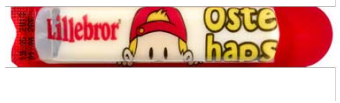
LOW CARBOHYDRATE AVAILABILITY & CAFFEINE

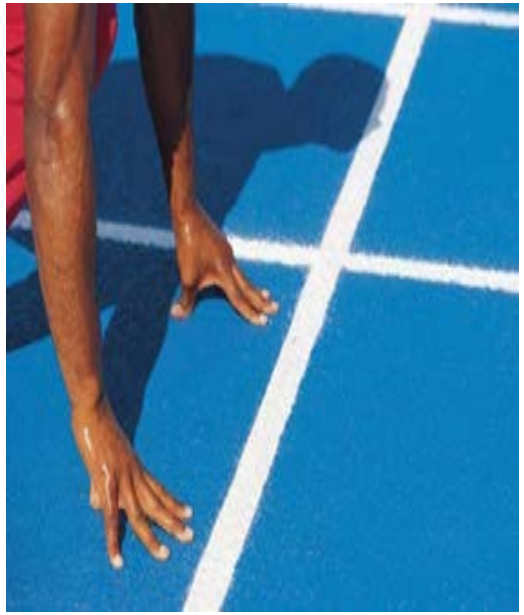
- influence on adaptation & performance in endurance athletes

"Fuel for the work required"

"Periodizing CHO intake"



Carbohydrates – The muscles favorit fuel



Before

During

After

1936; *If athletes were encouraged by the Athletic Organization to eat candy during competition, it is possible that there will be new records in long distance running.*

Textbook on Exercise by Eggleton

Sports Med (2014) 44 (Suppl 1):S25–S33
DOI 10.1007/s40279-014-0148-z

REVIEW ARTICLE

A Step Towards Personalized Sports Nutrition: Carbohydrate Intake During Exercise

Asker Jeukendrup

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

Carbohydrates

– Should the endurance athlete just love them or limit the intake?



Competition/Competition specific training – Submaximal volume training – Training for weight loss/health

Performance

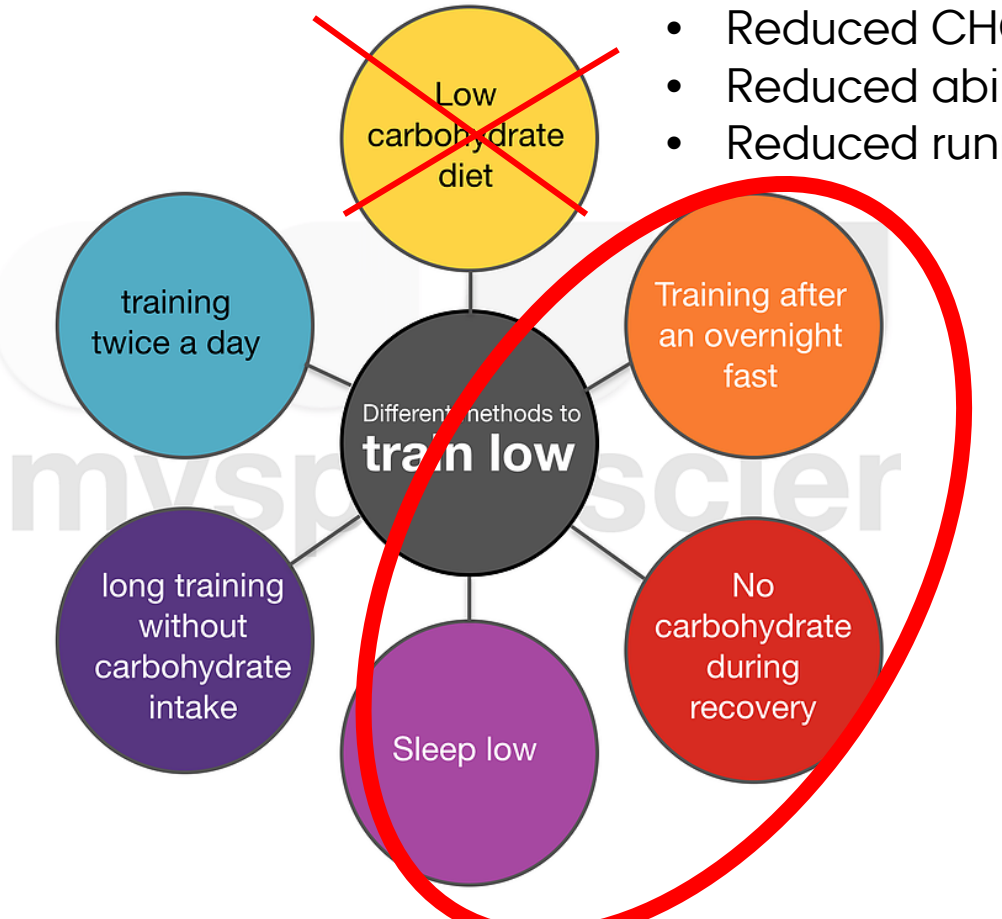
<u>Amplified response to training stimuli</u>
Cell signaling
Mitochondria capacity
Fat loss

Performance ⇑

Train low – compete high

Reduced carbohydrate availability → amplified response to training stimuli → endurance performance ?

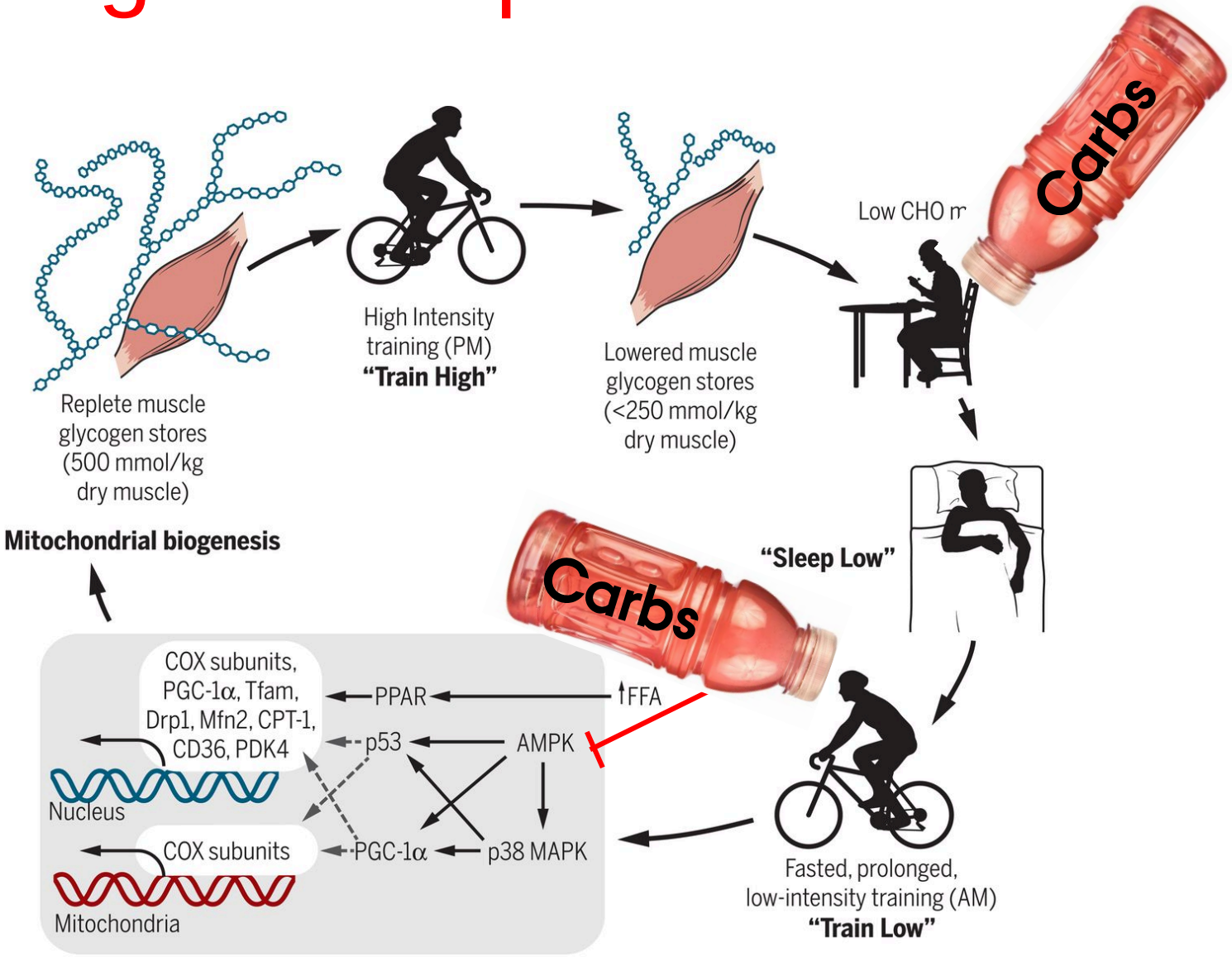
A shortfall between CHO supplies & exercise/energy demand



- Reduced CHO uptake from the gut
- Reduced ability for using CHO as fuel
- Reduced running economy

Jeukendrup et al, Sport med, 2017
Burke et al, J Physiol, 2017
MSSE, 2016, 48(4):663-72
Burke et al, IJSNEM, 28, 2018
Burke &Hawley, Science, 2018

Train High→Sleep Low→Train Low



Louise M. Burke, and John A. Hawley Science 2018;362:781-787

Science
AAAS

Summary of key outcomes from Train-Low studies

	Positive	No/equivalent chang	Negative
Muscle signaling (n=11)	73% ($n = 8$) Steinberg et al. [21] Cochran et al. [22] Yeo et al. [23] Akerstrom et al. [27] Wojtaszewski et al. [36] Chan et al. [37] Bartlett et al. [38] Lane et al. [39]	27% ($n = 3$) Hammond et al. [43] Impey et al. [48] Lee-Young et al. [49]	0%
Gen Expression (n=12)	75% ($n = 9$) Pilegaard et al. [15a, b] Pilegaard et al. [16] Steinberg et al. [21] Psilander et al. [24] Chan et al. [37] Bartlett et al. [38] Lane et al. [39] Impey et al. [48]	25% ($n = 3$) Cochran et al. [22] Hammond et al. [43] Jensen et al. [54]	0%
Enzyme activity/protein content (n=9)	78% ($n = 7$) Hansen et al. [9] Yeo et al. [17] Morton et al. [18] Hulston et al. [19] Van Proeyen et al. [30] De Bock et al. [31] Nybo et al. [32]	22% ($n = 2$) Cochran et al. [20] Gejl et al. [52]	0%

Impey et al, Sports Med, 48(5), 2018

Summary of key outcomes from Train-Low studies

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Lipid oxidation (n=17)	47% ($n = 8$) Yeo et al. [17] Hulston et al. [19] Akerstrom et al. [27] Wojtaszewski et al. [36] Bartlett et al. [38] Lane et al. [39] Hammond et al. [43] Impey et al. [48]	53% ($n = 9$) Pilegaard et al. [15a] Marquet et al. [40, 41] Van Proeyen et al. [30] De Bock et al. [31] Nybo et al. [32] Burke et al. [45] Lee-Young et al. [49] Gejl et al. [52]	0%

47%

53%

Impey et al, Sports Med, 48(5), 2018

Summary of key outcomes from Train-Low studies:

Endurance Performance

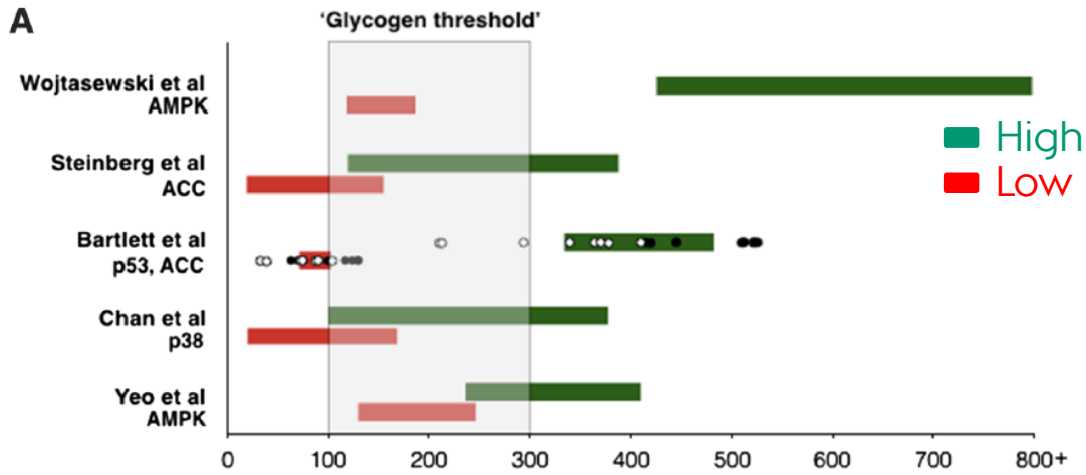
	3 studies in untrained/ moderate trained	NO-effect studies
Exercise performance changes ($n = 11$)	37% ($n = 4$) 	63% ($n = 7$) 
	Hansen et al. [9]	Yeo et al. [17]
	Cochran et al. [20]	Morton et al. [18]
	Marquet et al. [40, 41]	Hulston et al. [19]
		Van Proeyen et al. [30]
		Nybo et al. [32]
		Burke et al. [45]
		Gejl et al. [52]

- Well-trained have already optimized mitochondria capacity
- Mitochondria capacity is not a limiting factor for performance
- The performance test-protocols have not been long enough
- You have to "go very Low" to gain a superior effect

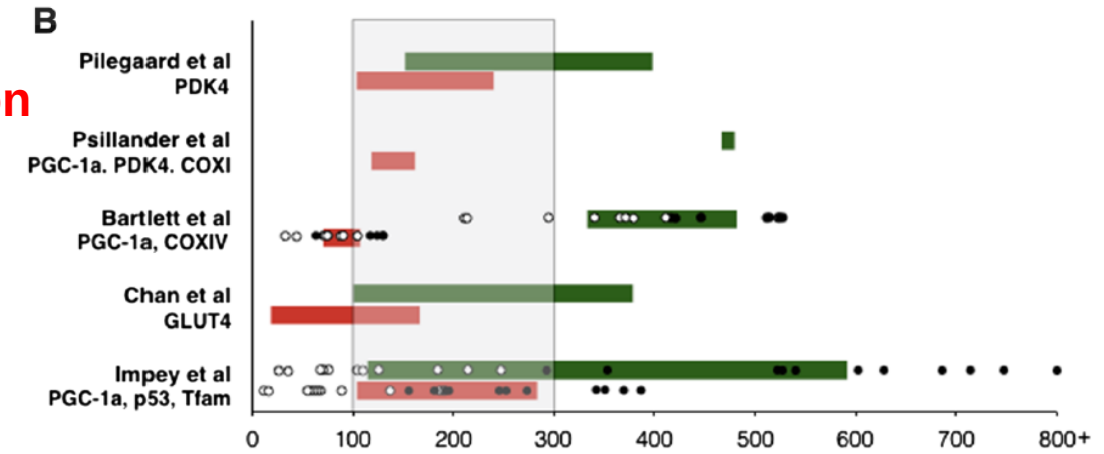
Impey et al, Sports Med, 48(5), 2018

Studies supporting the glycogen threshold hypothesis.

Cell signaling



Gene expression



A window of muscle glycogen conc. that:

- Permits completion of required training workloads
- Activation of the molecular machinery regulating training adaptations

Impey, et al, Sports Med, 48(5), 2018

No Superior Adaptations to Carbohydrate Periodization in Elite Endurance Athletes

Kasper Gejl

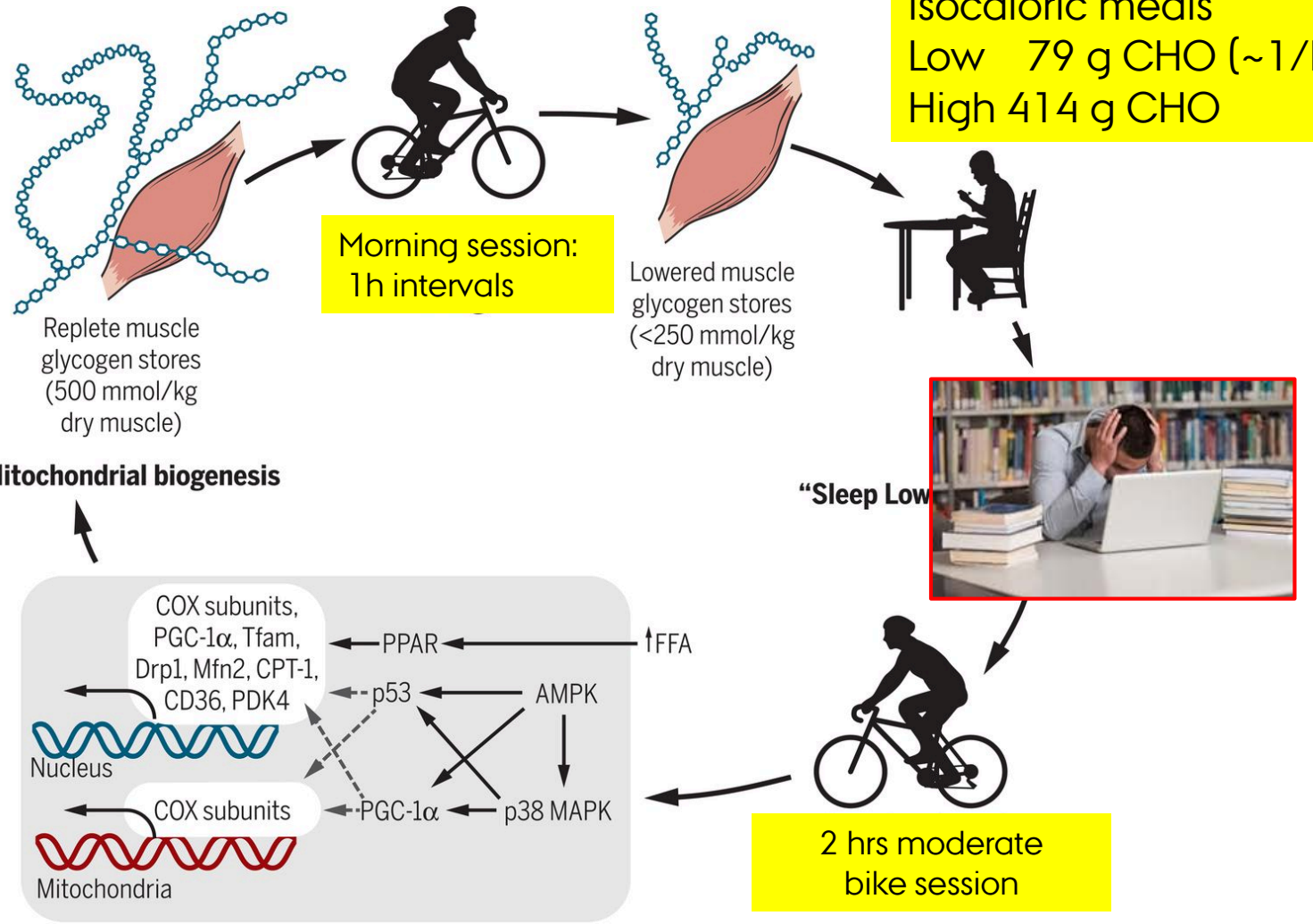
KASPER DEGN GEJL[1], LINE BORK THAMS[1], METTE HANSEN[2], TORBEN ROKKEDAL-LAUSCH[3], PETER PLOMGAARD[4,5], LARS NYBO[6], FILIP J. LARSEN[7,8], DANIELE A. CARDINALE[8,9], KURT JENSEN[1], HANS-CHRISTER HOLMBERG[10,11], KRISTIAN VISSING[2], and NIELS ØRTENBLAD[1,10]

Med. Sci. Sports Exerc., Vol. 49, No. 12, pp. 2486–2497, 2017.

Train high, ***study*** low”

Kasper Gejl

Isocaloric meals
Low 79 g CHO (~1/kg)
High 414 g CHO



Louise M. Burke, and John A. Hawley Science 2018;362:781-787

Med. Sci. Sports Exerc., Vol. 49, No. 12, pp. 2486–2497, 2017.

This study was supported financially by Team Danmark, The Danish Ministry of Culture, and The Swedish National Centre for Research in Sports.

Biopsy

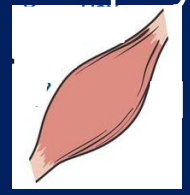
Morning: 1h intervals

7 hrs rest

4 weeks intervention
(manipulation 3*/week)

2 hrs moderate bike session

Biopsy



LOW menu

Formiddag	133 g	1358 kJ
Low Carb Bar, Nutramino, Vanilla & Almond	1 bar	803 kJ
Avocado	0,5 x 1 mellem ud...	555 kJ

Frokost	375 g	4991 kJ
Low carb bageblanding, Øko, Urtekram	150 g	3750 kJ
Cherrytomat, rød	5 x 1 mellem	94 kJ
Makrel i tomat, dåse	1 dåse	1031 kJ
Oliven, sorte, uden sten, i saltlage	5 stk	116 kJ

Eftermiddag	511 g	2530 kJ
Avocado	1 mellem uden sten	1109 kJ
Agurk	300 g	135 kJ
Ostehaps, Lillebror, Arla	2 stk	432 kJ
Valnødder	10 stk	854 kJ

Biopsy

Morning: 1h intervals

7 hrs rest

4 weeks intervention
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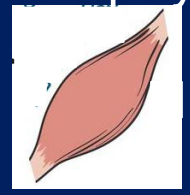
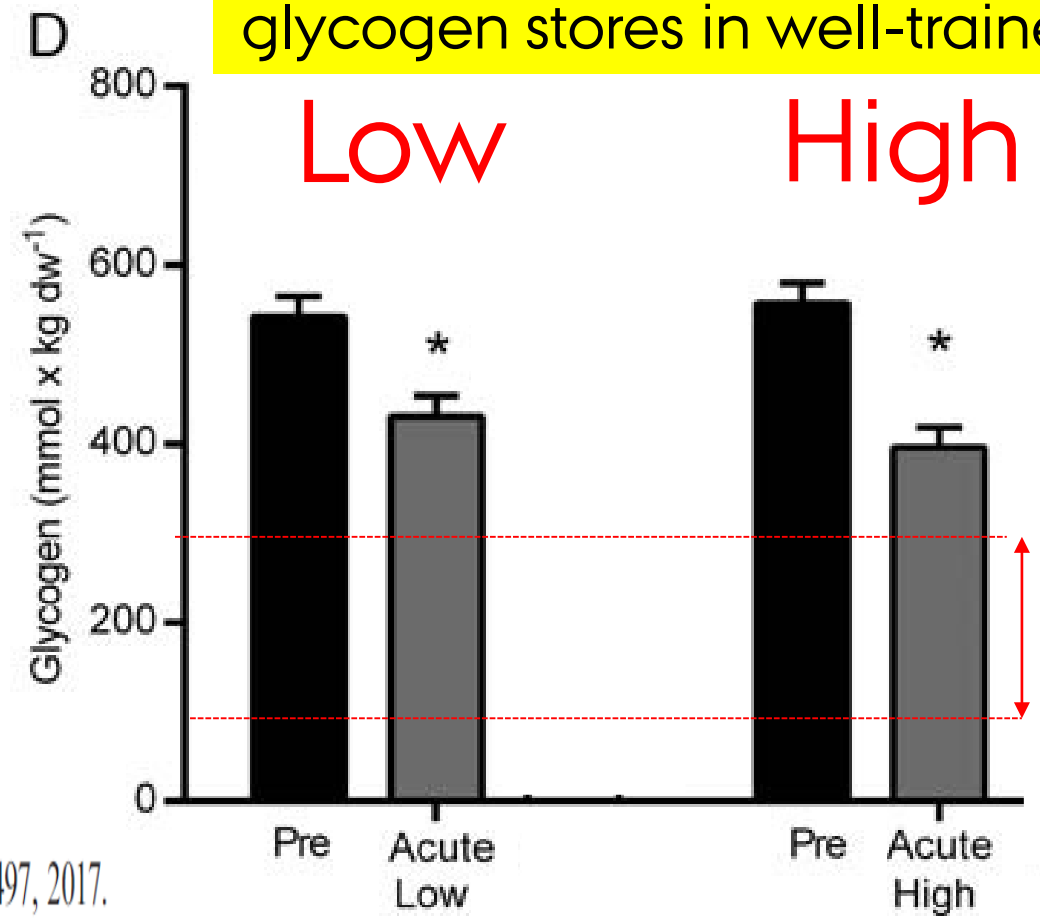
2 hrs moderate
bike session

Biopsy



Difficult to empty muscle glycogen stores in well-trained



Suggested glycogen threshold
(Impey et al, 2018)

Kasper Gejl

Med. Sci. Sports Exerc., Vol. 49, No. 12, pp. 2486–2497, 2017.

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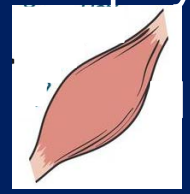
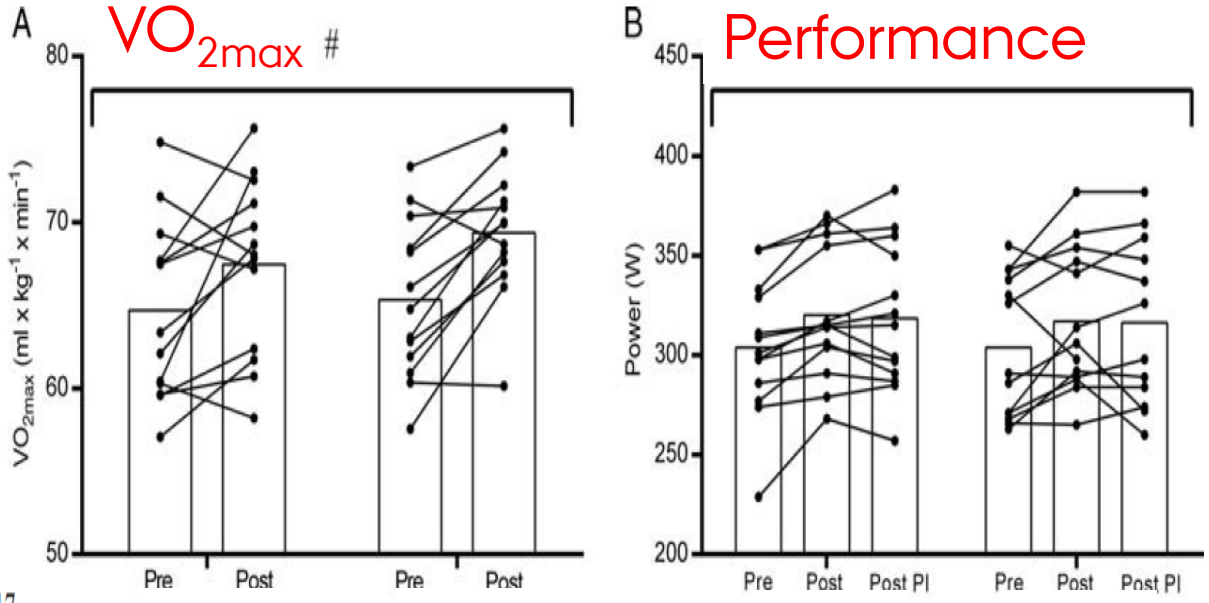


No difference in improvement in VO_{2max} or performance

90min Intermittent exercise±Carbs	30 min TT

Kasper Gejl



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Train low – compete high

Reduced carbohydrate availability → amplified response to training stimuli → endurance performance ?

Summary

- To gain an amplified response (cell signaling, gen expression) to training you probably need to ”go very low” in muscle glycogen
  - This may be difficult in well-trained
  - This may be difficult if not combined with energy-restriction
- Effect of ”Train low” on performance (in well-trained) is debatable
  - May depend on the strategy (How low do you go… in carbs and energy))
  - May depend on the duration & intensity of the endurance challenge – is your glycogen stores challenged?
- *Consider drawbacks (motivation, immunfunction, injuries protein metabolism, **training quality**)*

MSSE, 2016, 48(4):663-72
Burke et al, IJSNEM, 28, 2018

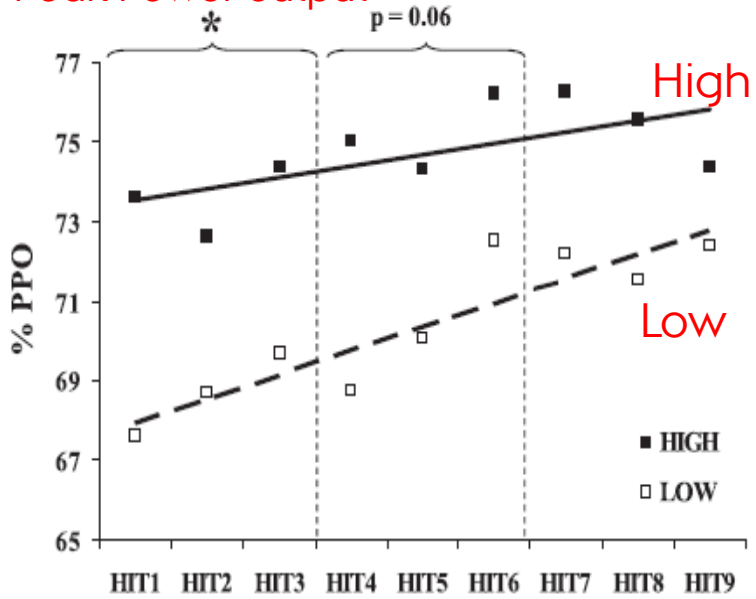
Impaired training intensity when training “Low”

J Appl Physiol 105: 1462–1470, 2008.
First published September 4, 2008; doi:10.1152/japplphysiol.90882.2008.

Skeletal muscle adaptation and performance responses to once a day versus twice every second day endurance training regimens

Wee Kian Yeo,[1] Carl D. Paton,[2] Andrew P. Garnham,[3] Louise M. Burke,[4] Andrew L. Carey,[1] and John A. Hawley[1]

% of Peak Power output

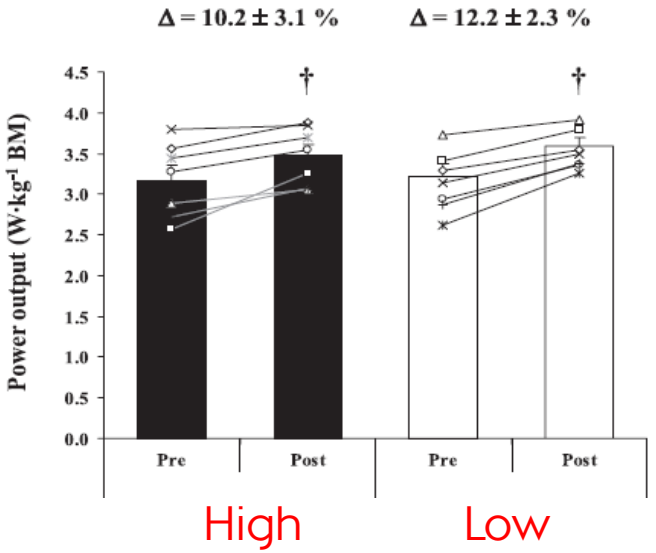


HIT; 8 x 5 min at maximum self-selected effort

Training “Low” with lower intensity for 3 weeks →

- Superior enzymatic adaptation in “Low”
- Similar improvement in performance as “High”

After 3 weeks training (60 min TimeTrial)



60-min steady-state ride + 60-min TT

Confirmed by Hulston et al 2010 and Lane et al , 2013

Dietary supplements and sports products to improve sports performance and recovery

<u>Vitamins & Minerals</u>

Improve performance and health if you for some reason is ***not able to cover your requirement*** for a specific nutrient

<u>Sports products</u> (e.g. sports beverage, bars, protein suppl, electrolytes)

Are a convenient and easy way to get carbohydrate, protein and electrolytes associated with exercise and competition

<u>Legal performance enhancing supplements (documented effects)</u>

Creatine, **Caffeine**, Bicarbonate and β-alanin

IOC statement

Effect of Caffeine on Sport-Specific Endurance Performance: A Systematic Review

Matthew S. Ganio, Jennifer F. Klau, Douglas J. Casa, Lawrence E. Armstrong, and Carl M. Maresh

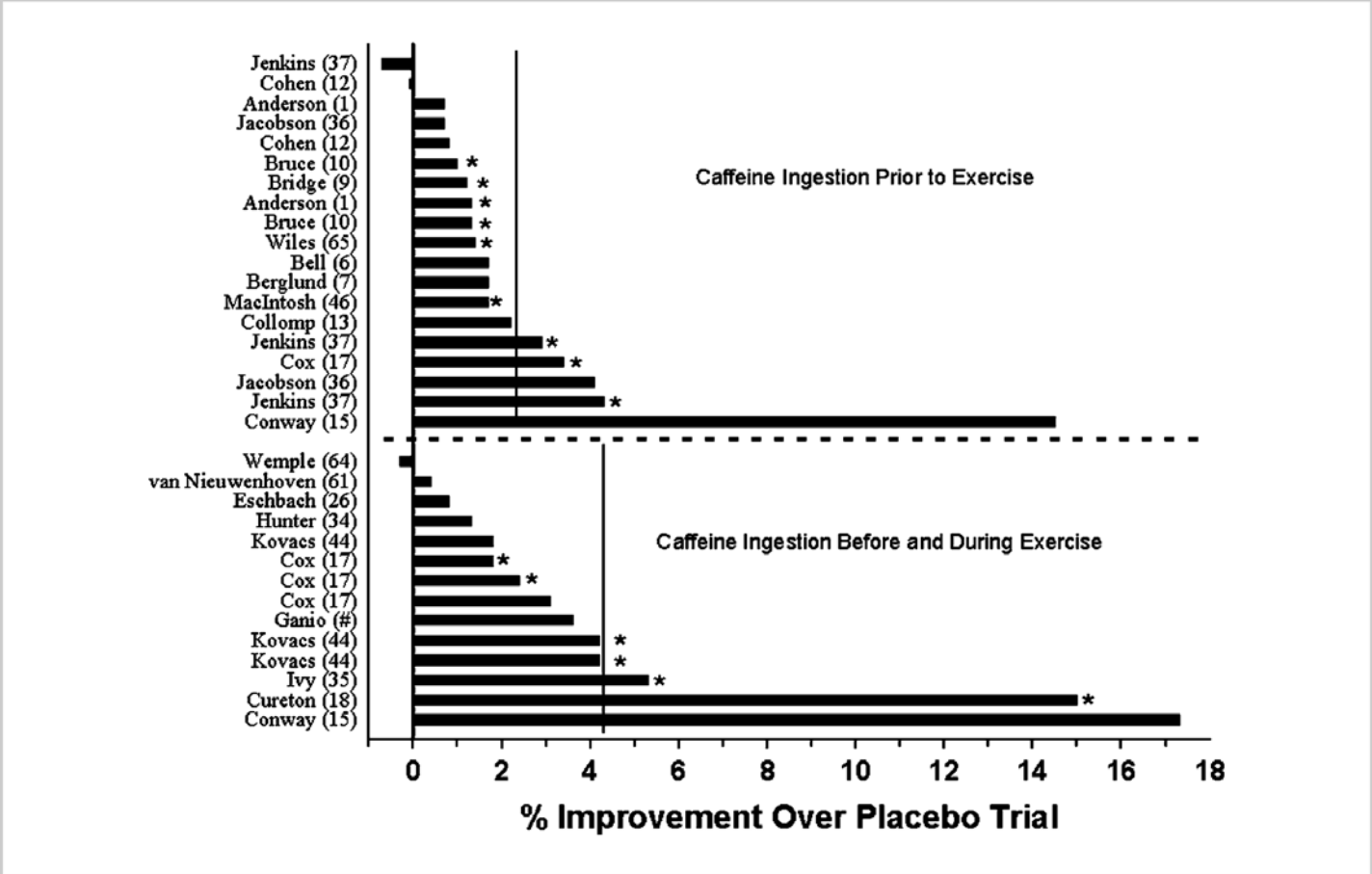


Figure 2. The effect of caffeine (CAF) on exercise performance when ingesting CAF before exercise (above horizontal hashed line) or before and during exercise (below horizontal hashed line). Vertical lines represent mean percent improvement of all studies (2.3 ± 3.2 and 4.3 ± 5.3% for above and below the hashed line, respectively). *Significantly different from placebo ($p < 0.05$). #Ganio (personal communication, August 12, 2007).

- Reach maximal level in the blood 30-90 min. after intake
- A high concentration is maintained for 3-4 hours. (Half-life 5½ hrs)
- Ergogenic dose 3-6 mg/kg
- Ergogenic in both habitual users and non-users

Ganio et al 2009 systematic review
Graham et al,1995 Dose of Caffeine
Gonçalves, et al, 2017. Habituation

Effect of restricted carbohydrate intake with caffeine supplement on fat oxidation and performance in moderately trained women

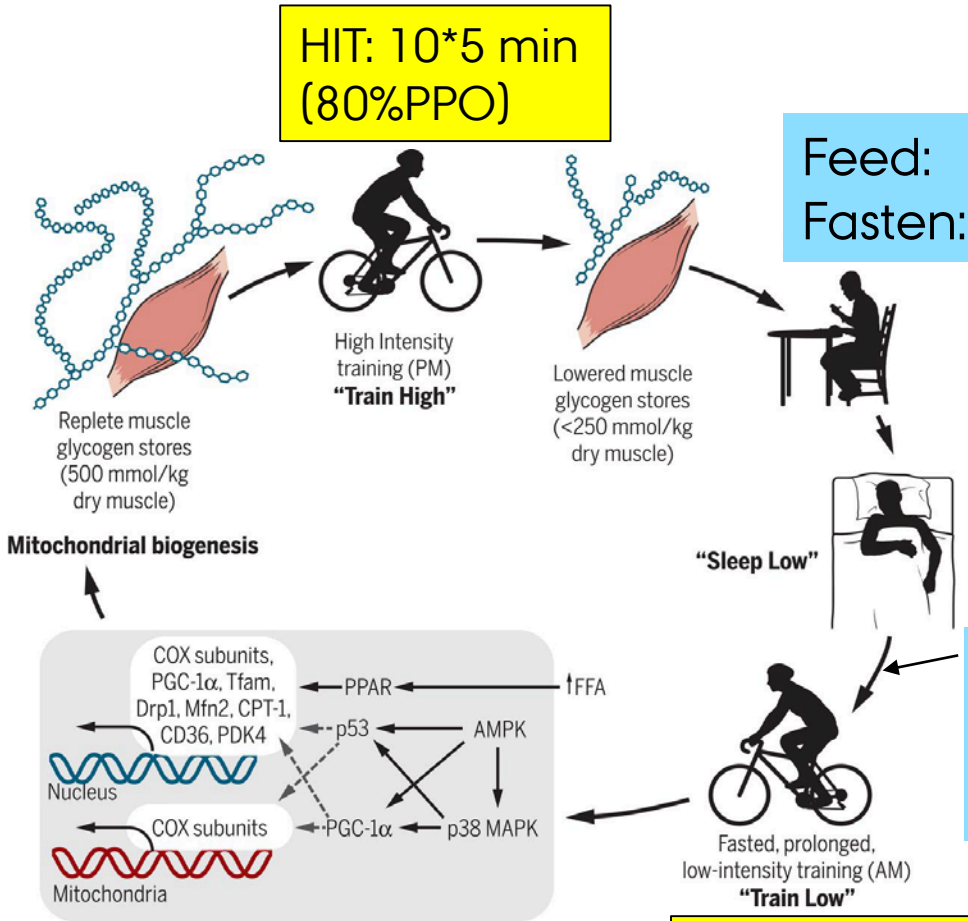
Camilla Søgaard, Simon Riis, and Mette Hansen

Camilla Søgaard

Cross-over design

7 trained women

(26±1,3 yrs, Vo2max 53±2)



Feed: 3 g CHO/kg or
Fasten: 0 g CHO

300 mg caffeine (4.8 mg/kg)
1 hr before TT or
Placebo

35 min FATox test
+ 20 min TT

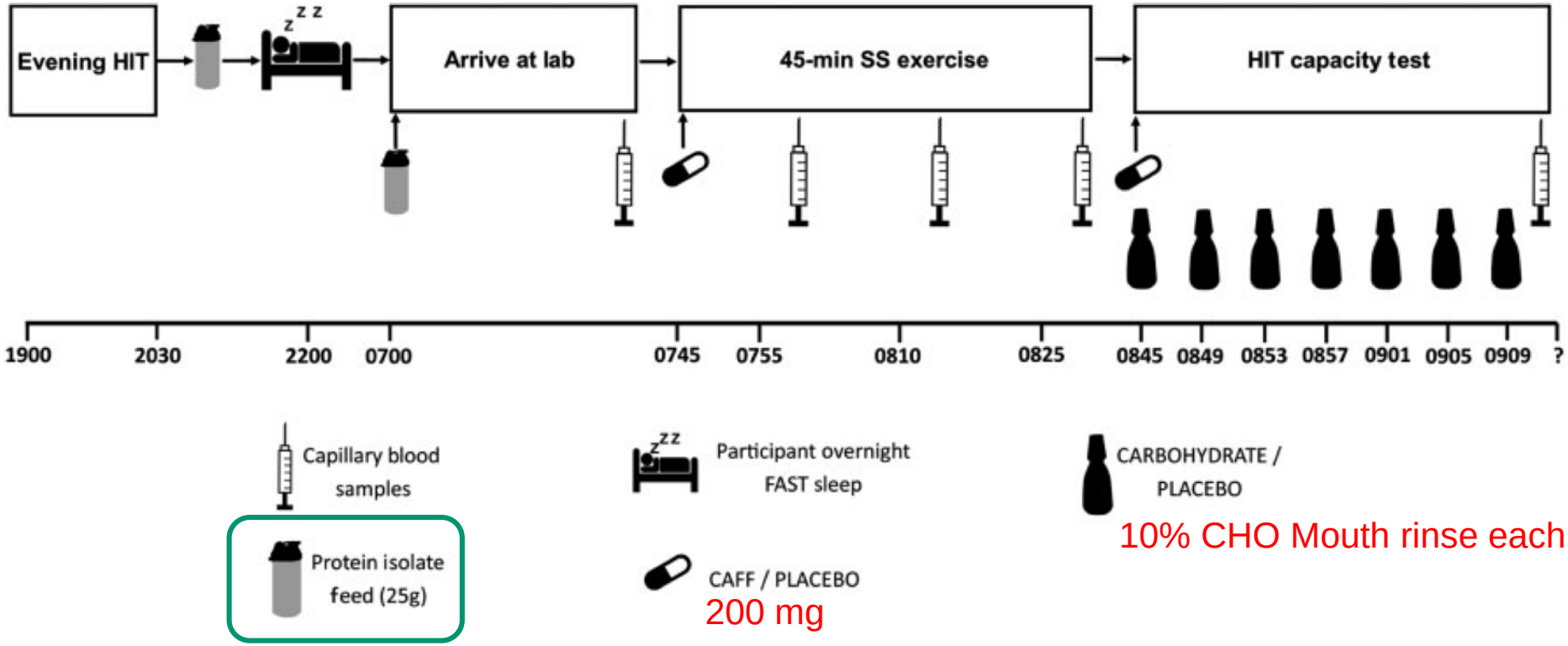
Camilla Søgaard, Master Thesis

Funded by: TEAM DANMARK

Carbohydrate mouth rinse and caffeine improves high-intensity interval running capacity when carbohydrate restricted

ANDREAS M. KASPER, SCOTT COCKING, MOLLY COCKAYNE, MARCUS BARNARD, JAKE TENCH, LIAM PARKER, JOHN MCANDREW, CARL LANGAN-EVANS, GRAEME L. CLOSE, & JAMES P. MORTON

LOW + CHO mouth rinse ± Caffeine



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LOW + CHO mouth rinse ± Caffeine

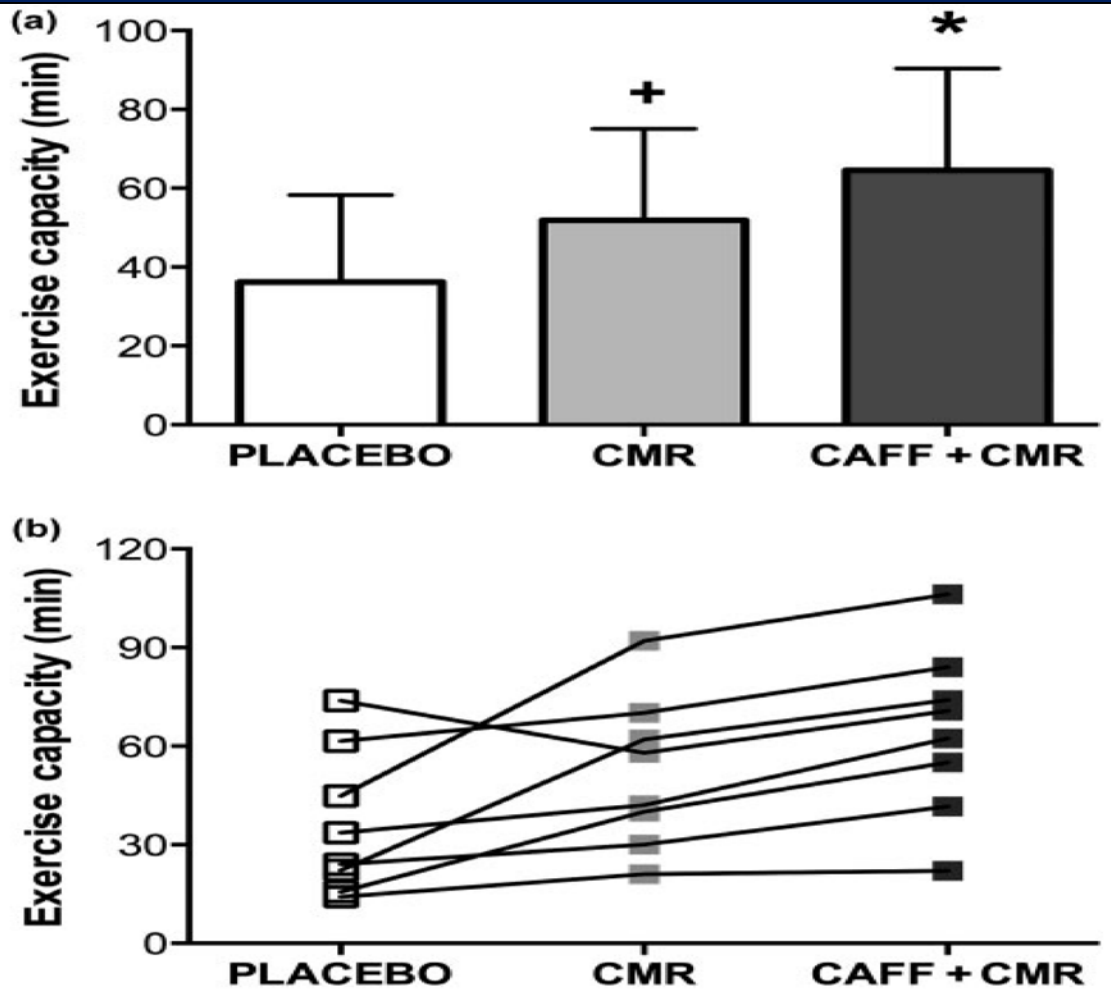
8 males, cross-over design

45min steady state running (65%VO_{2max}) +

HIT: interval running capacity

- 1 min intervals at 80%VO2max
- 1 min "pause" walking at 6 km/h

→ **total distance covered until fatigue**

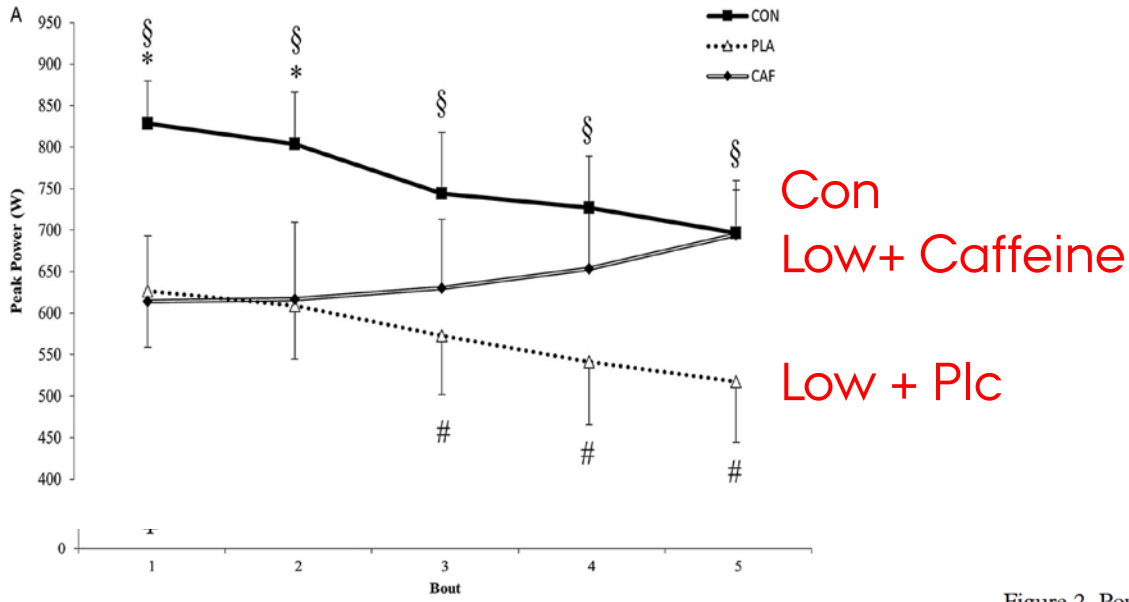


Influence of a caffeine mouth rinse on sprint cycling following glycogen depletion

Joseph Kizzi, Alvin Sum, Fraser E. Houston & Lawrence D. Hayes

10 sec caffeine mouth rinse between 6s sprint (25 ml 2%)

Peak power



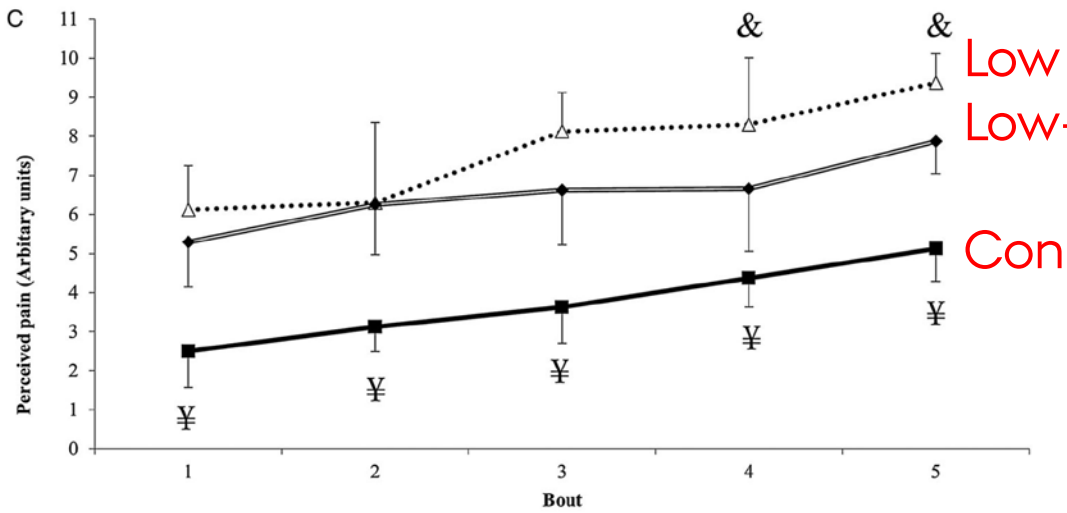
Con

Low+ Caffeine

Low + Plc

Figure 2. Power profiles and ratings of perceived pain for five, 6 s sprints separated by 24 s active rest in control (CON), glycogen depletion and placebo (PLA), and glycogen depletion and caffeine (CAF) conditions. (a) Peak power; (b) mean power; and (c) perceived pain. Data are presented as mean ± SD. §CON significantly greater than PLA ($P < .05$). *CON significantly greater than CAF ($P < .05$). #CAF significantly greater than PLA ($P < .05$). ¥CON significantly less than PLA ($P < .05$). &CAF significantly less than PLA ($P < .05$).

Feeling of pain



Low + Plc

Low+ Caff.

Con

Figure 2. Power profiles and ratings of perceived pain for five, 6 s sprints separated by 24 s active rest in control (CON), glycogen depletion and placebo (PLA), and glycogen depletion and caffeine (CAF) conditions. (a) Peak power; (b) mean power; and (c) perceived pain. Data are presented as mean ± SD. §CON significantly greater than PLA ($P < .05$). *CON significantly greater than CAF ($P < .05$). #CAF significantly greater than PLA ($P < .05$). ¥CON significantly less than PLA ($P < .05$). &CAF significantly less than PLA ($P < .05$).

Eur J Sport Science, 2016

Take-home message

<u>Endurance volumen training sessions</u>

Go ”Low” if you wish to

- Amplify metabolic training response
- (Maybe) enhance improvements in performance
- Burn fat (calories)→ (Maybe) reduce fat mass

+

….longtermed studies needed to test effect of LOW+CAF.

Working Group: Training, hormones and Nutrition

In perspective to performance and health

Mette Hansen

Obese runners & injury risk

Post doc:

Line B Dalgaard

Lars Hvid

PH.D students:

Mads S. Larsen

Michael Bertelsen

Tine V Dam

Line Thams

Sofie Kaas Ovensen

Research assistents and pre-graduate student involved in on-going projects this autumm:

Caffeine

Stevia

Milk protein
Whey protein hydrolysate
Kollagen protein
Insect protein

Working Group: Training, hormones and Nutrition

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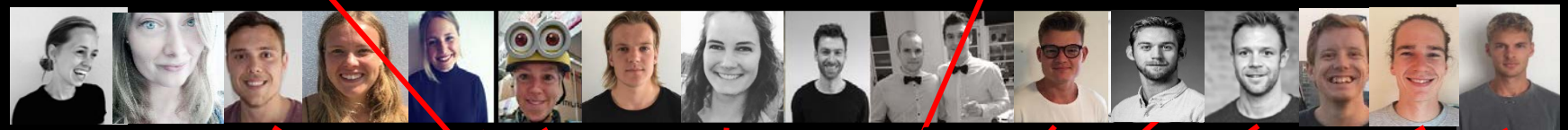

Estrogen replacement therapy

Oral contraceptives

Menstrual cycle

Thank you for your attention