SOCIETÀ ITALIANA
Nutrizione Sport e Benessere

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Nutrizione e Supplementazione nell'attività di endurance

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NUTRIZIONE DELLO SPORT
Dal principiante in sovrappeso all'atleta di Elite,
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Sport nutrition: A review of the latest guidelines for exercise and sport nutrition from the American College of Sport Nutrition, the International Olympic Committee and the International Society for Sports Nutrition

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Physical activity level	kcal/kg/day	kcal/day
General physical activity 30-40 minutes/day, 3 times a week	Normal diet, 25-35	1 800-2 400[a]
Moderate levels of intense training 2-3 hours/day, 5-6 times a week[b]	50-80	2 500-8 000[c]
High-volume intense training 3-6 hours/day, 1-2 sessions/day, 5-6 times a week[b]	50-80	2 500-8 000[c]
Elite athletes[d]	150-200	Up to 12 000[e]
Large athletes[d]	60-80	6 000-12 000[f]

a: Values estimated for a 50-80 kg individual
b: Moderate levels of intense training use lower level of range, high-volume intense training uses upper level of range
c: Values estimated for a 50-100 kg individual
d: Depending on training periodisation, and the volume and intensity of training
e: Values estimated for a 60-80 kg athlete
f: Values estimated for a 100-150 kg athlete

CARBOHYDRATE REPLACEMENT

Durante intensità moderata (65-70% _VO2max), il carboidrato è ossidato ad una velocità di 1 grammo di carboidrati al minuto o 60 grammi di carboidrati all'ora

(Jeukendrup AE. Carbohydrate intake during exercise and performance. Nutrition 20: 669–677, 2004 - Jeukendrup AE and Jentjens R. Oxidation of carbohydrate feedings during prolonged exercise: Current thoughts, guidelines and directions for future research. Sports Med 29: 407–424, 2000..).

Le riserve interne generalmente esaurite entro 60' -90' di esercizio prolungato = preoccupazione primaria per un atleta! TEMPO PIU' PROLUNGATO ADOTTANDO STRATEGIE DI **Carbohydrate loading**

Molte soluzioni di carboidrati-elettroliti in commercio possono fornire carboidrati ad una concentrazione del 6-8%. A questa concentrazione, consumando 120-350 ml di fluido ogni 10-15 minuti costituisce una soluzione ottimale per il ripristino dei carboidrati ossidati (oltre a essere utile per liquidi ed elettroliti persi).

Tecniche disponibili **post attività fisica**:

- aumento dei carboidrati nelle 2 ore successive della sessione allenante: 1,2g/kg/h
- aumento dei carboidrati nei giorni successivi alla sessione allenante: 8-10g/kg/die

CARBOHYDRATE REPLACEMENT

Table I. Recommendations for carbohydrate (CHO) intake during different endurance events.

Event	CHO required for optimal performance and minimizing negative energy balance	Recommended intake	CHO type	Single carbohydrate (e.g. glucose)	Multiple transportable carbohydrates (e.g. glucose : fructose)
<30 min	None required	–	–	–	–
30–75 min	Very small amounts	Mouth rinse	Most forms of CHO	•	•
1–2 h	Small amounts	Up to 30 g · h^{-1}	Most forms of CHO	•	•
2–3 h	Moderate amounts	Up to 60 g · h^{-1}	Forms of CHO that are rapidly oxidized (glucose, maltodextrin)	○	•
>2.5 h	Large amounts	Up to 90 g · h^{-1}	Only multiple transportable CHO		•

Note: •, optimal; ○, OK, but perhaps not optimal. These guidelines are intended for serious athletes, exercising at a reasonable intensity (>4 kcal · min^{-1}). If the (absolute) exercise intensity is below this, the figures for carbohydrate intake should be adjusted downwards.

Nutrition for endurance sports: Marathon, triathlon, and road cycling

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DOI: 10.1080/02640414.2011.610348 · Source: PubMed

CARBOHYDRATE REPLACEMENT

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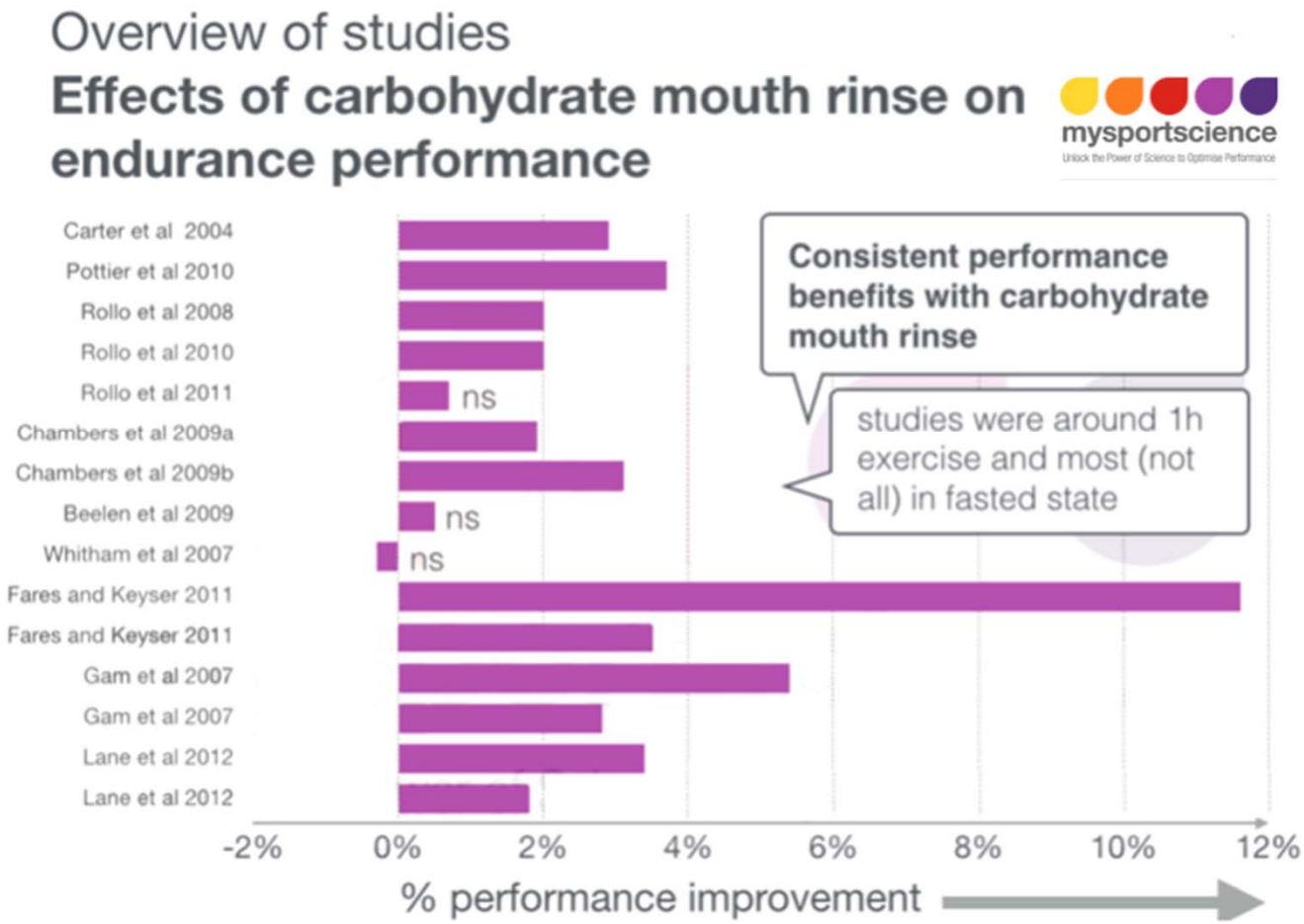

Summary of the studies investigating the effect of carbohydrate mouth rinse on performance during exercise.

Reference	Type of activity/exercise protocol	Sample (*n*)	Fast (h)	Design	Duration of mouth rinse/beverage concentration (%)	Number of mouth rinses	Distinguish between the solutions ***	Main results (mean ± SD)	(% Enhanced Performance)
Chambers *et al.* [1]	Cycling Time-trial ~1 h (914 ± 29 kJ) ~75% W_{max}	8 M (ET)	6	Double-Blinded	10 s/Glucose (6.4%) *vs.* PLA (saccharin + aspartame in water: 150 mL/1000 mL)	8	0	Time (min) 60.4 ± 3.7 *vs.* 61.6 ± 3.8	Yes, 1.99%
Chambers *et al.* [1]	Cycling Time-trial ~1 h (914 ± 29 kJ) ~75% W_{max}	6 M and 2 W (ET)	6	Double-Blinded	10 s/MALT (6.4%) + saccharin and aspartame *vs.* PLA (saccharin and aspartame in water: 150 mL/1000 mL)	8	0	Time (min) 62.6 ± 4.7 *vs.* 64.6 ± 4.9	Yes, 3.19%
Carter *et al.* [2]	Cycling Time-trial ~1 h (~914 ± 40 kJ) ~75% Wmax	7 M and 2 W (ET)	4	Blinded	5 s/MALT (6.4%) *vs.* Water	8	4 (4)	Time (min) 59.6 ± 0.5 *vs.* 61.4 ± 0.5	Yes, 3.02%
Rollo *et al.* [7]	Running Time-trial 30 min ~60% VO_2max	10 * (ET)	Overnight fast	Double-Blinded	5 s/CHO (6%) *vs.* PLA	9	2 (**)	Distance (m) 6584 ± 520 *vs.* 6469 ± 515	Yes, 1.78%
Pottier *et al.* [8]	Cycling Time-trial ~1 h (975 ± 85 kJ) ~75% W_{max}	12 * (ET)	3	Double-Blinded	5 s/CHO-E (6%) *vs.* PLA	8	**	Time (min) 61.7 ± 5.1 *vs.* 64.1 ± 6.5	Yes, 3.89%
Pottier *et al.* [8]	Cycling Time-trial ~1 h (975 ± 85 kJ) ~75% W_{max}	12 * (ET)	3	Double-Blinded	Ingestion CHO-E (6%) *vs.* PLA	8	**	Time (min) 63.2 ± 6.9 *vs.* 62.5 ± 6.9	No, −1.11%
Beelen *et al.* [12]	Cycling Time-trial ~1 h (1.053 ± 48 kJ) ~75% W_{max}	14 M (ET)	2	Double-Blinded	5 s/MALT (6.4%) *vs.* Water	8	5 (4)	Time (min) 68.1 ± 0.3 *vs.* 67.5 ± 0.3	No, −0.91%
Sinclair *et al.* [13]	Cycling time trial 30-min	11 M	4	Blinded	5 s/MALT (6.4%) *vs.* Water	5	11 (5)	Power Output (W) 153 ± 17 *vs.* 146 ± 13	Yes, 4.34%
Sinclair *et al.* [13]	Cycling time trial 30-min	11 M	4	Blinded	10 s/MALT (6.4%) *vs.* Water	5	11 (6)	Power Output (W) 156 ± 17 *vs.* 146 ± 13	Yes, 6.36%
Fares and Kayser [14]	Cycling ~60% W_{max} until exhaustion	13 M (NA)	3	Blinded	5–10 s/CHOFS (6.4%) *vs.* PLAFS (water)	12	8 (4)	Time (min) 56.6 ± 12.2 *vs.* 54.7 ± 11.3	Yes, 3.47%
Fares and Kayser [14]	Cycling ~60% W_{max} until exhaustion	13 M (NA)	Overnight fast	Blinded	5-10 s/FCHO (6.4%) *vs.* FPLA (water)	12	7 (4)	Time (min) 53.9 ± 12.8 *vs.* 48.3 ± 15.3	Yes, 11.59%
Rollo *et al.* [15]	Running Time-trial ~1 h ~60% VO_{2max}	10 M (ET)	~14	Double-Blinded	5 s/CHO-E (6.4%, mouth rinse without intake) *vs.* PLA (mouth rinse + intake)	4	**	Distance (m) 14283 ± 758 *vs.* 14190 ± 800	No, 0.65%
Rollo *et al.* [15]	Running Time-trial ~1 h ~60% VO_{2max}	10 M (ET)	~14	Double-Blinded	5 s/CHO-E (6.4%, mouth rinse + intake) *vs.* PLA (mouth rinse + intake)	4	**	Distance (m) 14515 ± 756 *vs.* 14190 ± 800	Yes, 2.29%
Whitham and Mckinney [16]	Running Time-trial 45 min (1.053 ± 48 kJ) ~65% VO_{2max}	7 M (RA)	4	Double-Blinded	5 s/ MALT (6% maltodextrin-97% polysaccharide, 2% disaccharide, 1% glucose + 3% lemon juice) *vs.* PLA (3% lemon juice)	10	1 (1)	Distance (m) 9333 ± 988 *vs.* 9309 ± 993	No, 0.26%
Rollo *et al.* [17]	Running Time-trial ~1 h ~60% VO_{2max}	20 M (ET)	~14	Double-Blinded	5 s/CHO-E (6.4%) *vs.* PLA	4	0	Distance (m) 14298 ± 685 *vs.* 14086 ± 732	Yes, 1.50%
	Cycling		Overnight	Double-				Power output (W) 286	

* No gender specification; ** Not reported; *** Number of distinguishing (number of correct distinguishing is given in parentheses). M—men; W—women; ET—endurance trained; RA—recreationally active; NA—nonathletic; CHO-E—electrolyte solution at carbohydrate; GLU—glucose; MALT—maltodextrin; PLA—placebo; FCHO—carbohydrate rinse in fasted state; FPLA—placebo in fasted state; CHOFS—carbohydrate rinse in fed state; PLAFS—placebo in fed state; MALTFS—maltodextrine rinse in fed state; FMALT—maltodextrine rinse in fast state.

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Can Carbohydrate Mouth Rinse Improve Performance during Exercise? A Systematic Review

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Table II: Carbohydrate requirements for physical activity[2,3,5,12]

Physical activity level	g/kg BW/day	Comments
Daily or habitual carbohydrate requirements		
ACSM		
Athletes	6-10 g/kg BW/day	Depends on the athlete's total daily energy expenditure, type of sport, gender and environmental conditions.
ISSN		
General physical activity, 30-60 minutes/day, 3-4 times a week	3-5 g/kg BW/day	Complex carbohydrates. Low to moderate GI. Concentrated carbohydrates.
Moderate- to high-intensity volume, 2-3 hours/day, 5-6 times a week	5-8 g/kg BW/day	
High-volume, intense exercise, 3-6 hours/day, 1-2 sessions, 5-6 time a week	8-10 g/kg BW/day	
IOC		
Low-intensity or skill-based activities	3-5 g/kg BW/day	Include pre-, during and post-training intake. Individual tolerance and preference. Nutrient-dense choices.
Moderate exercise programme, ~ 1 hour/day	5-7 g/kg BW/day	
Endurance programme, moderate to high intensity, 1-3 hours/day	6-10 g/kg BW/day	
Strength-trained athletes	4-7 g/kg BW/day	
Extreme commitment, moderate to high intensity, > 4-5 hours/day	8-12 g/kg BW/day	
Pre-event/training carbohydrate requirements		
ACSM		
Pre-event meal	200-300 g, 3-4 hours prior	Low in fat and fibre. High carbohydrates, moderate protein.

Carbohydrate-loading requirement recommendations are provided by the ISSN[2,3] and the IOC.[12] The ISSN suggests a lower range (8-10 g/kg BW) ingested for 1-3 days prior to an endurance event,[2,3] while the IOC advocates the ingestion of 7-12 g/kg BW for 24 hours, or 10-12 g/kg BW for 36-48 hours, prior to the endurance event.[12]

Physical activity level	g/kg BW/day	Comments
IOC		
During brief exercise < 45 minutes	Not needed	Practice plan before event. Higher carbohydrate intakes associated with increased exercise performance. Multiple transportable carbohydrates should be included (glucose and fructose mixtures) to increase carbohydrate oxidation.
During sustained high-intensity exercise lasting 45-75 minutes	Small amounts including mouth rinse	
During endurance exercise including "stop and start" sports lasting 1-2.5 hours	30-60 g/hour	
During ultra-endurance exercise lasting > 2.5-3 hours	Up to 90 g/hour	
Post-event or training carbohydrate requirements		
ACSM		
After exercise	1.0-1.5 g/kg BW during first 30 minutes, and again every 2 hours for 4-6 hours	Adequate fluid, electrolytes, energy and carbohydrates.
ISSN		
Post-exercise carbohydrate ingestion	1.5 g/kg BW or 0.6-1.0 g/kg BW during the first 30 minutes, and again every 2 hours for 4-6 hours	Within 30 minutes post-exercise.
IOC		
Speedy refuelling, < 8 hours recovery between two fuel-demanding sessions	1-1.2 g/kg BW/hour for first 4 hours, then resume daily fuel needs	Small, regular snacks. Compact carbohydrate-rich foods.

ACSM: American College of Sport Nutrition, BW: body weight, GI: glycaemic index, IOC: International Olympics Committee, ISSN: International Society for Sports Nutrition

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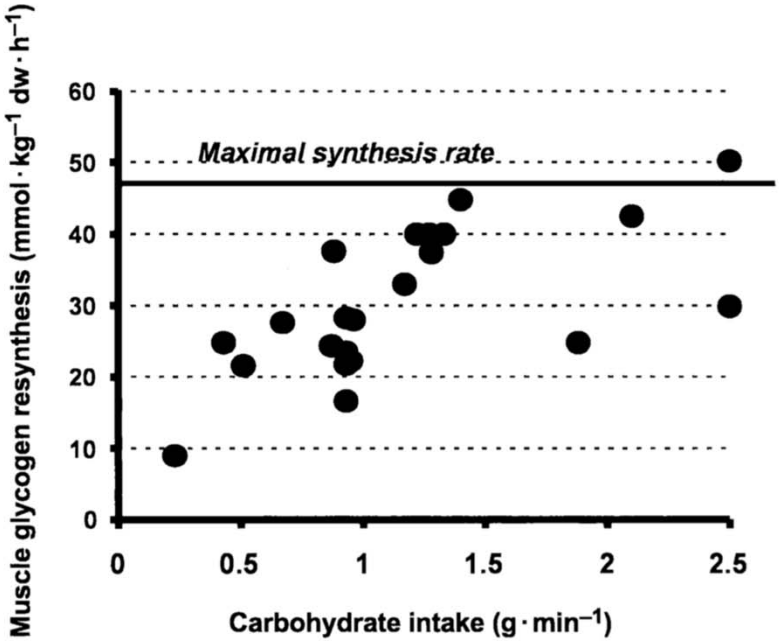

ıl muscle glycogen synthesis rates after the ingestion of different amounts of carbohydrate in the first few hours after

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Science and cycling: current knowledge and future directions for research

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Supplements for Endurance Athletes

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Supplements for Endurance Athletes

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IDRATAZIONE

Rate of fluid loss and required fluid replacement

Body mass (lbs)	Percent of body mass lost (in lbs)						
	1%	2%	3%	4%			
	Pounds of body mass lost						
140	1.4	2.8	4.2	5.6			
160	1.6	3.2	4.8	6.4			
180	1.8	3.6	5.4	7.2			
200	2	4	6	8			
220	2.2	4.4	6.6	8.8			
240	2.4	4.8	7.2	9.6			
260	2.6	5.2	7.8	10.4			
280	2.8	5.6	8.4	11.2			
300	3	6	9	12			
320	3.2	6.4	9.6	12.8			
340	3.4	6.8	10.2	13.6			

Sweat rate							
Time (min)	0.5 L/h	1 L/h	1.5 L/h	2 L/h	2.5 L/h	3 L/h	3.5 L/h
	Amount of fluid lost (in lbs) according to sweat rate						
30	0.6	1.1	1.7	2.2	2.8	3.3	3.9
60	1.1	2.2	3.3	4.4	5.5	6.6	7.7
90	1.7	3.3	5.0	6.6	8.3	9.9	11.6
120	2.2	4.4	6.6	8.8	11.0	13.2	15.4
150	2.8	5.5	8.3	11.0	13.8	16.5	19.3
180	3.3	6.6	9.9	13.2	16.5	19.8	23.1
	Cups of fluid needed to replace body mass loss						
30	1	2	3	4	5	6	7
60	2	4	6	8	11	13	15
90	3	6	10	13	16	19	22
120	4	8	13	17	21	25	30
150	5	11	16	21	26	32	37
180	6	13	19	25	32	38	44

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IDRATAZIONE

FLUIDI ED ELETTROLITI

Atleti endurance: sudorazione da 1,2 a 1,7 litri / ora di fluido corporeo (cioè circa il 2% del peso corporeo in un atleta di 70 kg), fino al il più alto tasso di sudore documentato pari a 4,2 litri per ora
(Tarnopolsky MA, Gibala M, Jeukendrup AE,and Phillips SM. Nutritional needs of eliteendurance athletes. Part I: Carbohydrate and fluid requirements. Eur J Sport Sci 5: 3–14, 2005).

Considerando che si può verificare un decremento delle prestazioni dopo solo una riduzione del 2% della massa corporea, agli atleti di resistenza bisogna assicurare una reidratazione ottimale.

NON SOLO ACQUA, ma anche ELETTROLITI (sodio in particolare per evitare situazioni di iponatremia).

Il consiglio più pratico sembra essere pesarsi prima e dopo l'esercizio fisico monitorando che le perdite di massa non superino all'1% durante una sessione di circa 90'.

CONSIGLIO BASILARE: 100ml di fluidi ogni 10' = 600ml/h

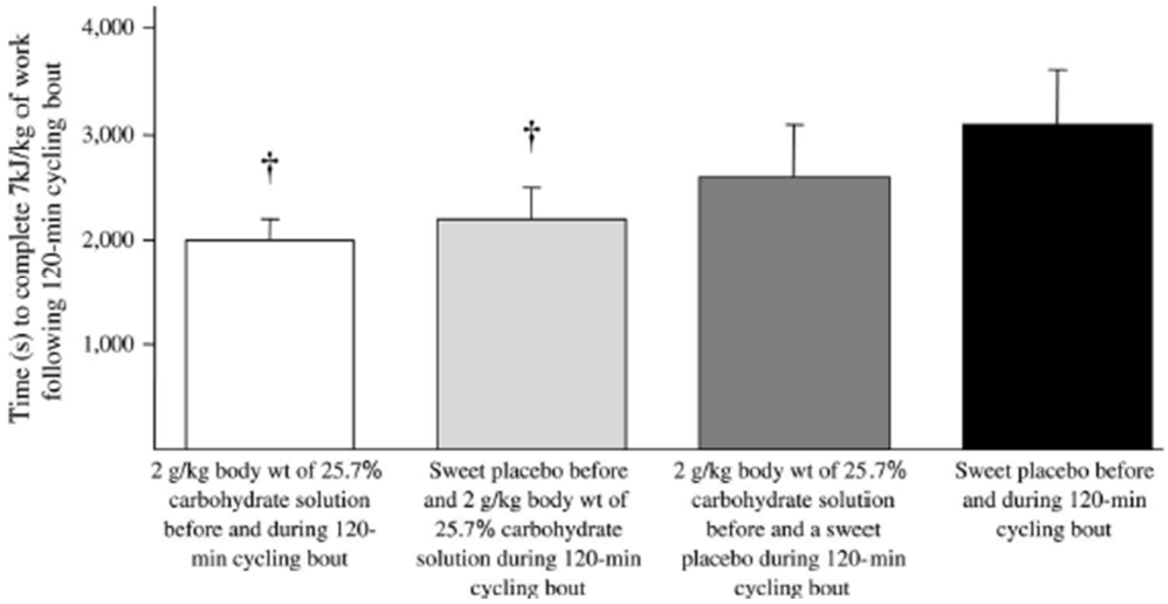

Figure 1. Performance enhancing effect of carbohydrate ingestion before and during prolonged cycling exercise. Data shown illustrates the amount of time to complete a standardized amount of work after a 120-minute bout of cycling at 65% $\dot{V}O_2$max under 4 conditions: (a) ingestion of a 25.7% carbohydrate solution before and during the exercise bout (white), (b) ingestion of a sweet placebo before and a 25.7% carbohydrate solution during the exercise bout (light gray), (c) ingestion of a 25.7% carbohydrate before exercise and a sweet placebo during the exercise bout (dark gray), and (d) ingesting a sweet placebo before and during the exercise bout (black). Time to complete a standardized amount of work (7 kJ/kg body mass) was significantly lower ($p < 0.05$) and indicated by † when the 25.7% carbohydrate solution was ingested during the exercise bout. Modified with permission from Febbraio et al. (23).

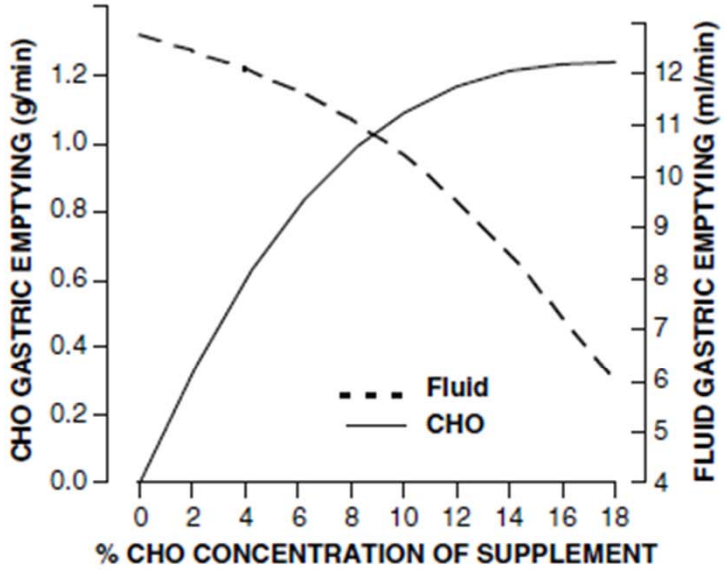

Fig. 1. Effect of carbohydrate (CHO) concentration on the rate of gastric emptying of fluids and carbohydrate from the stomach during exercise. Carbohydrate concentrations of 8% to 10% maximize carbohydrate gastric emptying without substantially reducing fluid delivery. From Gisolfi and Lamb *(100)*, with permission.

EFFETTO DI CARBOIDATI + PROTEINE

L'aggiunta di piccole quantità di proteine ai carboidrati per mantenere un rapporto carboidrati / proteine 3: 1 o 4: 1 può aiutare a facilitare una migliore prestazione, minimizzare il danno muscolare e allo stesso tempo promuovere il recupero massimale di glicogeno muscolare

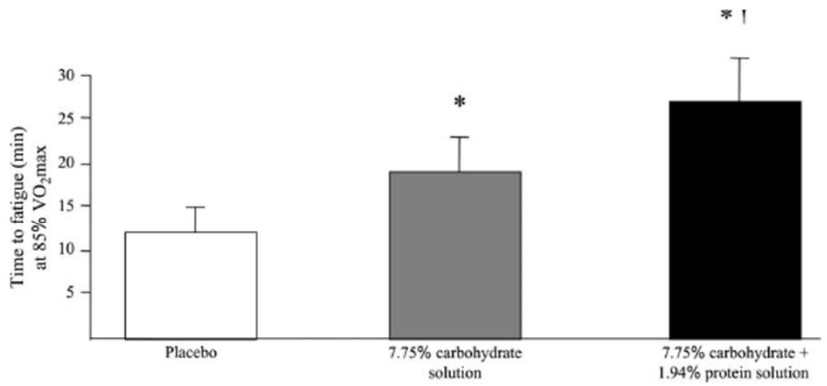

Figure 3. Time to fatigue during a cycling bout at 85% $\dot{V}O_2$max. Before the time trial, subjects exercised for 30 minutes at 45% $\dot{V}O_2$max and performed 15 × 3 to 8-minute intervals at 75% $\dot{V}O_2$max interjected with 15 × 3 to 8-minute active recovery periods at 45% $\dot{V}O_2$max. Following this 180-minute sequence, subjects cycled to fatigue at 85% $\dot{V}O_2$max. Equal boluses of each supplement were provided at 10-minute intervals over the 180-minute period before the fatigue test. * = greater than the placebo ($p < 0.05$); † = greater than 7.75% carbohydrate solution. Modified with permission from Ivy et al. (31).

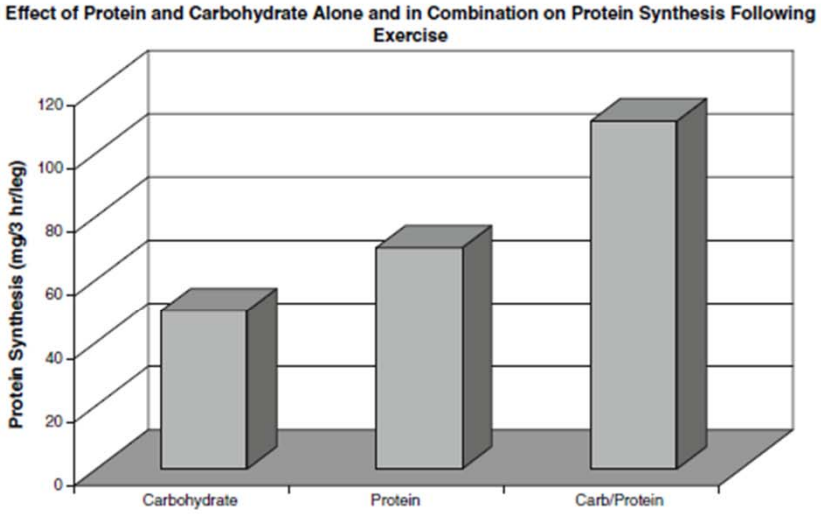

Fig. 2. Effect of protein and carbohydrate alone and in combination on protein synthesis, measured after exercise. From Tarnopolsky et al. *(37)*, with permission.

CAFFEINA

Capacità di:

- aumentare le prestazioni di resistenza,
- massimizzare le riserve di glicogeno
- promuovere una maggiore ossidazione dei grassi
- prevenire l'affaticamento
- ridurre la percezione dello sforzo.

entra nel flusso sanguigno rapidamente (entro 15-45 minuti) e ha un'emivita di 2,5-7,5 ore.

benefici ergogenici a dosi che vanno da 3 a 9 mg / kg.
A dosi di 2-3 mg / kg, la risposta ergogenica sembra essere più variabile.

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Practical applications for the use of supplements for endurance athletes
Glycogen stores inside the body are limited and may only last for 60–90 minutes of moderate intensity exercise and depend largely on body mass, recovery efforts, and training volume/intensity of the athlete. Any athlete who exercises for this duration will need to replace lost carbohydrate.
The number of available dietary supplements to increase endurance performance continues to grow. Those products, however, which have been supported by science to increase performance, recovery, or health of an endurance athlete, are limited.
The premise of dietary supplementation is based on the thought that all athletes and coaches follow sound dietary practices and is currently getting adequate nutrients from their current dietary regimen. In this respect, all strategies discussed throughout this article have their limitations because variations in dietary intake and other recovery steps can impact the efficacy of the discussed strategies.
Athletes and coaches should monitor fluid losses during prolonged exercise bouts in hot/humid environments to determine the rate at which fluid is lost as sweat from the body because many factors can influence an individual's sweat rate. Minimally, consuming 100 mL (~0.5 cups) of fluid every 10 minutes has been shown to help offset fluid losses and is recommended as a baseline recommendation.
Ingesting 4–12 fluid ounces (~0.5–1.5 cups) of a 6–8% carbohydrate-electrolyte solution every 10–15 minutes during exercise can serve as an effective means to replace lost carbohydrate, fluid, and electrolytes. Athletes and coaches need to experiment with what timing and dosing strategies work best and understand that every athlete's response is different.
Supplementing with caffeine at a dose of 3–6 mg/kg body mass 30–60 minutes before exercise has been shown to effectively increase different types of endurance performance. Increased caffeine intake can also increase oxidation of fat, spare glycogen, and reduce the athlete's perception of effort.
Adding a small amount of protein to a carbohydrate source has been shown to help restore greater levels of muscle glycogen, increase performance, and prevent the amount of muscle damage that occurs during a prolonged bout of endurance exercise.

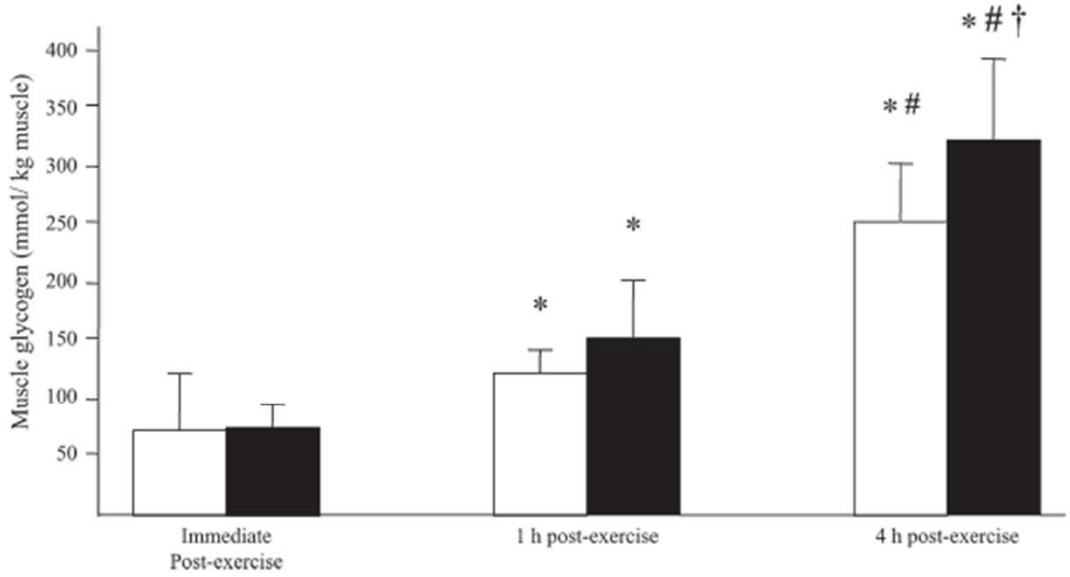
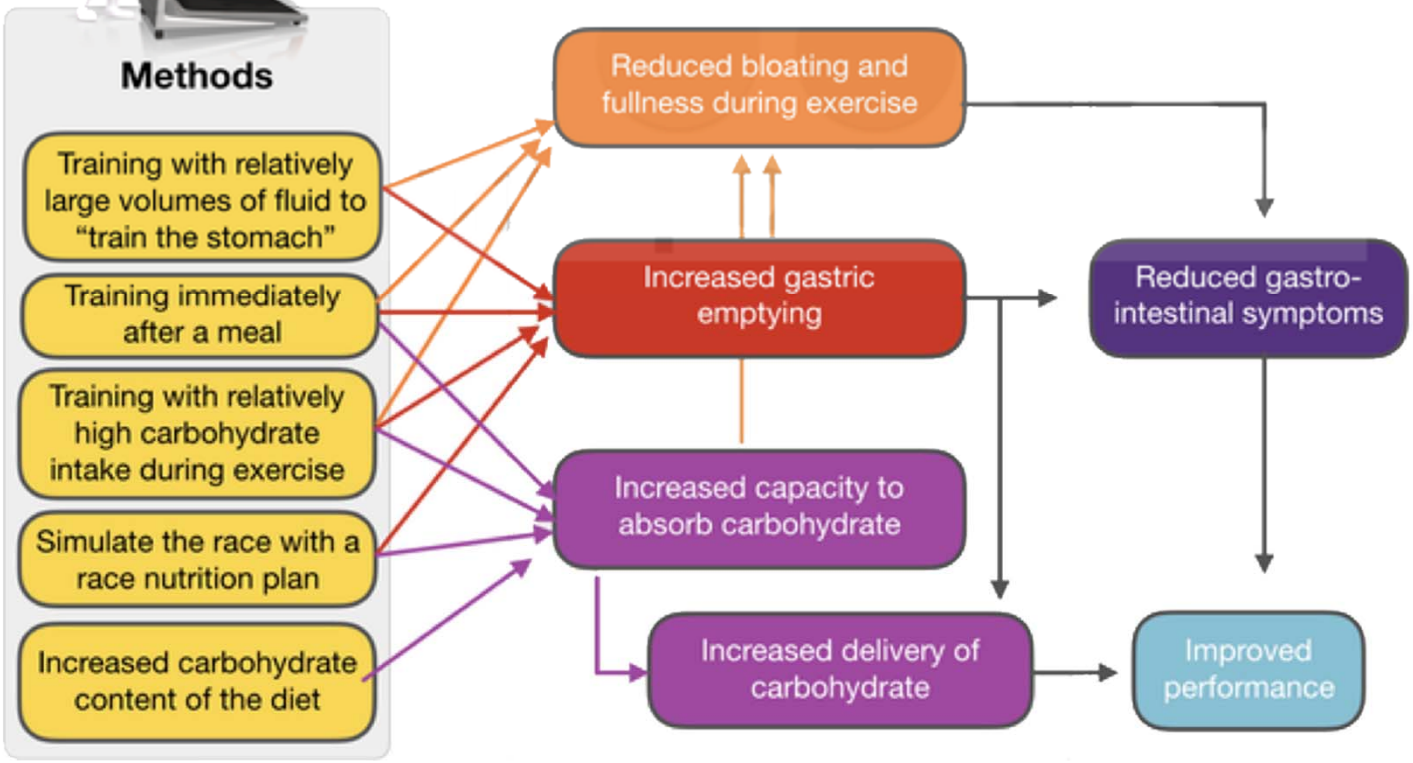


Figure 2. Skeletal muscle glycogen content immediately, 1 hour, and 4 hours after a prolonged cycling bout to fatigue at 70% $\dot{V}O_2$peak. Open bars signify 1 gram per kilogram of body mass of carbohydrate consumption, whereas closed bars indicate carbohydrate + 8 milligram per kilogram of body mass of caffeine consumption. During the carbohydrate-only trial, boluses were ingested within 5 minutes after exercise and 60, 120, and 180 minutes after exercise. During the carbohydrate + caffeine trial, subjects followed the same carbohydrate ingestion pattern and a total of 8 milligram per kilogram of body mass caffeine was given in 2 doses immediately and 2 hours after exercise. * = significant difference from immediate postexercise ($p < 0.05$); # = significant difference from 1-hour postexercise ($p < 0.05$); † = significant difference between trials at 4-hour postexercise ($p < 0.05$). Modified with permission from Pedersen et al. (51).


Methods
Training with relatively large volumes of fluid to "train the stomach"
Training immediately after a meal
Training with relatively high carbohydrate intake during exercise
Simulate the race with a race nutrition plan
Increased carbohydrate content of the diet
Physiological effect
Reduced bloating and fullness during exercise
Increased gastric emptying
Increased capacity to absorb carbohydrate
Increased delivery of carbohydrate
Benefit
Reduced gastro-intestinal symptoms
Improved performance

International Journal of Sport Nutrition and Exercise Metabolism, 2008, 18, 191-203
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Choline: An Important Micronutrient for Maximal Endurance-Exercise Performance?

Jason T. Penry and Melinda M. Manore

Choline plays a central role in many physiological pathways, including neurotransmitter synthesis (acetylcholine), cell-membrane signaling (phospholipids), lipid transport (lipoproteins), and methyl-group metabolism (homocysteine reduction). Endurance exercise might stress several of these pathways, increasing the demand for choline as a metabolic substrate. This review examines the current literature linking endurance exercise and choline demand in the human body. Also reviewed are the mechanisms by which exercise might affect blood choline levels, and the links between methyl metabolism and the availability of free choline are highlighted. Finally, the ability of oral choline supplements to augment endurance performance is assessed. Most individuals consume adequate amounts of choline, although there is evidence that current recommendations might be insufficient for some adult men. Only strenuous and prolonged physical activity appears sufficient to significantly decrease circulating choline stores. Moreover, oral choline supplementation might only increase endurance performance in activities that reduce circulating choline levels below normal.

Effects of Endurance Exercise on Acute Free Blood Choline Concentrations

Study	Sample gender*	Activity	Duration (min)	Intensity (% VO_{2max})	Baseline†/Pre‡ vs. post (nmol/mL)	*p*
Buchman et al., 1999	23 M + F	marathon	not given	max effort	19.2† vs. 14.6	.005
Buchman et al., 2000	6 M + F	marathon	156–348	max effort	9.6† vs. 7.0	.09
Burns et al., 1988	10 M	cycle	120	70% (105 min) + max effort (15 min)	not given	>.05
Conlay et al., 1986	17[a]	marathon	not given	max effort	10.1‡ vs. 6.2	<.001
Deuster et al., 2002	13 M	load carriage	~110	70%	8.5‡ vs. 6.5[b]	>.05
Pierard et al., 2004	21 M	combat course	7,200	~35%	2.95% decrease†	<.01
Spector et al., 1995	10 M	cycle	72	70%	8.5† vs. 10.0[b]	>.05
von Allwörden et al., 1993	4 M, 6 F	cycle	120	35 km/hr	12.08‡ vs. 10.04	<.01
von Allwörden et al., 1993	10 M, 4 F	cross-country run	30–60	max effort	14.51‡ vs. 14.95	>.05
Warber et al., 2000	14 M	load carriage	240	38%	8.14‡ vs. 7.98	>.05

Note. M = male; F = female.

[a]Gender of participants not disclosed in published paper. [b]Estimated from published figure.

COLINA

Possibili meccanismi di calo della performance:

- aumento della domanda di colina come donatore di gruppi metilici durante il periodo di stress fisiologico (attività fisica). (metti figura)

- diminuzione della quantità di colina disponibile per la sintesi di acetilcolina, quindi inibendo l'accoppiamento eccitazione-contrazione alla giunzione neuromuscolare.

- la colina può anche essere incorporata come fosfolipide (fosfatidilcolina) nella membrana cellulare. Le carenze prolungate di colina fanno sì che il corpo mobiliti la fosfatidilcolina situata nelle stesse membrane cellulari, compromettendo l'integrità della membrana cellulare.

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COLINA

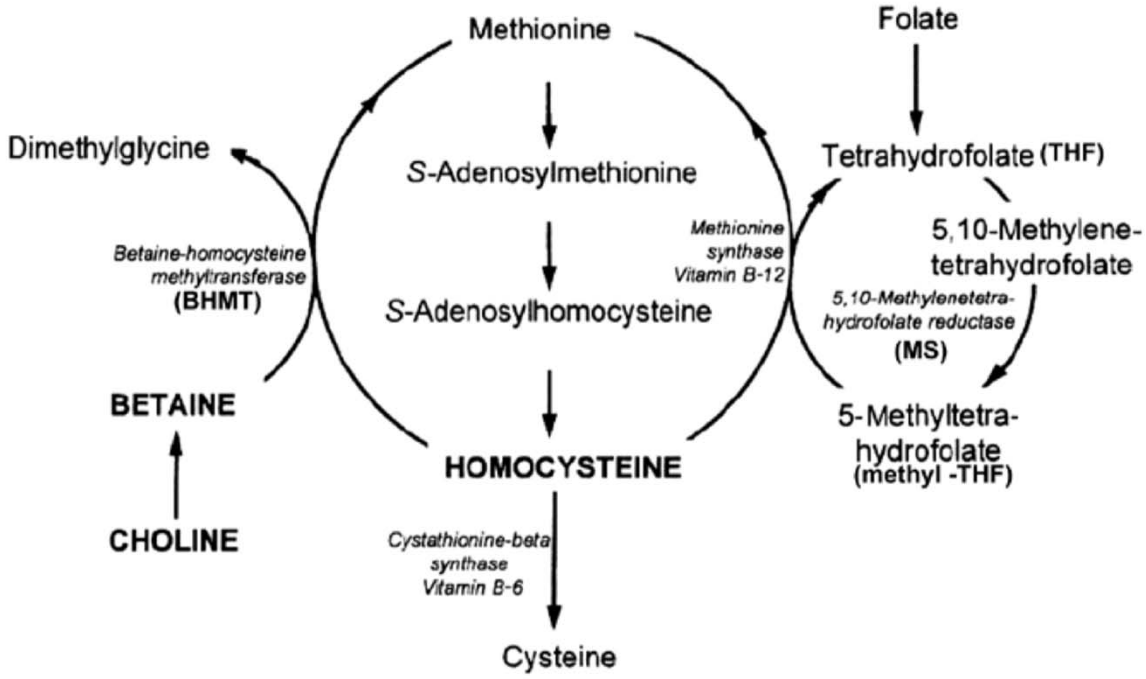

Figure 1 — A brief overview of methionine-homocysteine methyl metabolism. Note the two pathways used to recycle homocysteine to methionine: the choline-dependent BHMT pathway on the left and the folate-dependent MS pathway on the right. Adapted from Olthof et al.

According to the IOC, the following supplements increase exercise performance. This is strongly supported by evidence:

- Alkalinising agents (sodium bicarbonate and sodium citrate) increase anaerobic exercise performance.
- L-arginine boosts aerobic endurance. (There is little, but convincing evidence in this regard).
- Beta-alanine enhances anaerobic and aerobic exercise performance.
- Caffeine improves endurance and reaction time.
- Creatine increases performance in strength and power events.
- Nitrate advances aerobic endurance exercise.
- Carbohydrates, proteins, water, electrolytes and amino acids have ergogenic properties.[35]

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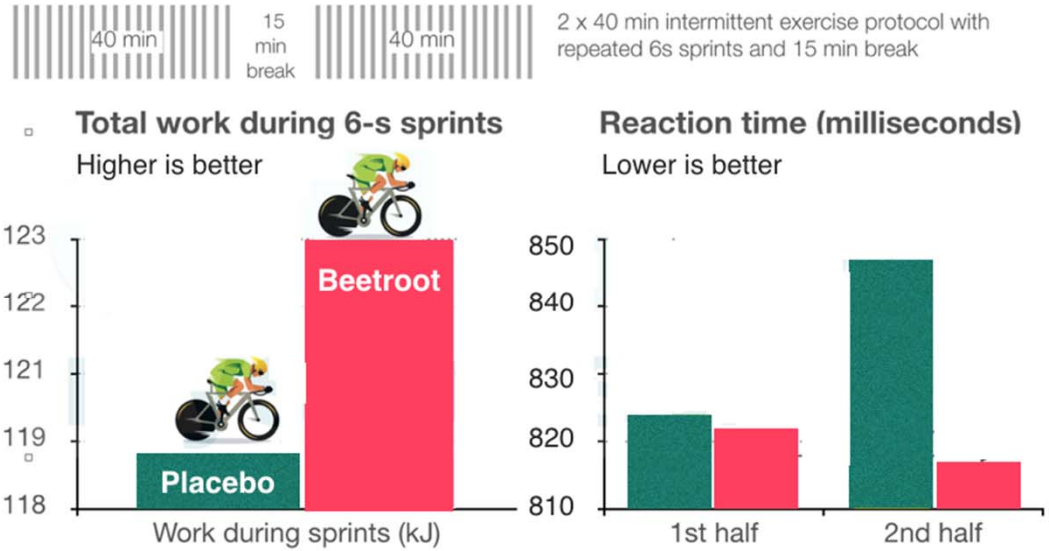
Beet root juice improves intermittent exercise performance and cognitive function

mysportscience



From: Thompson et al EJAP 2015C Thompson, LJ Wylie, J Fulford, J Kelly, MI Black, STJ McDonagh, AE Jeukendrup, A Vanhatalo, AM Jones. Dietary nitrate improves sprint performance and cognitive function during prolonged intermittent exercise. Eur J Appl Physiol Published online April 7, 2015.

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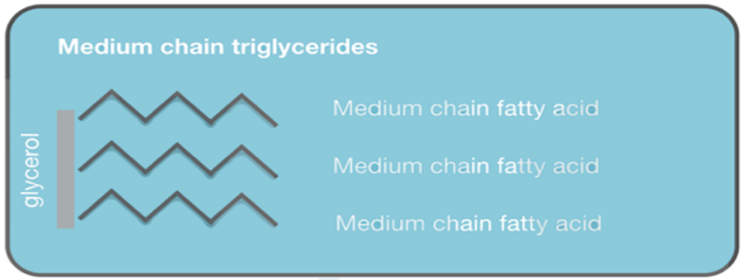
List of popular supplements that have alleged physiological effects in endurance athletes			
Performance-enhancing ingredients	**pH and fluid modulators**	**Fuel provision ingredients**	**Recovery-enhancing ingredients**
Acetylcholine	β-Alanine	α-Lipoic acid	5-HT
Carbohydrate-electrolyte drinks or gels	Carnosine	Branched-chain amino acids	Adaptogens (i.e., extracts from *Rhodiola rosea*, *Cordyceps sinensis*, *Panax ginseng*, and so on)
Citrulline	Creatine	Caffeine	Antioxidants (i.e., vitamins C and E, catechins, polyphenols)
Creatine	Polylactate	Carbohydrate/electrolyte drinks or gels	HMB
Dimethylglycine	Sodium tablets	Creatine	Carbohydrate-protein beverages
Ginseng (i.e., extracts from *Panax ginseng*)	Sodium bicarbonate	L-Carnitine	Colostrum
		Coenzyme Q10	Echinacea
Iron	Sodium citrate	Glycerol	GABA
Inosine		Medium-chain triglycerides	Glucosamine and chondroitin sulfate
Phosphatidylserine		Modified corn starch	L-Glutamine
Smilax (Sarsaparilla root)		Phosphate	Ketoisocaproate
Taurine		Pyruvate	
		Ribose	5-HT
		Synephrine	

5-HT = 5-hydroxytryptophan; HMB = β-hydroxy-β-methybutyrate; GABA = γ-aminobutyric acid.

Medium chain triglycerides
A new fuel for athletes?

- Does not slow gastric emptying
- Rapid absorption
- Rapid oxidation during exercise
- May cause gastro-intestinal problems at higher doses (>30g)
- Need high dose to see effects
- Studies show no performance benefits



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