training dehydrated**
- **Training with supplements**

Jeukendrup (2017) Sports Med 47:S51–S63

Periodized Nutrition

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5 Chronic Dietary Strategies Used by Endurance Athletes for Training Adaptation and Event Preparation

1 High-Carbohydrate (CHO) Diet

- Lacks a single or clear definition.
- Is typically considered a static target for CHO intake.
- Represents original sports nutrition guidelines.
- **Various metrics for CHO intake have included:**

>50% of total energy intake
500–600 g/day
7–10 g/kg body mass/day

2 High-CHO Availability Diet

- Total daily targets vary according to training goals.
- Includes specifically targeting intakes around & during training sessions.
- Usually represented as gram per kilogram of body mass as a proxy for the size of the exercising musculature.
- **Typical range for CHO intake has been:**

3-12 g/kg body mass/day
depending on training load

3 Periodized CHO Availability Diet

- Dietary plan in which CHO availability for each workout is varied according to the type of session and its goals within a periodized training cycle.
- May include "train high" & "train low" strategies .

Train high: commence training session with sufficient muscle glycogen stores to fuel entire session.

Train low: commence training session with suboptimal or low muscle glycogen stores relative to fuel demands.

4 Nonketogenic LCHF (Low-CHO, high-fat) Diet

- Dietary plan in which CHO availability is chronically (days/weeks/months) maintained below muscle CHO needs to promote adaptations favoring fat oxidation, but with sufficient CHO to avoid sustained ketosis.
- **Typical intake**

15–20% CHO
(<2.5 g/kg body mass/day)
15–20% protein
60–65% fat

5 Ketogenic LCHF (Low-CHO, high-fat) Diet

- Dietary plan in which chronic ketosis is achieved by severely restricted CHO intake and moderate protein intake.
- Fats, principally saturated and monounsaturated, contribute the major energy source.
- **Typical intake**

<5% CHO
(<50 g/day)
15–20% protein
75–80% fat

Created by Adam Virgile adamvirgile.com

Social Media @AdamVirgile @AVSportSci

Graphic References PRESENTERMEDIA.COM

Burke, L.M., Hawley, J.A., Jeukendrup, A., Morton, J.P., Stellingwerff, T. and Maughan, R.J., 2018. Toward a common understanding of diet–exercise strategies to manipulate fuel availability for training and competition preparation in endurance sport. *International Journal of Sport Nutrition and Exercise Metabolism*, *28*(5), pp.451-463.

General Overview

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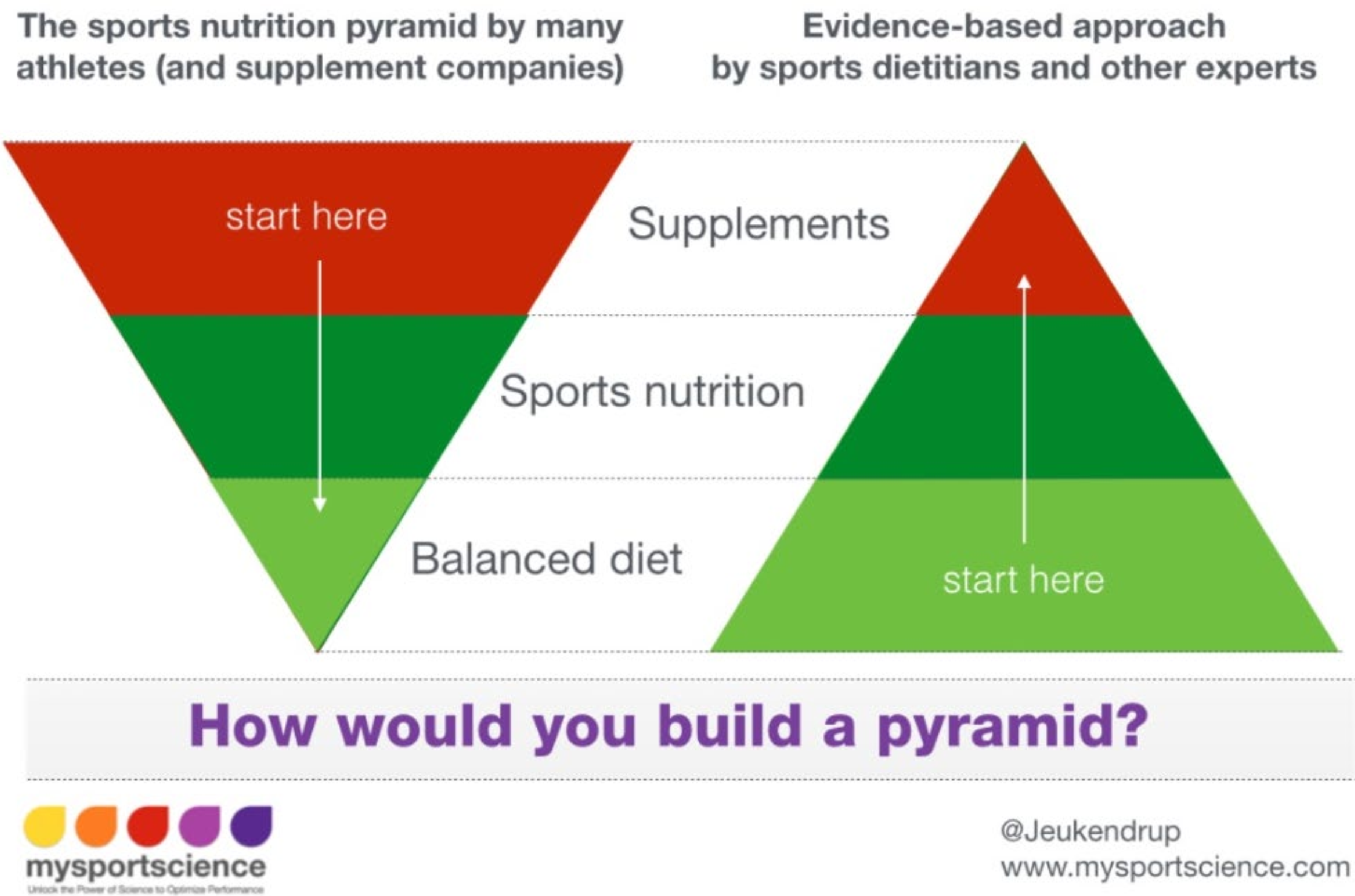

General Overview

- The use of nutritional supplements is a common and legitimate strategy employed by athletes to enhance performance
- BUT… supplements serve as an **addition** to a healthy, balanced diet, not as a *substitute*

General Overview

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Group A

Overview of category	Sub-categories	Examples
Evidence level: **Supported for use in specific situations in sport using evidence-based protocols.** **Use within Supplement Programs:** **Provided or permitted for use by some athletes according to Best Practice Protocols**	**Sports foods** Specialised products used to provide a convenient source of nutrients when it is impractical to consume everyday foods.	Sports drink
		Sports gel
		Sports confectionery
		Sports bar
		Electrolyte supplement
		Isolated protein supplement
		Mixed macronutrient supplement (Bar, powder, liquid meal)
	Medical supplements Supplements used to prevent or treat clinical issues including diagnosed nutrient deficiencies. Best used with advice from an appropriate medical/nutrition practitioner.	Iron supplement
		Calcium supplement
		Multivitamin supplement
		Vitamin D supplement
		Probiotics
	Performance supplements Supplements/ingredients that can support or achieve an enhancement of sports performance. Best used with an individualised and event-specific protocol, with the advice of appropriate sports science/nutrition practitioner	Caffeine
		B-alanine
		Bicarbonate
		Beetroot juice/Nitrate
		Creatine
		Glycerol

Group B

Overview of category	Sub-categories	Examples
Evidence Level: **Deserving of further research and could be considered for provision to athletes under a research protocol or case-managed monitoring situation** **Use within Supplement Programs:** **Provided to athletes within research or clinical monitoring situations.** **Note that some of the products currently listed in Group B have been included due to their interest by Key Stakeholders.** **Our new Evidence Map approach will aim to better define the scientific support for these products**	**Food polyphenols** Food compounds which may have bioactivity including antioxidant and anti-inflammatory properties. May be consumed in food forms or as isolated chemicals.	Cherries, berries and black currants
		Quercitin, ecgc, epicatechins & others
	Other Compounds which attract interest for potential benefits to body metabolism and function	Collagen support products
		Carnitine
		HMB
		Ketone supplements
		Fish oils
		Phosphate
		Circumin
	Sick Pack Multi-supplement approach to address an issue or health or well-being Best used with advice from an appropriate medical/nutrition practitioner	Zinc lozenges and Vitamin C
	Amino Acids Constituents of protein which may have effects when taken in isolation, or may be consumed individually by the athlete to fortify an existing food/supplement that is lacking in this amino acid.	BCAA/Leucine
		Tyrosine
	Antioxidants Compounds often found in foods which protect against oxidation or reactions with free-radical chemicals. May be consumed in food forms or as isolated chemicals	Vitamin C & E
		N-acetyl cysteine

https://www.ais.gov.au/nutrition/supplements

General Overview

Group C

Overview of category	Subcategories	Examples
Evidence Level: **Have little meaningful proof of beneficial effects** **Use within Supplement Programs:** **Not provided to athletes within Supplement Programs** **May be permitted for individualized use by an athlete where there is specific approval from, or reporting to, a Sports Supplement Panel.**	Category A and B products used outside approved protocols	See list for Category A and B products
	The rest If you can't find an ingredient/product in Groups A, B or D, it probably deserves to be here	The AIS Supplement Framework will no longer name Group C supplements or supplement ingredients in this top line layer of information. This will avoid the perception that these supplements are special.

Group D

Overview of category Use within AIS system	Subcategories	Examples
Evidence level: **Banned or at high risk of contamination with substances that could lead to a positive drug test** **Use within Supplement Programs** **Should not be used by athletes**	**Stimulants** Consult WADA list for all examples: https://www.wada-ama.org/	Ephedrine Strychnine Sibutramine Methylhexanamine (DMAA) 1,3-dimethylbutylamine (DMBA) Other herbal stimulants
	Prohormones and hormone boosters Consult WADA list for all examples: https://www.wada-ama.org/	DHEA Androstenedione 19-norandrostenione/ol Other prohormones Tribulus terrestris and other testosterone boosters* Maca root powder*
	GH releasers and "Peptides" Consult WADA list for all examples: https://www.wada-ama.org/	Technically, while these are sometimes sold as supplements (or have been described as such) they are usually unapproved pharmaceutical products
	Beta-2 agonists Consult WADA list for all examples: https://www.wada-ama.org/	Higenamine
	Selective Androgen Receptor Modulators (SARMS)	Andarine Ostarine Ligandrol
	Metabolic modulators	GW1516 (Cardarine)

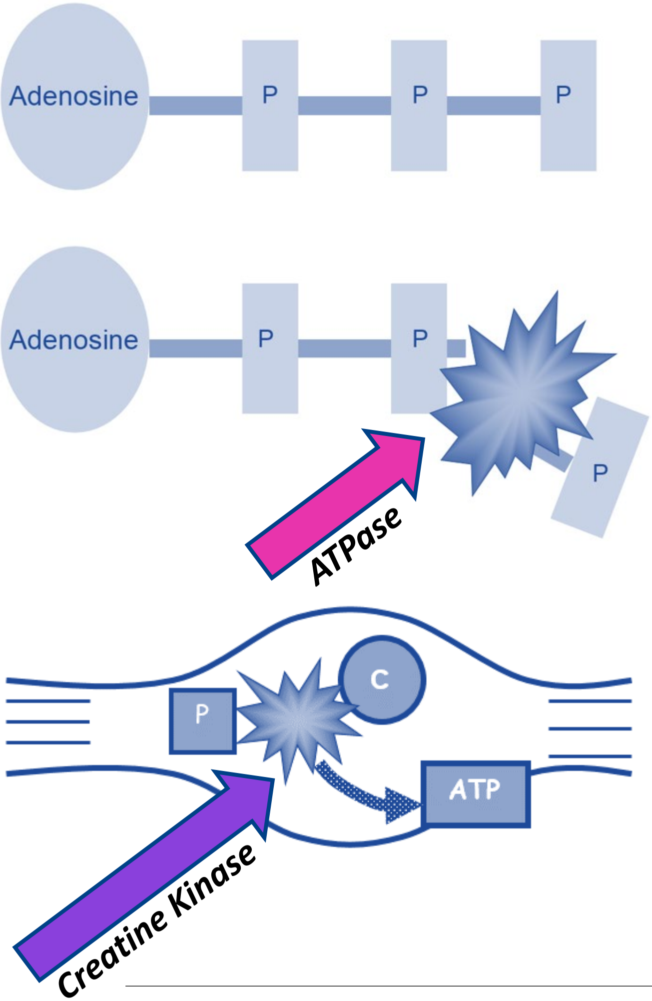
https://www.ais.gov.au/nutrition/supplements

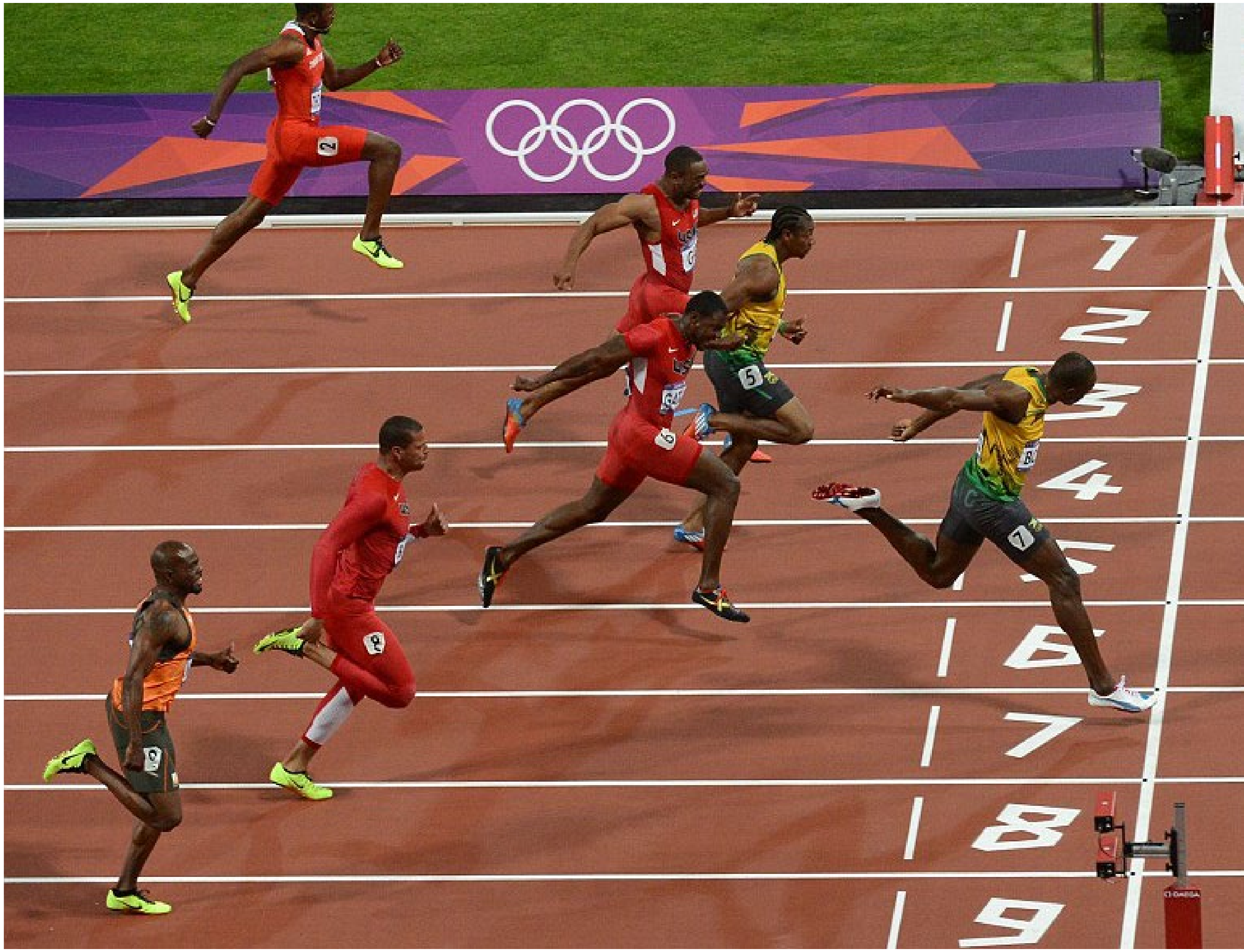
General Overview

Specific performance supplements	Ergogenic effects	Physiological effects/mechanism of ergogenic effect	Concerns regarding use[a]	Evidence
Creatine	Improves performance of repeated bouts of high-intensity exercise with short recovery periods - Direct effect on competition performance - Enhanced capacity for training	Increases Creatine and Phosphocreatine concentrations May also have other effects such as enhancement of glycogen storage and direct effect on muscle protein synthesis	Associated with acute weight gain (0.6–1 kg) which may be problematic in weight sensitive sports May cause gastrointestinal discomfort Some products may not contain appropriate amounts or forms of creatine	Tarnopolsky (2010)[143]
Caffeine	Reduces perception of fatigue Allows exercise to be sustained at optimal intensity/output for longer	Adenosine antagonist with effects on many body targets including central nervous system Promotes Ca^{2+} release from sarcoplasmic reticulum	Causes side-effects (tremor, anxiety, increased heart rate, etc.) when consumed in high doses Toxic when consumed in very large doses Rules of National Collegiate Athletic Association competition prohibit the intake of large doses that produce urinary caffeine levels exceeding 15 ug/ml Some products do not disclose caffeine dose or may contain other stimulants	Astorino (2010)[144] Tarnopolsky (2010)[143] Burke (2013)[145]
Sodium bicarbonate	Improves performance of events that would otherwise be limited by acid–base disturbances associated with high rates of anaerobic glycolysis - High intensity events of 1–7 minutes - Repeated high-intensity sprints - Capacity for high-intensity "sprint" during endurance exercise	When taken as an acute dose pre-exercise, increases extracellular buffering capacity	May cause gastrointestinal side-effects which cause performance impairment rather than benefit	Carr (2011)[146]
Beta-alanine	Improves performance of events that would otherwise be limited by acid–base disturbances associated with high rates of anaerobic glycolysis - Mostly targeted at high-intensity exercise lasting 60–240 seconds - May enhance training capacity	When taken in a chronic protocol, achieves increase in muscle carnosine (intracellular buffer)	Some products with rapid absorption may cause paresthesia (tingling sensation)	Quesnele (2014)[147]
Nitrate	Improves exercise tolerance and economy Improves performance in endurance exercise at least in non-elite athletes	Increases plasma nitrite concentrations to increase production of nitric oxide with various vascular and metabolic effects that reduces O_2 cost of exercise	Consumption in concentrated food sources (eg, beetroot juice) may cause gut discomfort and discoloration of urine Efficacy seems less clear cut in high caliber athletes	Jones (2014)[148]

Thomas et al. (2016) Med Sci Sports Exerc 48: 543–568

Creatine





Creatine

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- Creatine (Cr) is a naturally occuring compund mostly found (95%) in muscle tissue (the other 5% is found in various organs: brain, liver, kidneys, testes)
- The primary dietary sources are fish and red meats (see Table 11.4 in Jeukendrup & Gleeson), but it can also be synthesised by the body
- Cr in muscle is phosphorylated and 60–70% is stored as PCr, with TII fibres storing ~ 30% more Cr than TI fibres
- Greenhaff et al. (1993): the first study to show ↑ performance (by 6%) with Cr supplementation (CrS)
- Most performance studies now show positive effects of CrS
- Loading: 4 x 5 g for 6 days (+ 2 g/day for maintenance over 35 days)
  1 x 3 g for 28 days
- The largest increases are seen in those with low initial concentrations

Creatine

- Increases of ~ 0.5–3.5 kg BM may occur with CrS, perhaps due to ↑ intracellular water, ↑ protein synthesis or ↓ protein breakdown
- This may or may not be a problem, depending on the sport
- CrS is generally considered beneficial for high-intensity exercise performance and resistance training
- The proposed mechanisms are:
  - Increased PCr availability
  - Increased rate of PCr resynthesis
  - Reduced anaerobic glycolysis
  - Buffering of H^+
- There is no scientific evidence for any detrimental health effects, although anecdotal reports include various problems
- More information is required regarding the health risks of CrS

Buffers

- During intense exercise H+ concentration increases in the muscle cells, leading to an acidic environment
- Increased muscle acidity is a limiting factor (i.e., a cause of fatigue) for performance in events lasting ~ 1–10 min
- Accumulated H+ are “buffered” by extra- and intracellular buffering mechanisms
  - Extracellular buffer: **sodium bicarbonate (citrate)**
  - Intracellular buffer: **beta-alanine (carnosine)**
- These buffers provide an effective and rapid way of normalising the H+ concentration
- Improving these buffering systems appears to delay the onset of fatigue due to muscle acidity, thus improving performance

Buffers

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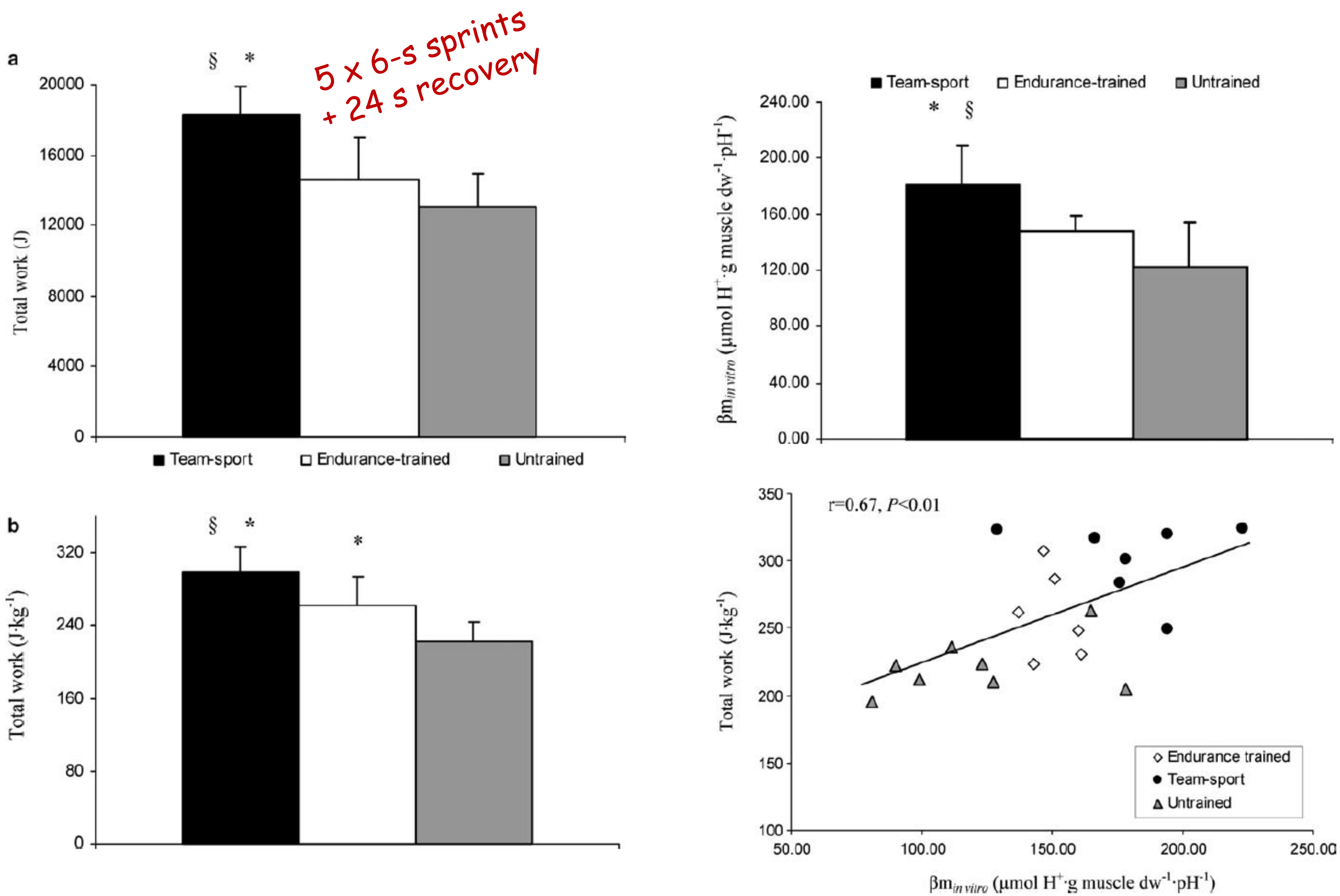
Johann Edge · David Bishop · Stephen Hill-Haas
Brian Dawson · Carmel Goodman

Comparison of muscle buffer capacity and repeated-sprint ability of untrained, endurance-trained and team-sport athletes

Edge et al. (2006) Eur J Appl Physiol 96: 225-234

Buffers



Edge et al. (2006) Eur J Appl Physiol 96: 225-234

Buffers: Bicarbonate

- Bicarbonate is a Group A supplement according to the AIS ("supported for use in specific situations in sport")
- Bicarbonate is an extracellular buffer, buffering H+ in the blood
- Bicarbonate is useful for high-intensity sports relying upon anaerobic glycolysis, including team and racket sports
- Very explosive movements and long-duration exercise are generally unaffected, with events lasting 1–7 min perhaps benefitting most
- A 1-h maximal cycle effort was also ↑ by 13-14% with bicarbonate

Buffers: Bicarbonate

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- The most common way to load with bicarbonate: an acute dose of 300 mg/kg BM taken ~ 1–2 h before the session/performance? (see Figure 11.15 in Jeukendrup & Gleeson)
- Loading may also occur over several days to increase buffer capacity, although this method requires further investigation
- Many individuals experience diarrhoea, gastro-intestinal discomfort, bloating and cramps with bicarbonate supplementation
- In order to overcome the gastrointestinal discomfort athletes can split 600 mg/kg BM over a day (or perhaps load over a period of days and stop supplementing 24 h before competition)
- In any case, methods of ingestion should be practiced first!

Buffers: Beta-Alanine

- Beta-alanine was elevated from Group B ("deserving of further research") to Group A ("supported for use in specific situations in sport") according to the AIS
- ↑ beta-alanine → ↑ carnosine → ↑ buffering → ↑ high-intensity performance
- 4–8 doses achieving 3.2–6.4 g/day for 4–10 weeks = 60–80% ↑ carnosine
- But is performance improved?
- Possibly, where acidosis is considered the primary cause of fatigue (i.e., short, high-intensity exercise)

Buffers: Beta-Alanine

- Beta-alanine in the blood rises and falls within ~ 2 h of supplementation and all individuals appear to respond to it
- However, tingling (kittlande) feelings have been reported, and even discomfort
- High intensity cycling (110% maximal power) increased after 4 and 10 weeks of beta-alanine supplementation by 13% and 16%, respectively, perhaps due to ↑ muscle buffer capacity
- Beta-alanine may be used as well as bicarbonate, due to the differing buffering locations (i.e., intra- versus extraceullar)

Caffeine

- Most common sources: coffee, tea, cola and energy drinks
- Stimulating effect on the central nervous system (CNS)
- No longer classed by WADA as doping
- 100 mL coffee ≈ 100 mg caffeine
- Habitual use may not affect sensitivity
- Always practice individually prior to use

Caffeine

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TIMING

- Rapidly absorbed following oral consumption
- Peak blood (plasma) levels after ~ 30–60 min
- Half-life ~ 2–10 h, varying between individuals
- Best practice: ~ 1 hour before exercise

DOSE

- 2–9 mg/kg body mass
- 300–500 mg
- Best practice: 3 mg/kg?

Caffeine

MECHANISMS – Original explanations

- ↑ availability of plasma fatty acids, thus increasing fat metabolism and suppressing CHO metabolism and ↓ glycogen utilisation
- But studies have since shown performance improvements without any changes in fat oxidation rates

MECHANISMS – More recent explanations

- **CNS** blocking adenosine receptors in the brain → blocking the substance that reduces motor activity + alertness
- ...Reduced sensation of effort, a given task "feels" easier
- **Changes to muscle contractility:** Altered neuromuscular pathways that facilitate muscle fibre recruitment
- …Enhanced anaerobic energy production?

Caffeine

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Suggested Mechanisms by Which Caffeine Exerts Its Ergogenic Effect

Caffeine increases lipolysis and spares muscle glycogen.

1. Caffeine increases circulating epinephrine levels, which stimulates lipolysis.
2. Caffeine antagonizes adenosine receptors that normally inhibit hormone-sensitive lipase and FA oxidation (only shown *in vitro*).
3. Caffeine inhibits phosphodiesterase leading to an increased concentration of 3',5'-cyclic monophosphate (cAMP) (only shown *in vitro*).

Caffeine increases excitability of the muscle fibers.

1. Caffeine has a direct effect on key regulatory enzymes such as phosphorylase.
2. Caffeine increases influx of calcium from the extracellular space.
3. Caffeine increases release of calcium from the sarcoplasmic reticulum.
4. Caffeine increases the sensitivity of the myofilaments to calcium.

Caffeine influences signal transduction from the brain to the motor neuron.

1. Caffeine stimulates catecholamine release and the release of neurotransmitters (dopamine, β-endorphins), possibly resulting in decreased perception of effort.
2. Caffeine may lower the excitation threshold for motor neuron recruitment.
3. Caffeine alters excitation/contraction coupling.
4. Caffeine increases ion transport within the muscle.
5. Caffeine facilitates transmission of nervous signals.

Jeukendrup & Glesson, Sports Nutrition (2nd edition)

Caffeine

DIURETIC

- Promoting the production of urine
- Increasing the risk of dehydration and poor temperature regulation

but...

- ...minor effects on urine losses / overall dehydration
- ...caffeine-containing drinks provide a significant source of fluid (Stear et al., 2010 BJSM)
- Killer et al. (2014):

No Evidence of Dehydration with Moderate Daily Coffee Intake: A Counterbalanced Cross-Over Study in a Free-Living Population

Sophie C. Killer[¤], Andrew K. Blannin[*], Asker E. Jeukendrup[¤]
School of Sport and Exercise Sciences, University of Birmingham, Birmingham, West Midlands, United Kingdom

Nitrate

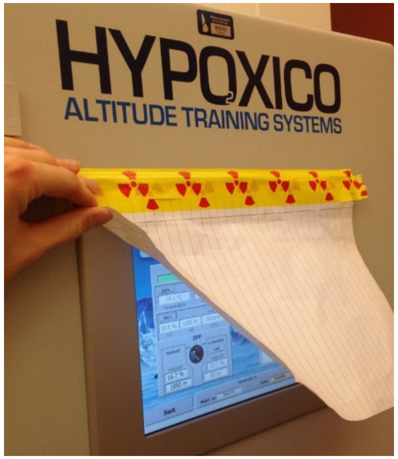
Nitrate

- Nitrate is a Group A supplement according to the AIS (“supported for use in specific situations in sport”)
- It is produced in the body and found in our diets (particularly in beetroot, celery, lettuce, rocket and spinach)
- Nitrate is reduced to nitrite, which is further reduced to nitric oxide (NO)
- NO is important for modulating skeletal muscle function (regulation of blood flow, muscle contractility, glucose and calcium homeostasis, mitochondrial biogenesis and respiration)
- A 70 mL “SHOT” = 300 mg nitrate, while 200 mL juice = 260 mg nitrate
- Nitrate is rapidly absorbed, with plasma levels peaking after around 1 h
- 5–6 mmol (300-400 mg) of nitrate is typically consumed ~ 2–2.5 h before exercise
- Supplementation seems to improve the O_2 cost of exercise and performance

Nitrate

Physiological and performance effects of nitrate supplementation during roller-skiing in normoxia and normobaric hypoxia

Linn Nybäck [a], Caroline Glännerud [a], Gustav Larsson [a], Eddie Weitzberg [b], Oliver Michael Shannon [c], Kerry McGawley [a,*]



Nybäck et al. (2017) Nitric Oxide 70:1-8

Nitrate

A B S T R A C T

The present study examined the effects of acute nitrate (NO_3^-) supplementation ingested in the form of concentrated beetroot juice on cross-country roller-ski performance in normoxia (N) and normobaric hypoxia (H). Eight competitive cross-country skiers (five males: age 22 ± 3 years, $\dot{V}O_{2max}$ 71.5 ± 4.7 mL $kg^{-1} \cdot min^{-1}$; three females: age 21 ± 1 years, $\dot{V}O_{2max}$ 58.4 ± 2.5 mL $kg^{-1} \cdot min^{-1}$) were supplemented with a single dose of NO_3^--rich beetroot juice (BRJ, ~13 mmol NO_3^-) or a NO_3^--depleted placebo (PL, ~0 mmol NO_3^-) and performed 2 x 6-min submaximal exercise bouts and a 1000-m time-trial (TT) on a treadmill in N (20.9% O_2) or H (16.8% O_2). The four experimental trials were presented in a randomised, counter-balanced order. Plasma NO_3^- and nitrite concentrations were significantly higher following BRJ compared to PL (both $p < 0.001$). However, respiratory variables, heart rate, blood lactate concentration, ratings of perceived exertion, and near-infrared spectroscopy-derived measures of muscle tissue oxygenation during submaximal exercise were not significantly different between BRJ and PL (all $p > 0.05$). Likewise, time to complete the TT was unaffected by supplementation in both N and H ($p > 0.05$). In conclusion, an acute dose of ~13 mmol NO_3^- does not affect physiological or performance responses to submaximal or maximal treadmill roller-skiing in competitive cross-country skiers exercising in N and H.

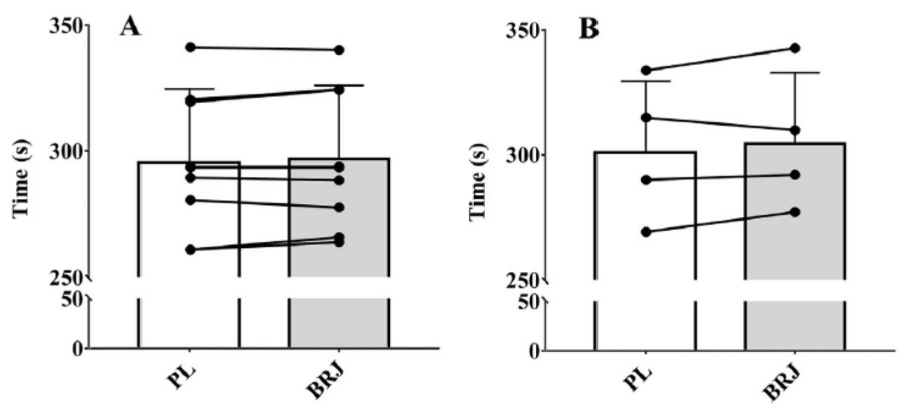


Fig. 2. 1000-m time-trial (TT) performance in (A.) normoxia and (B.) hypoxia following placebo (PL) and beetroot juice (BRJ) supplementation.

Nitrate

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Sports Med (2017) 47:2155–2169
DOI 10.1007/s40279-017-0744-9

CrossMark

REVIEW ARTICLE

"Beet-ing" the Mountain: A Review of the Physiological and Performance Effects of Dietary Nitrate Supplementation at Simulated and Terrestrial Altitude

Oliver Michael Shannon[1] · Kerry McGawley[2] · Linn Nybäck[2] · Lauren Duckworth[1] · Matthew John Barlow[1] · David Woods[1,3] · Mario Siervo[4] · John Paul O'Hara[1]

Key Points

The findings of this review demonstrate that dietary nitrate (NO_3^-) supplementation may reduce the oxygen cost of exercise, elevate arterial and tissue oxygenation, improve muscle metabolic function, and enhance exercise capacity/performance at simulated altitude.

Current preliminary evidence from training studies conducted at simulated altitude suggests that NO_3^- supplementation has no effect on performance-related adaptations, although further investigations are warranted.

Additional studies are required to confirm whether the beneficial effects of NO_3^- supplementation that have been demonstrated at simulated altitude also manifest at terrestrial altitude.

Nitrate

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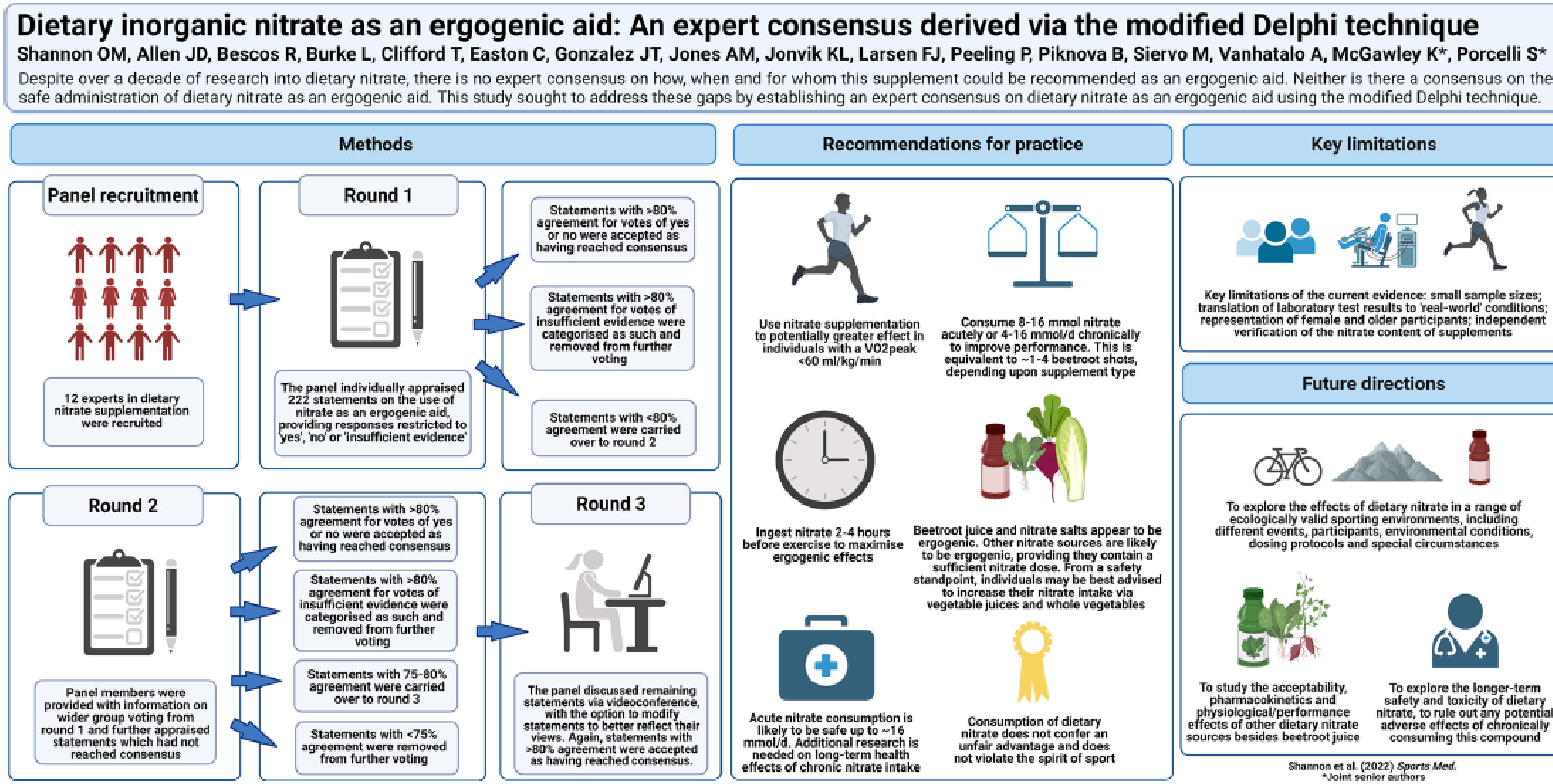

Combining Ergogenic Aids

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No individual or combined effects of caffeine and beetroot-juice supplementation during submaximal or maximal running

Johanna Oskarsson and Kerry McGawley

Abstract: Dietary supplements such as caffeine and beetroot juice are used by athletes in an attempt to optimize performance and therefore gain an advantage in competition. The aim of this study was to investigate the individual and combined effects of caffeine and beetroot-juice supplementation during submaximal and maximal treadmill running. Seven males (maximal oxygen uptake: 59.0 ± 2.9 mL·kg^{-1}·min^{-1}) and 2 females (maximal oxygen uptake: 53.1 ± 11.4 mL·kg^{-1}·min^{-1}) performed a preliminary trial followed by 4 experimental test sessions. Each test session consisted of two 5-min submaximal running bouts (at ~70% and 80% of maximal oxygen uptake) and a maximal 1-km time trial (TT) in a laboratory. Participants ingested 70 mL of concentrated beetroot juice containing either 7.3 mmol of nitrate (BR) or no nitrate (P_{BR}) 2.5 h prior to each test session, then either caffeine (C) at 4.8 ± 0.4 (4.3–5.6) mg/kg of body mass or a caffeine placebo (P_C) 45 min before each test session. The 4 test sessions (BR-C, BR-P_C, P_{BR}-C, and P_{BR}-P_C) were presented in a counterbalanced and double-blind manner. No significant differences were identified between the 4 interventions regarding relative oxygen uptake, running economy, respiratory exchange ratio, heart rate (HR), or rating of perceived exertion (RPE) at the 2 submaximal intensities ($P > 0.05$). Moreover, there were no significant differences in performance, maximum HR, peak blood lactate concentration, or RPE during the maximal TT when comparing the interventions ($P > 0.05$). In conclusion, no beneficial effects of supplementing with typical doses of caffeine, beetroot juice, or a combination of the two were observed for physiological, perceptual, or performance responses during submaximal or maximal treadmill running exercise.

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Combining Ergogenic Aids

Acute effects of beetroot juice and caffeine co-ingestion during a team-sport-specific intermittent exercise test in semi-professional soccer players: a randomized, double-blind, placebo-controlled study

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Combining Ergogenic Aids

Abstract

Background: Beetroot juice (BJ) and caffeine (CAF) are considered as ergogenic aids among athletes to enhance performance, however, the ergogenic effects of BJ and CAF co-ingestion are unclear during team-sport-specific performance. This study aimed to investigate the acute effects of BJ and CAF co-ingestion on team-sport-specific performance, compared with placebo (PL), BJ, and CAF alone.

Method: Sixteen semi-professional male soccer players (age: 19.8 ± 2.2 years, body mass: 69.2 ± 6.1 kg, height: 177.3 ± 6.0 cm) completed four experimental trials using a randomized, double-blind study design: BJ + CAF, CAF + PL, BJ + PL, and PL + PL. Countermovement jump with arm swing (CMJAS) performance and cognitive function by Stroop Word-Color test were evaluated before and after the Yo–Yo Intermittent Recovery Test level 1 (YYIR1). Also, rate of perceived exertion (RPE), heart rate, and gastrointestinal (GI) discomfort were measured during each session.

Results: No significant differences were shown between test conditions for total distance covered in YYIR1 (BJ + CAF: 1858 ± 455 m, CAF + PL: 1798 ± 422 m, BJ + PL: 1845 ± 408 m, PL + PL 1740 ± 362 m; $p = 0.55$). Moreover, CMJAS performance, cognitive function, and RPE during the YYIR1 were not significantly different among conditions ($p > 0.05$). However, the average heart rate during the YYIR1 was higher in CAF + PL compared to PL + PL (by 6 ± 9 beats/min; $p < 0.05$), and GI distress was greater in BJ + CAF compared to PL + PL (by 2.4 ± 3.6 a.u.; $p < 0.05$).

Conclusion: These results suggest, neither acute co-ingestion of BJ + CAF nor BJ or CAF supplementation alone significantly affected team-sport-specific performance compared to the PL treatment.

Keywords: Nitrate, Countermovement jump, Ergogenic aids, Team-sport performance, Yo–Yo test

Combining Ergogenic Aids

- Burke et al. (2017) “Practical Issues in Evidence-Based Use of Performance Supplements: Supplement Interactions, Repeated Use and Individual Responses”. Sports Medicine, 47(Suppl 1):79-100

Thanks!