Nutritional supplements & the brain *in sports performance*

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Overview

1. Supplement use?
2. Brain and sports performance
3. How can supplements affect the brain in sports performance?

Nutritional supplements

- ***"Product intended to supplement the normal diet, containing a concentrated source of nutrients or other substances with a physiological effect"***
- > 50% of athletes
- Reasons

1. prevention or treatment of nutrient deficiencies (iron, calcium, Vit D)
2. convenient form of nutrient (energy drink, gels, protein supplements, vit)
3. potential ergogenic aid
4. placebo

Need for scientific evidence on efficacy of supplements

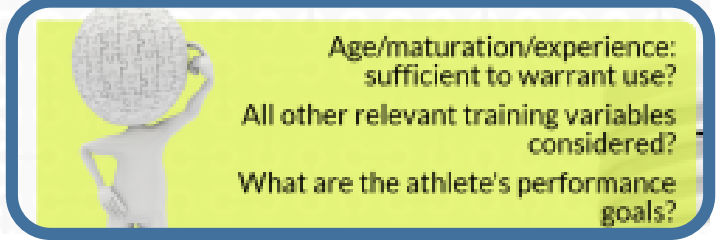
➔Need for clear evidence-based information for athletes and coaches

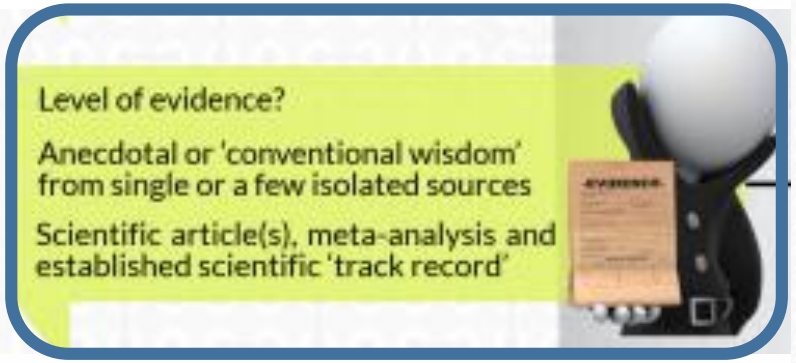
OPEN ACCESS

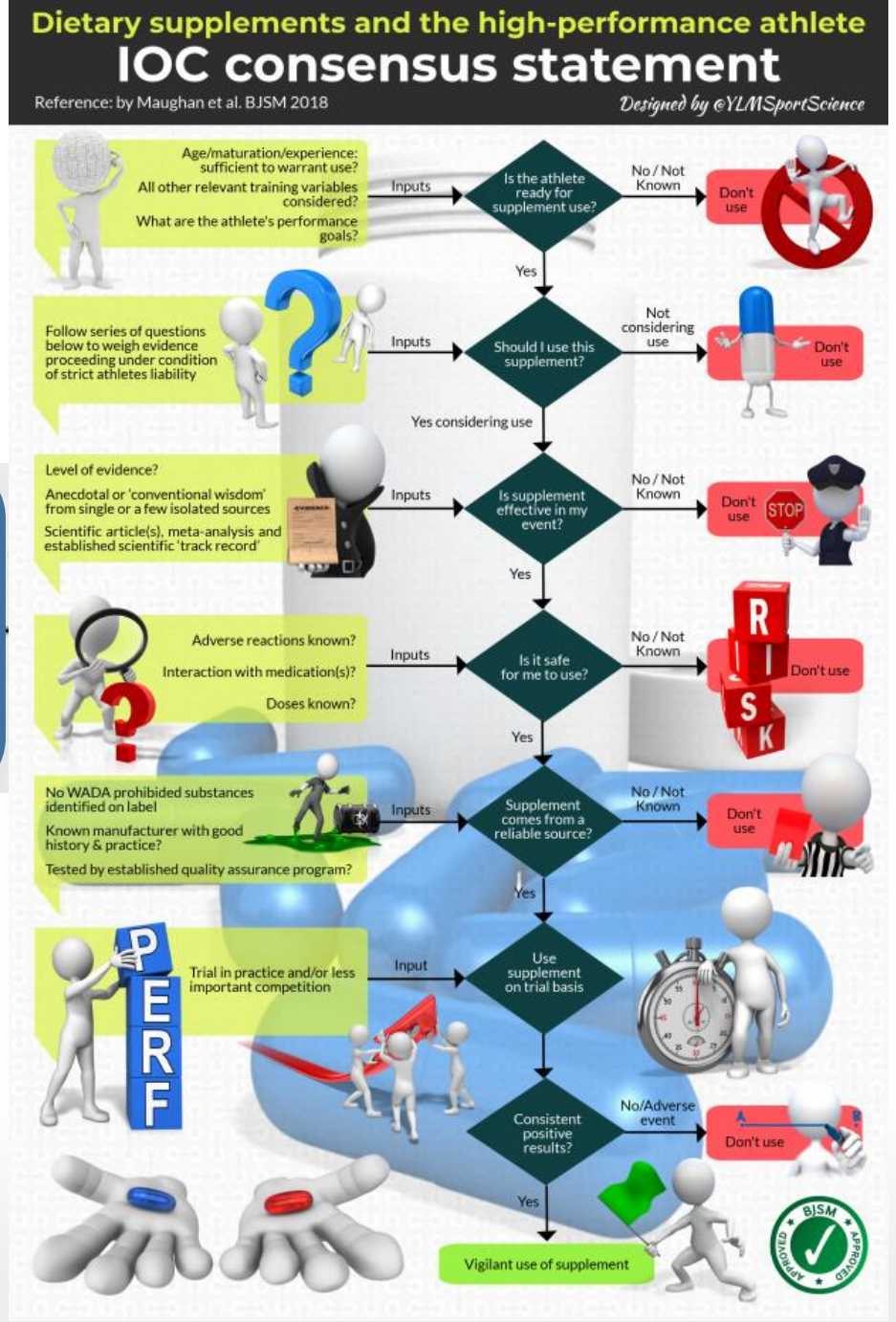
IOC consensus statement: dietary supplements and the high-performance athlete

Ronald J Maughan,[1] Louise M Burke,[2,3] Jiri Dvorak,[4] D Enette Larson-Meyer,[5] Peter Peeling,[6,7] Stuart M Phillips,[8] Eric S Rawson,[9] Neil P Walsh,[10] Ina Garthe,[11] Hans Geyer,[12] Romain Meeusen,[13] Lucas J C van Loon,[3,14] Susan M Shirreffs,[1] Lawrence L Spriet,[15] Mark Stuart,[16] Alan Vernec,[17] Kevin Currell,[18] Vidya M Ali,[19] Richard GM Budgett,[20] Arne Ljungqvist,[21] Margo Mountjoy,[22,23] Yannis P Pitsiladis,[19] Torbjørn Soligard,[20] Uğur Erdener,[19] Lars Engebretsen[20]

Br J Sports Med: first published as 10.1


Age/maturation/experience: sufficient to warrant use?
All other relevant training variables considered?
What are the athlete's performance goals?


Level of evidence?
Anecdotal or 'conventional wisdom' from single or a few isolated sources
Scientific article(s), meta-analysis and established scientific 'track record'

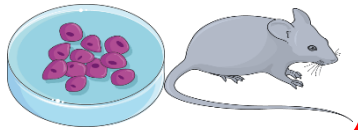

Dietary supplements and the high-performance athlete
IOC consensus statement
Reference: by Maughan et al. BJSM 2018
Designed by @YLMSportScience
Age/maturation/experience: sufficient to warrant use?
All other relevant training variables considered?
What are the athlete's performance goals?
Inputs
Is the athlete ready for supplement use?
No / Not Known
Don't use
Yes
Follow series of questions below to weigh evidence proceeding under condition of strict athletes liability
Inputs
Should I use this supplement?
Not considering use
Don't use
Yes considering use
Level of evidence?
Anecdotal or 'conventional wisdom' from single or a few isolated sources
Scientific article(s), meta-analysis and established scientific 'track record'
Inputs
Is supplement effective in my event?
No / Not Known
Don't use
STOP
Yes
Adverse reactions known?
Interaction with medication(s)?
Doses known?
Inputs
Is it safe for me to use?
No / Not Known
Don't use
R I S K
Yes
No WADA prohibided substances identified on label
Known manufacturer with good history & practice?
Tested by established quality assurance program?
Inputs
Supplement comes from a reliable source?
No / Not Known
Don't use
Yes
P E R F
Trial in practice and/or less important competition
Input
Use supplement on trial basis
Consistent positive results?
No/Adverse event
Don't use
Yes
Vigilant use of supplement
BJSM APPROVED

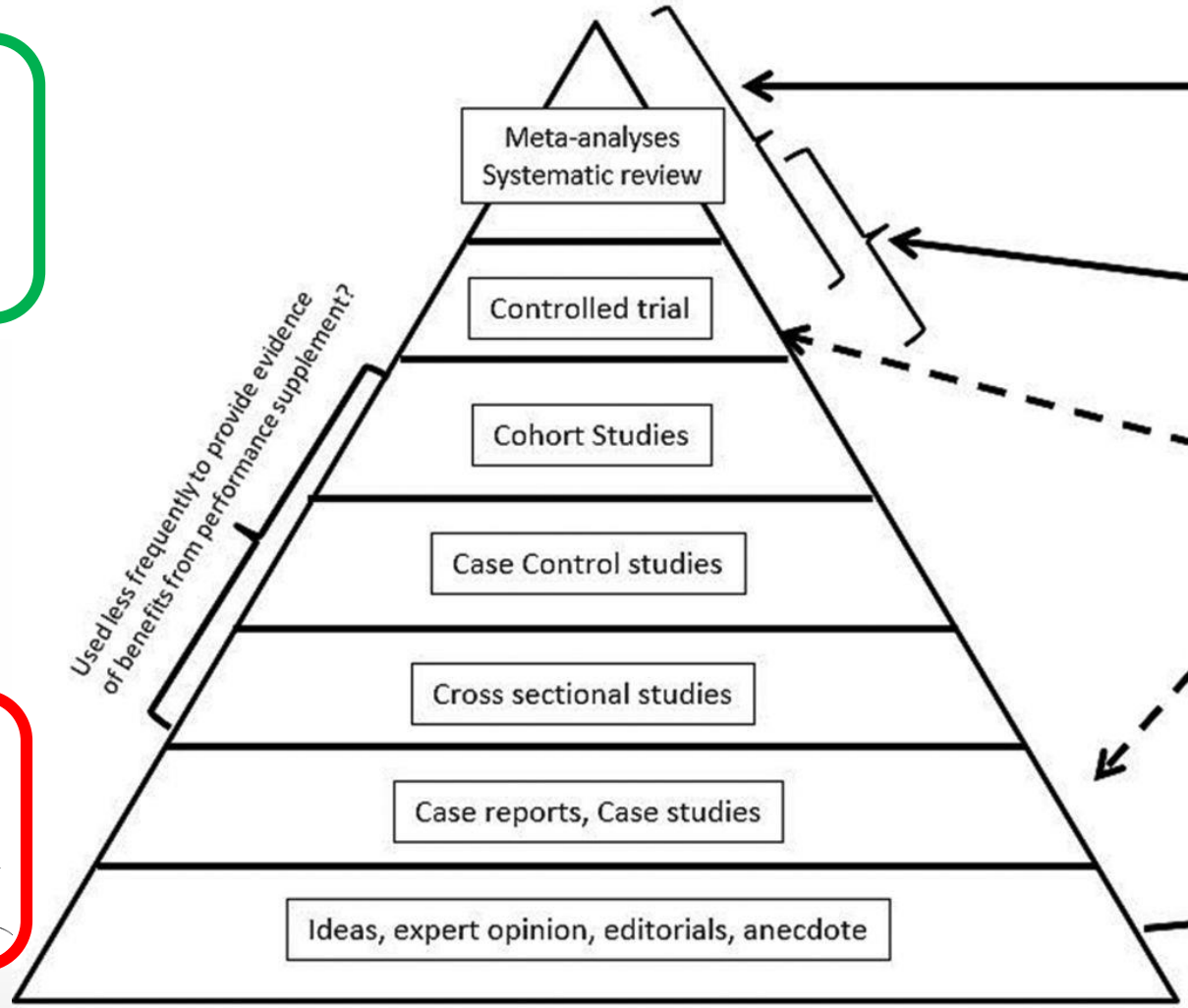
Hierarchy of Scientific Evidence

Evidence matrix for performance supplements

“Sense”

“No sense”





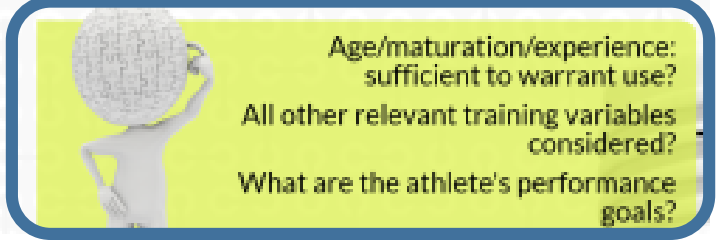
General:
(e.g. Does Supplement X work? how does it work, what is the best protocol? What type of events might it best work for?

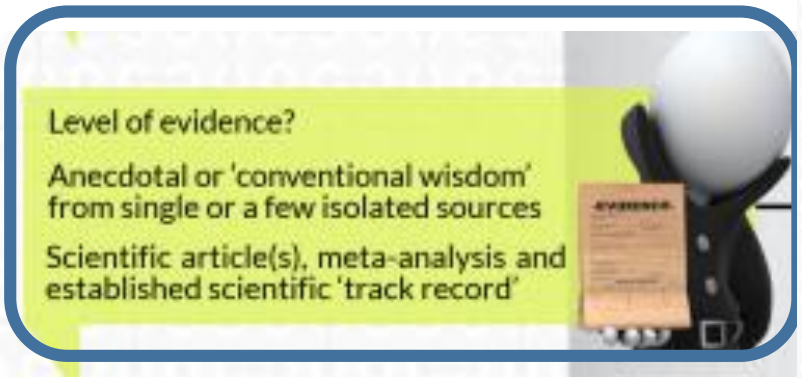
Specific
(e.g. Will this Supplement X protocol improve performance in 400 m swimming race? Will it improve marathon performance?)

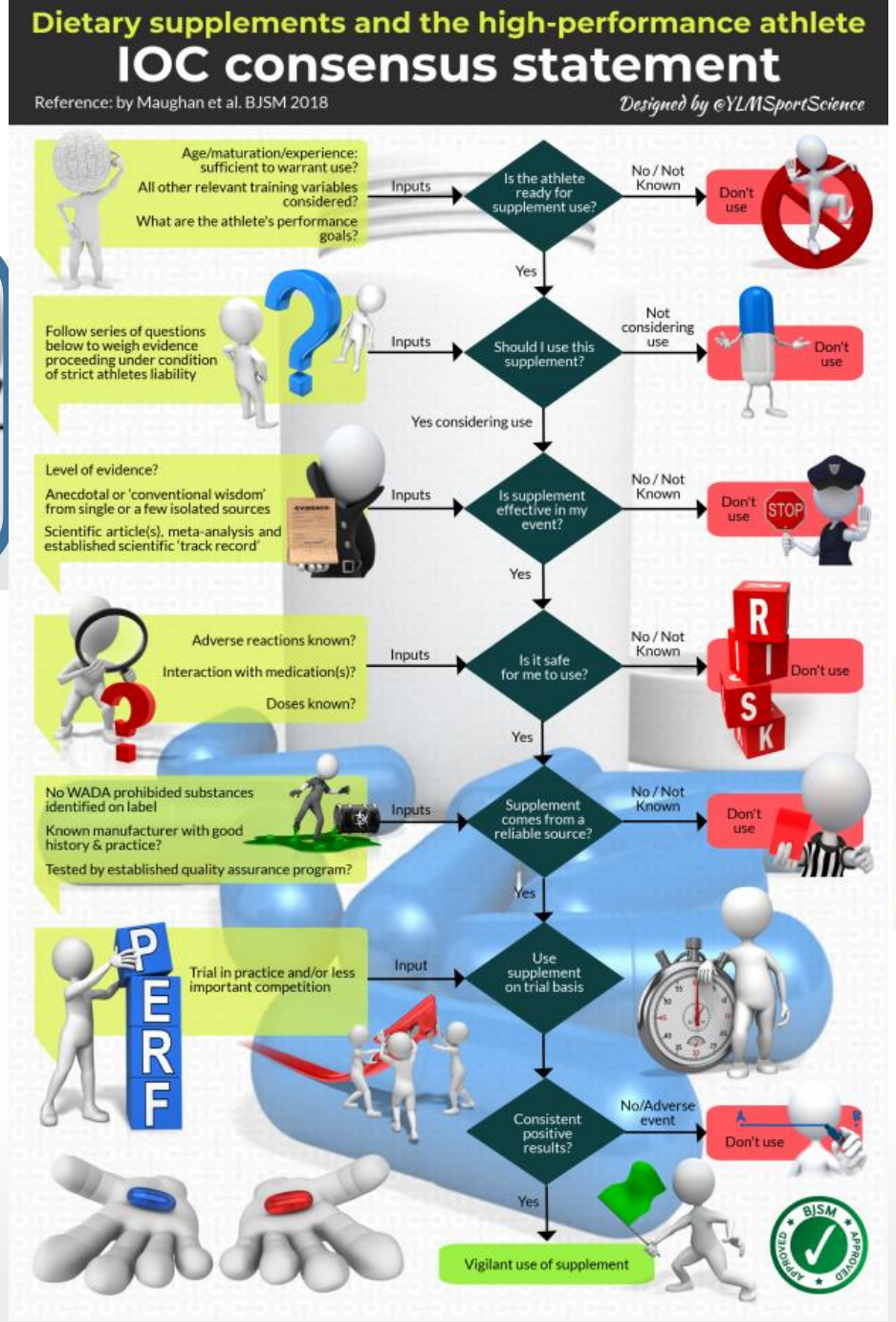
Very Specific
(e.g. Will Supplement X enhance performance of **my** marathon in hot and humid conditions when I am also taking caffeine? Can **I** use Supplement X for both the morning heats and evening finals of my 400 m swim?

Preliminary ideas/hypotheses
(e.g. What is Supplement X? How can it be used to alter metabolism? How might that be useful to a sports competition or training program? Is there any basis for thinking it might work?

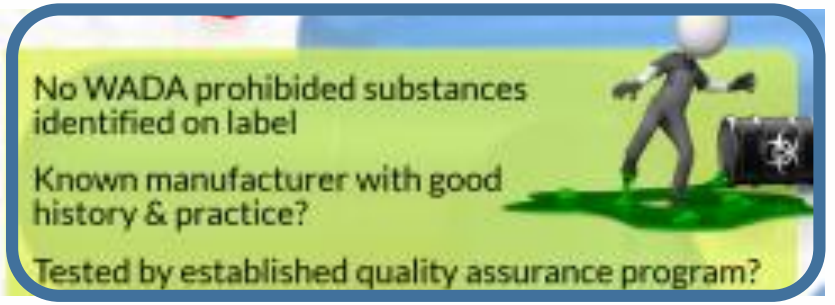
Maughan et al. 2018







5 – 20 % contaminated



International Journal of Sport Nutrition and Exercise Metabolism, 2018, 28, 200-211
https://doi.org/10.1123/ijsnem.2017-0314

Human Kinetics
SCHOLARLY REVIEW

Nutritional Supplements and the Brain

Romain Meeusen and Lieselot Decroix
Vrije Universiteit Brussel

Cognitive function plays an important role in athletic performance, and it seems that brain functioning can be influenced by nutrition and dietary components. Thus, the central nervous system might be manipulated through changes in diet or supplementation with specific nutrients including branched-chain amino acids, tyrosine, carbohydrates, and caffeine. Despite some evidence that branched-chained amino acids can influence ratings of perceived exertion and mental performance, several well-controlled studies have failed to demonstrate a positive effect on exercise performance. Evidence of an ergogenic benefit of tyrosine supplementation during prolonged exercise is limited. There is evidence that mild dehydration can impair cognitive performance and mood. The beneficial effect of carbohydrate supplementation during prolonged exercise could relate to increased substrate delivery for the brain, with numerous studies indicating that hypoglycemia affects brain function and cognitive performance. Caffeine can enhance performance and reduce perception of effort during prolonged exercise and will influence specific reward centers of the brain. Plant products and herbal extracts such as polyphenols, ginseng, ginkgo biloba, etc. are marketed as supplements to enhance performance. In several animal studies, positive effects of these products were shown, however the literature on their effects on sports performance is scarce. Polyphenols have the potential to protect neurons against injury induced by neurotoxins, suppress neuroinflammation, and to promote memory, learning, and cognitive function. In general, there remains a need for controlled randomized studies with a strong design, sufficient statistical power, and well-defined outcome measures before "claims" on its beneficial effects on brain functioning can be established.

Supplements *and the brain*

Supplements and the brain in *sports*

Fatigue and the brain

Physical fatigue

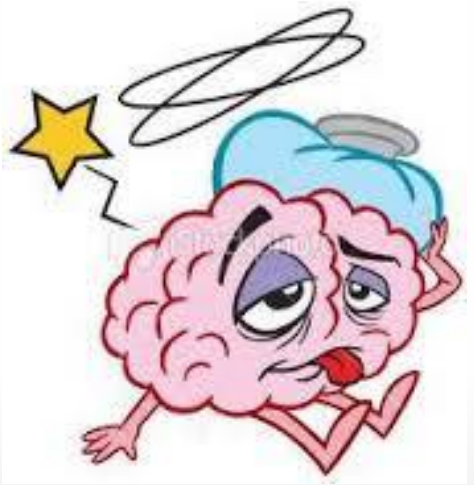
“failure to maintain the required force”

“inability to continue working at a given exercise intensity”

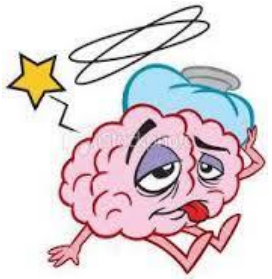
=> Central and peripheral fatigue

Mental fatigue

“change in psychobiological state caused by prolonged periods of demanding cognitive activity”



Mental fatigue



Exercise performance

Van Cutsem et al. 2017

Subjective

- Feeling of fatigue ↑
- Vigor ↓
- Alertness ↓

Behaviour

- Reaction time ↑
- Accuracy ↓

(Neuro)physiological

- HR ↑
- θ- en α-activity ↑
- P3-amplitude ↓

Physical fatigue: central + peripheral

✓Distal to the neuromuscular junction

- ✓ Substrate availability in the muscle
- ✓ Accumulation of metabolites
- ✓ Ca^{2+} distribution
- ✓ Disturbance of neuromuscular function

Central and/or peripheral fatigue?

Certain mechanisms in the brain contribute to fatigue

Eric Newsholme et al (1987)

failure of the central nervous system to excite or drive motor neurons adequately

✓Proximal to the neuromuscular junction:

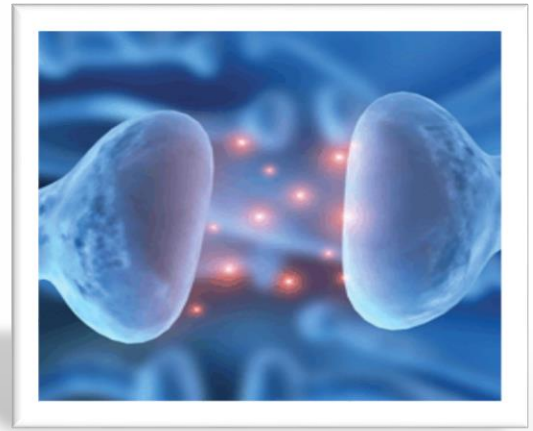
✓*Neurotransmitters:*

Dopamine ➔ *+ : motivation*

Serotonine => - : fatigue, sleep,…

Noradrenaline

Glutamate, Acetylcholine, GABA



Meeusen et al. 2016

Serotonine

L-Tryptophan

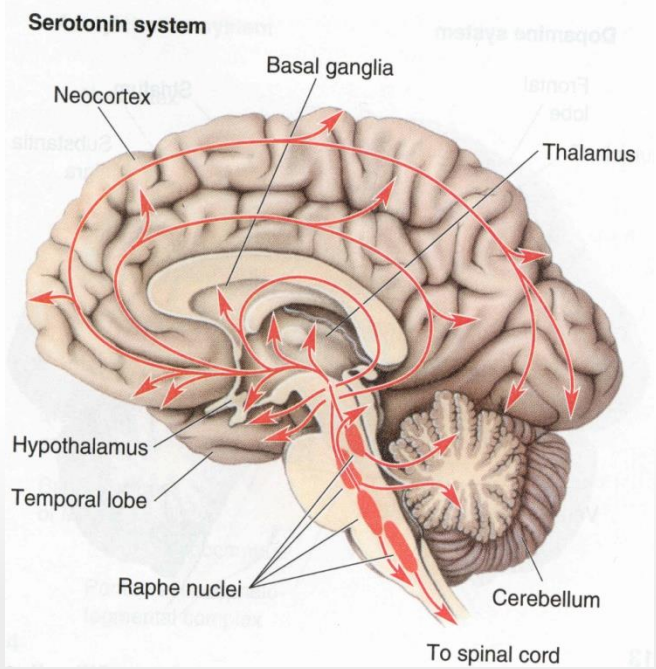
Hydroxylase

5-Hydroxytryptophan

No rate limiting step

Decarboxyla

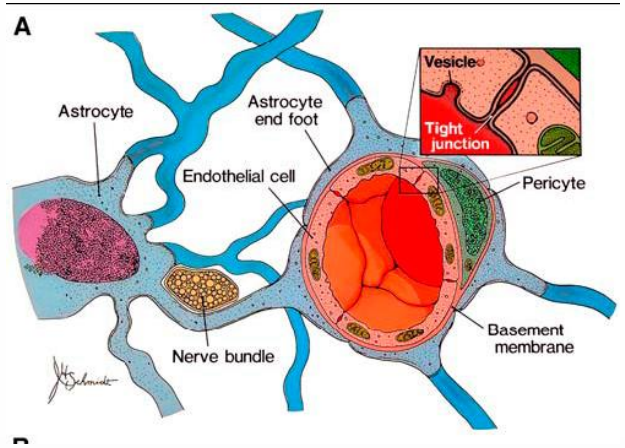
Serotonin
(5-HT)



Serotonine

Ratio *Tryptophan* - **BCAA**

(leucine, isoleucine, valine)



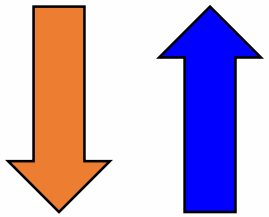
Competition transport BBB !

Brain [5-HT]

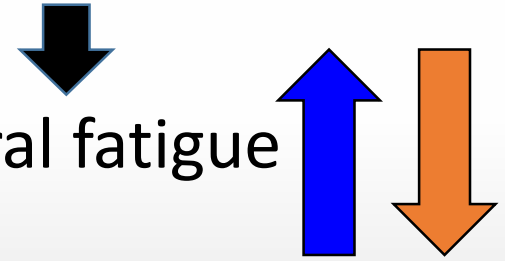
Central fatigue

Dopamine

- Motivation and motor behaviour
- Precursor: Tyrosine
  - Protein rich foods
  - Non-essential AA < liver
- ~ Amphetamines
- Ratio serotonine / dopamine (tyrosine precursor)



Central fatigue



Sport-related concussion

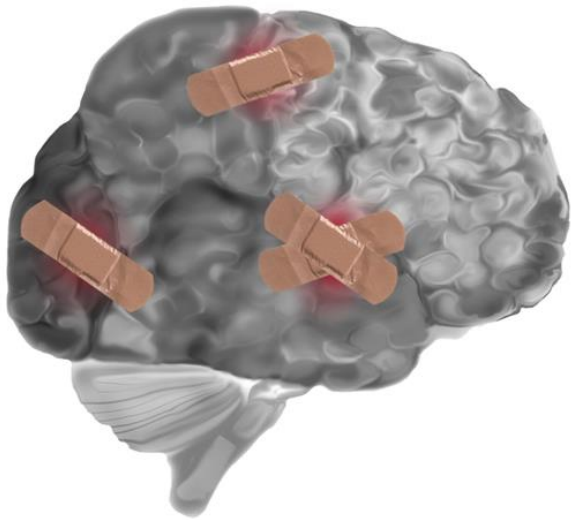
- Damage structural integrity of neuronal plasma membrane
- **↓ Cerebral blood flow**
- **Dysregulation of energy metabolism**
- **↑ Oxidative stress + inflammation**
- ↓ axon transport + cytoskeletal damage to microtubules

  ➔ neurofibrillary tangles ➔ CTE

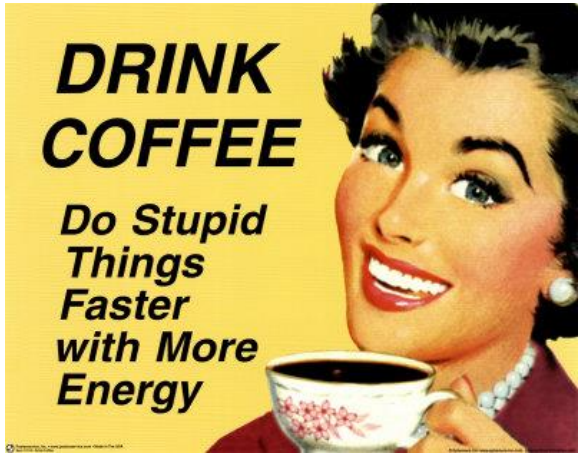
Manipulation of the brain by supplements?

Optimal brain functioning:



Caffeine



- Theory:
  - Adenosine antagonist ➔ ↓ inhibition dopamine release
  - ↑ endorphin release
- Scientific evidence?
    - 3 - 6 mg/kg *acute 60 min pre-exercise*
    - ↑ cognitive performance
      - ↑ vigilance, attention, alertness, RT *(Spriet 2014)*
    - ↑ physical performance
      - ↓ perception of effort
      - ↑ neuromuscular coordination
      - ↑ *endurance (3-7 %)*
      - ↑ *anaerobic performance (3 %)*
    - *Side effects*

Sense!

Carbohydrates

- Theory:
  - "Fuel" of the brain (substrate delivery)
- Scientific evidence?
  - ↓ perception of effort *(Williams & Rollo, 2015)*
  - Mouth rinse:
    - Physical and cognitive performance↑ (fasted state) *(Sanders et al. 2012)*
    - **↑ brain activation in reward centers** (Chambers et al. 2009, De Pauw et al. 2015)

1 - 10 Borg Rating of Perceived Exertion Scale	
0	Rest
1	Really Easy
2	Easy
3	Moderate
4	Sort of Hard
5	Hard
6	
7	Really Hard
8	
9	Really, Really, Hard
10	Maximal: Just like my hardest race

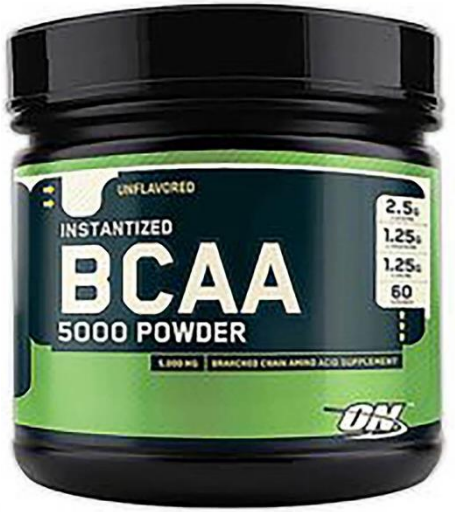
Sense!

Creatine-monohydrate

- Theory:
  - ↑ PCr resynthesis : ↑ brain energy
  - ↓ ROS and lipid peroxidation
  - ↑ brain levels of creatine by 10 % (2-4w 20g/day)

- Scientific evidence?
  - ↑ cognitive performance
    - *in suboptimal brain energy suppy*
    - ? in healthy brain *(Rae & Broer 2015; Rawson et al. 2018)*
  - ↑ recovery from concussion (*Rawson et al. 2018)*
  - Side effects: weight gain

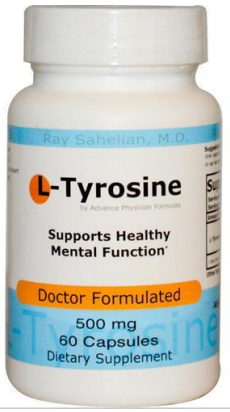
BCAA



- Theory:
  - ↓ Tryptophane transport ➔ brain
  - ↓ Serotonine
  - Prevention of central fatigue

- Scientific evidence?
  - Physical perfomance /
  - Cognitive performance /

Tyrosine



- Theory:
  - ↑ Adrenaline, noradrenaline en dopamine
  - ↓ Serotonin/dopamine
  - Prevention of central fatigue
- Scientific evidence?
  - Cognitive performance:
    - ↑ in extreme conditions *(Lieberman 2003)*
    - ↑ performance on soccer-specific skills in the heat
      - ⇔ follow up study *(Coul et al. 2015,2016)*
      - ⇔ composition?

Omega-3 fatty acids

- Theory:
  - Cell membrane components ➔ Intercellular signalling
  - Synaps function
- Scientific evidence?
  - Neurdevelopment + neurodegeneration
  - ↑ cognitive function *(Barett et al. 2014)*
    - Elderly – MCI - Alzheimer
    - Athletes?
  - Prevention/treatment of concussion:

    - ↓ white matter damage
    - ⇔ ↓ BDNF and ↓ CREB
  - Side effects

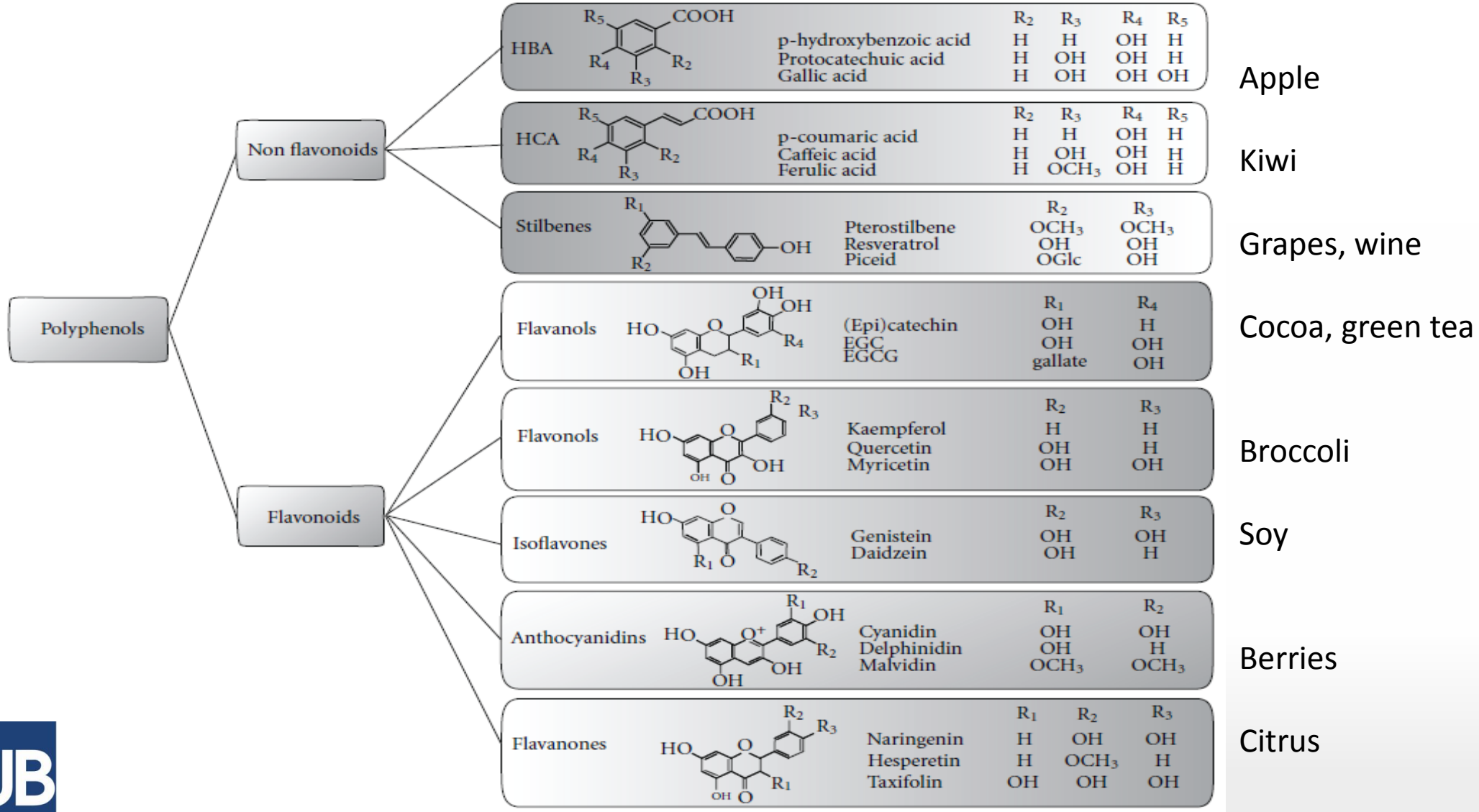
Ketones

- Theory:
  - Back-up “fuel” for the brain
  - Ketosis: ↓ inflammation
- Scientific evidence?
  - Nutritional ketosis (Alzheimer + MCI) *(Krikorian et al. 2012)*
    - ↓ neuroinflammation
    - ↑ cognitive function
    - Athletes?
  - Ketone-drinks:
    - No evidence for cognitive performance

Polyphenols

- Theory:
  - Strong antioxidants
  - Neuroprotective
  - ↑ CBF
- Scientific evidence?
  - ↑ Cognitive performance *(Vauzour 2012)*
    - Elderly
    - Athletes ?
  - ↑ Physical performance *(Somerville 2017)*
    - Quercetin

Polyphenols

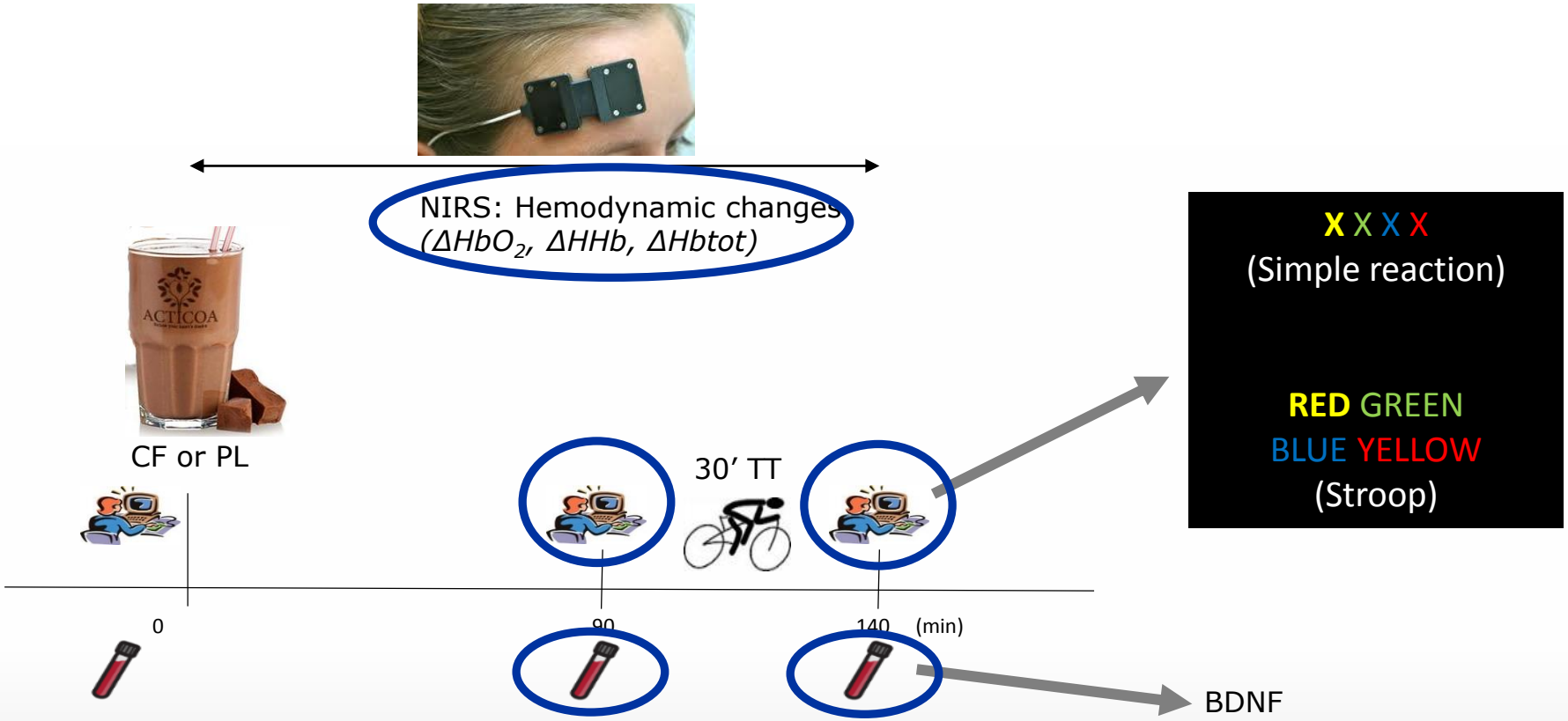


Cocoa flavanols

- Theory
  - Antioxidant
  - ↑ CBF
- Scientific evidence?
  - Cognitive performance:
    - ↑ in elderly, restricted cognitive/vascular function *(Socci 2017)*
    - / in athletes *(Decroix et al. 2017)*
  - Physical performance: / *(Decroix et al. 2018)*

Cocoa flavanol intake (athletes)

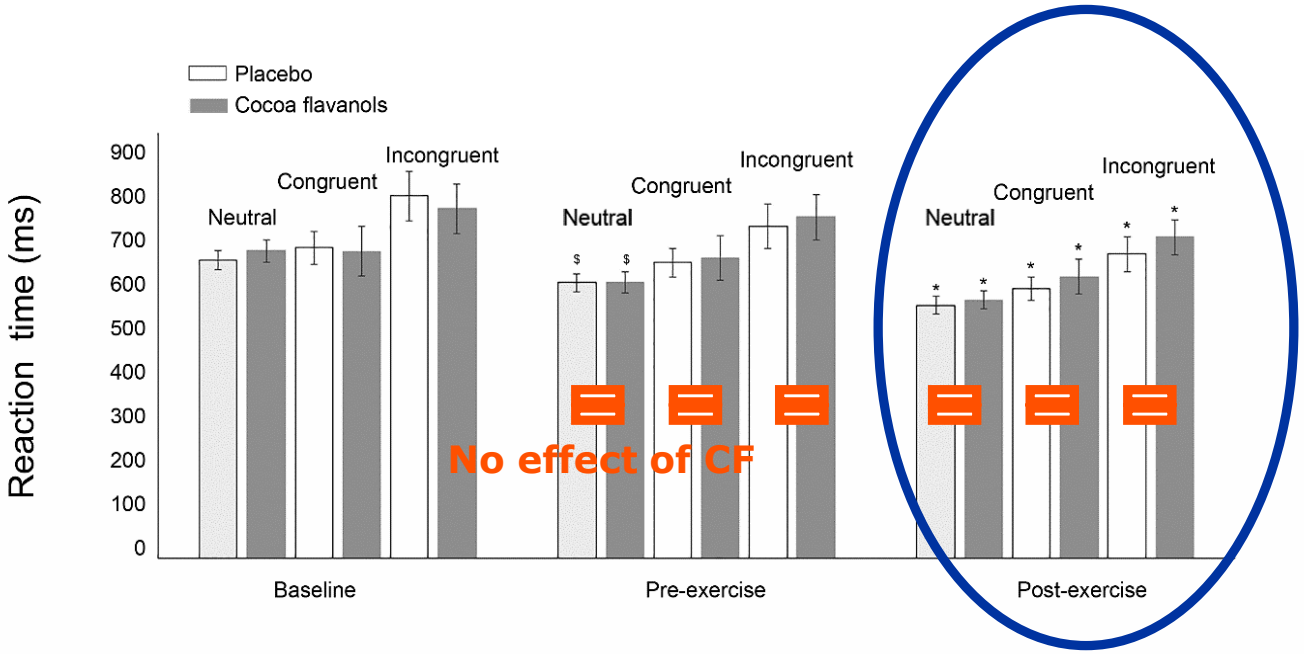
RCT
12 well-trained male athletes (30 ± 3 years, VO_2max 63.0 ± 3.5 mL/kg/min)

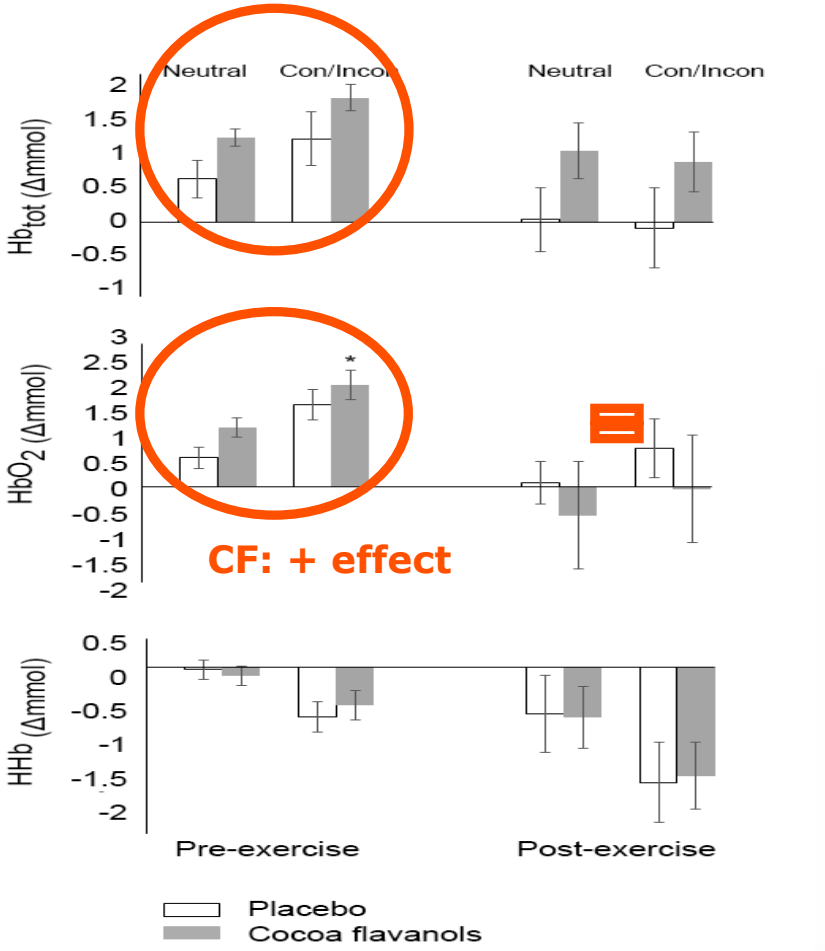


CF: *Cocoa flavanol*
PL: *Placebo*
NIRS: *Near-Infrared Spectroscopy*
TT: *Time trial (start at 75% Peak power output*

CF
Exercise

Exercise: ↓ RT

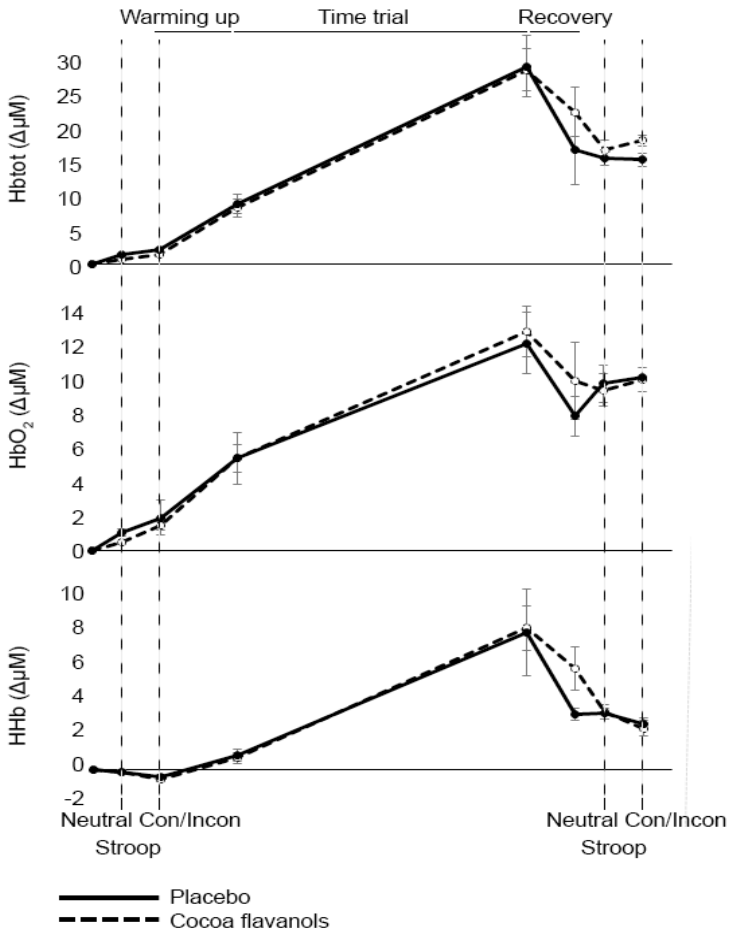




3. EFFECTS OF ACUTE CF INTAKE AND EXERCISE ON COGNITIVE FUNCTION

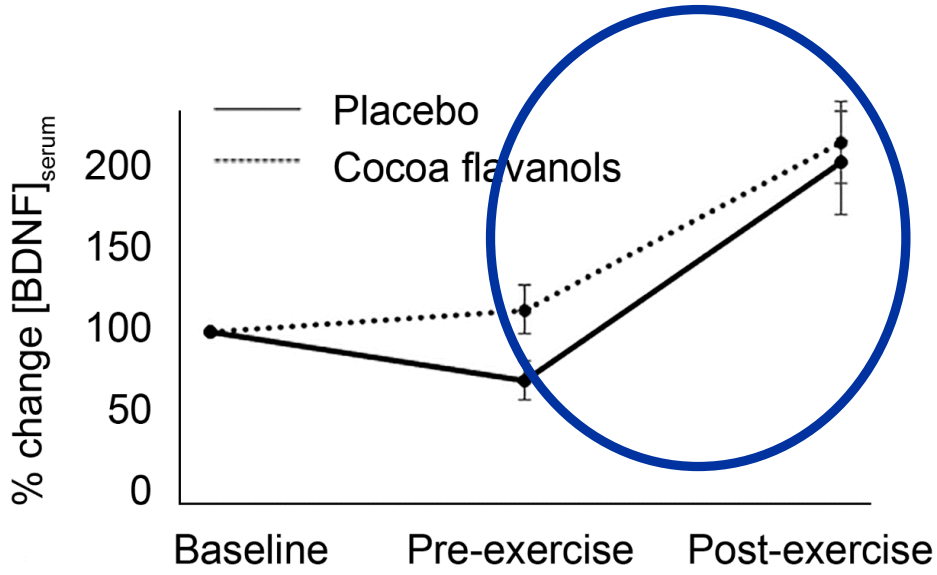
RESULTS/DISCUSSION

CF
Exercise



Exercise: ↑ CBF
CF: No effect

Exercise: ↑
CF: no effect



No additive effect of CF on exercise-induced increases

Beetroot juice

- Theory:
  - Nitrate
  - ↑ CBF
- Scientific evidence?
  - Cognitive perfomance:
    - *Potentially* ↑ cognitive performance *(Wightman et al. 2015, Thompson et al. 2015)*

Guarana

- °caffeine, sapponin, tannin, flavonoid
- Scientific evidence?
  - ↑ cognitive performance *(Kennedy 2004, Pomportes 2017)*
  - ↓ perceived fatigue
  - Attenuate mental fatigue

Ginseng

- Mechanism: unknown
- “Tonic for stamina”; “reduce fatigue”
- Scientific evidence
  - ↑ mood, motivation
  - ↑ sportspecific cognitive performance
  - ⇔ *(Gens et al. 2010, Smith et al. 2014)*

Ginkgo biloba

- Mechanism: unknown
- Scientific evidence
  - ↑ cognitive function and memory (*Gorby et al. 2010, Tan et al. 2015)*
  - Athletes?

Conclusions

The brain influences physical performance!

- Mental fatigue
- Physical fatigue: central fatigue
- Altered perception

Can supplements affect the brain?

1) Neurotransmitters **Caffeine, Tyrosine, BCAA**
2) Fuel for the brain **Carbohydrates, Creatine, ketones**
3) Cerebral blood flow **Polyphenols: cocoa, beetroot**
4) Brain structure **Omega-3 fatty acids**