

NUTRITION FOR COGNITIVE PERFORMANCE



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OVERVIEW

- Background on Cognition:
 - Define cognition
 - Describe cognitive domains
 - Explain how cognition relates to athletes
- Effects of Nutrition on Cognition:
 - Hydration
 - Macro/micronutrients
 - Functional ingredients



BACKGROUND ON COGNITION



WHAT IS COGNITION?

Cognition is the processes the mind uses to:

- Take in
- Digest
- Discern
- Use information

Example

Classroom role call is a simple task that includes many cognitive domains. A student needs to:

1. Recognize that the instructor is calling out names
2. Assess the knowledge of his own name
3. Listen to each name to determine if it the correct name
4. Decide if it is right to raise his hand
5. Control his hand and raise it to acknowledge his presence in class

Least Complex



Most Complex

Cognitive Domain	Sub Domains
Sensation & Perception	Multisensory Object Recognition Organizational Strategies
Motor Skills & Construction	Copying Drawing Praxic Skills
Attention & Concentration	Selective Attention Sustained Attention/Vigilance
Memory	Working Memory Episodic Memory Procedural Memory
Executive Functioning	Reasoning Problem Solving Component Skills Management
Processing Speed	Semantically Relevant Coding and Tracking
Language/verbal skills	Naming Fluency Reading and Comprehension

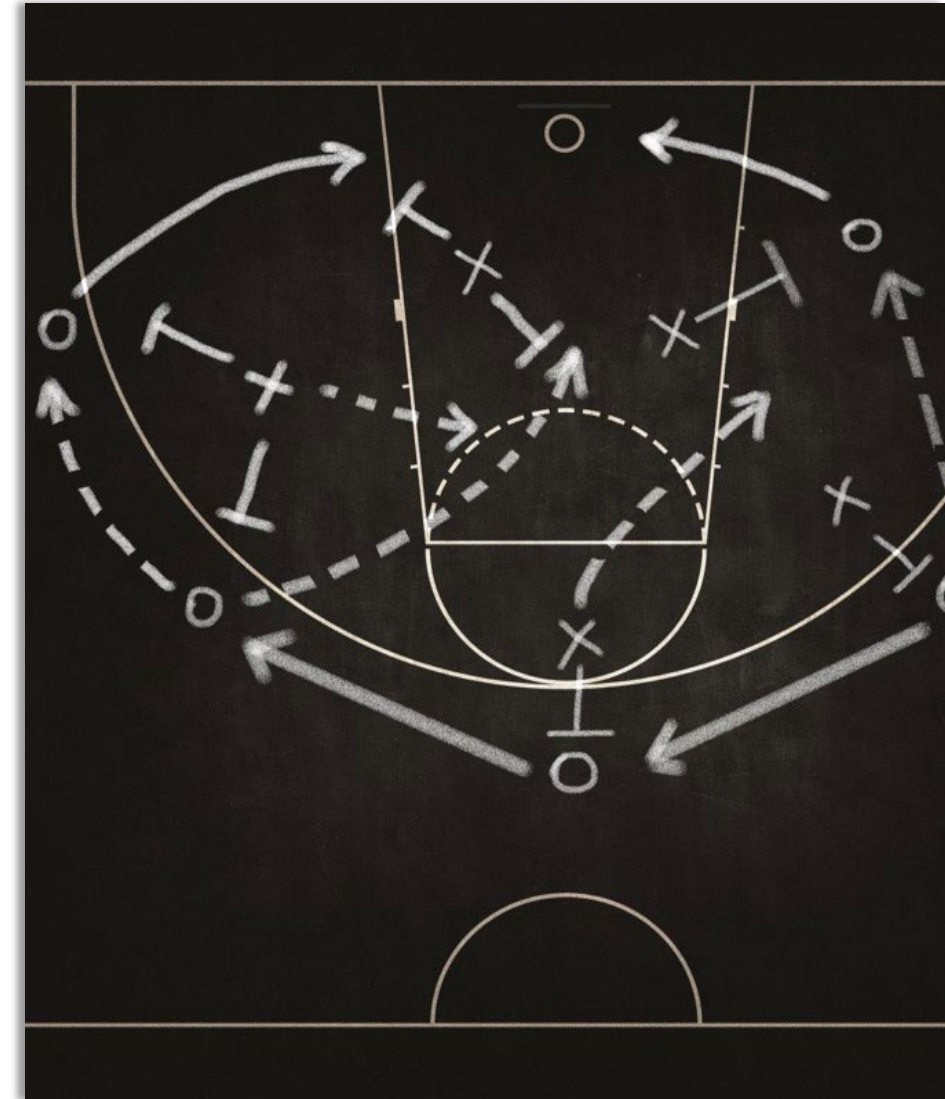
COGNITIVE TESTING SUMMARY

Cognitive Domain	Tests
Sensation & Perception	Visual object recognition Tactile object recognition Auditory recognition assessment Assessments of olfactory recognition
Motor Skills & Construction	Finger tapping Pegboard tasks Simple and grooved assessment of grip strength Copy component of the Rey Complex Figure Clock drawing paradigms
Attention & Concentration	Global-local task Dual task processing (e.g. Useful Field of View) Continuous performance task
Memory	Digit span task/ Digit span backwards Delayed response paradigms Word lists Hopkins Verbal Learning Test/California Verbal Learning Test/Rey Auditory Verbal Learning Test New Declarative Memory Tasks Cambridge Prospective Memory Test Memory for Intentions Screening Test
Executive Functioning	Wisconsin Card Sorting Test Trail Making
Processing Speed	Symbol coding Letter sequencing in the Trail Making Test
Language/verbal skills	Measuring fluency Object naming Instruction response

SPORTS AND COGNITIVE FUNCTION

In sports, performance relies heavily on cognitive function. Here are some examples:

- The ability to learn plays.
- The ability to remember plays.
- Sensations and perceptions react to a whistle or buzzer.
- Vigilance to understand what is happening within a play.
- Executive function to problem solve against the defense.
- Language skills to communicate with teammates.
- The motor skills to execute sport specific tasks (i.e. shooting, dribbling, passing).
- Reaction time.
- Coordination and balance.



EXAMPLES OF COGNITION IN DIFFERENT SPORTS



Endurance Cycling

- **Motor skills** and **Procedural Memory** to remember how to ride a bike and to stay balanced on the bike.
- **Prospective Memory** to remember when, what amount, and what type of nutrition to take during a multi-hour long training or competition.



Football

- **Selective Attention** to execute a specific role in the play called.
- **Processing Speed** for the quarterback to determine where to throw the ball before being sacked.
- **Language skills** to be able to hear and interpret plays being called.



Golf

- **Executive Functioning** to get the ball out of an unplanned location/situation.
- **Procedural Memory** to remember how to swing the club optimally.
- **Perception** to determine how hard to swing the club for the distance the ball needs to go.

NUTRITION & COGNITION

- The brain is a very metabolically demanding organ.
- Nutrition and hydration play an important role with the brain to support cognition.
- Nutrition and exercise play a role with neurogenesis (i.e., generation of new nerve cells).
- Other dietary aspects, such as high sugar, calories, and saturated fat may negatively impact neural function (↑ oxidative stress, ↓ cognitive function).
- From an exercise perspective, specific nutrition interventions may influence cognitive performance, but also fatigue development.



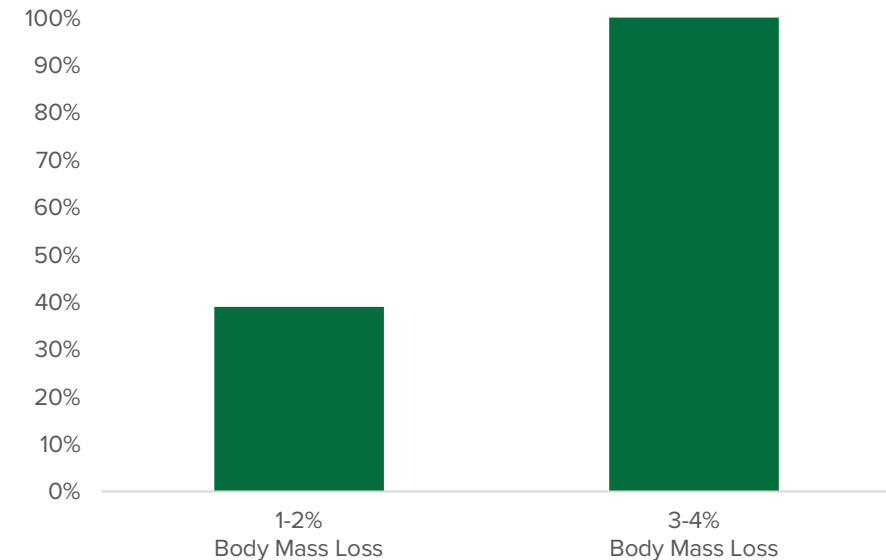


HYDRATION AND COGNITION

DEHYDRATION & COGNITION IMPAIRMENT

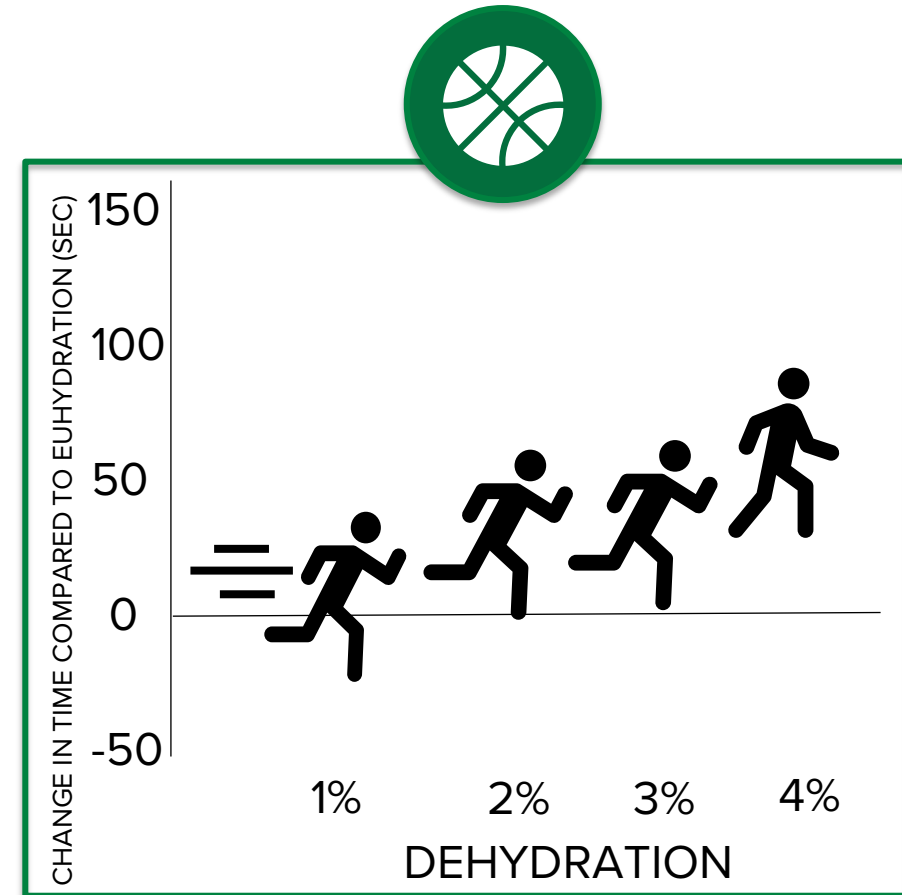
- There is large variability in the amount of sweat fluid teams sport athletes lose (within and between sports).
- The effect of hydration status on team sport performance has been mixed:
 - Some have found decrements (see graph)
 - While others have found no performance impairment
- Hydration is more likely to impair cognition, technical skill, and physical performance at higher levels of body mass loss and when combined with heat stress.

Percent of Team Sport Studies That Have Found Cognitive Impairment



HYDRATION DEFICITS & SPORT PERFORMANCE

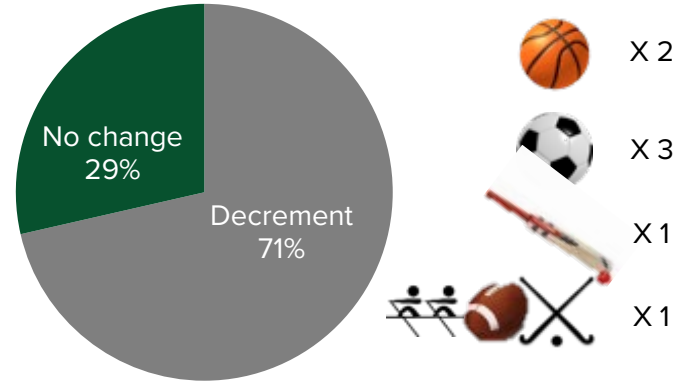
- Team sport performance involves:
 - Cognition (e.g. attention, decision making, reaction time)
 - Skill (e.g. shooting, passing, and dribbling)
 - Physical performance aspects (e.g. sport-specific lateral movements, sprinting, jumping/anaerobic power, high intensity running)
 - RPE and fatigue
- Studies have shown that with increased levels of dehydration (3-4% BML), team sport performance can be impacted:
 - One example is this study on a simulated basketball game.
 - With increased levels of dehydration, the players took longer to complete the drills.
- When heat stress is combined with dehydration, the impairment can be worsened.



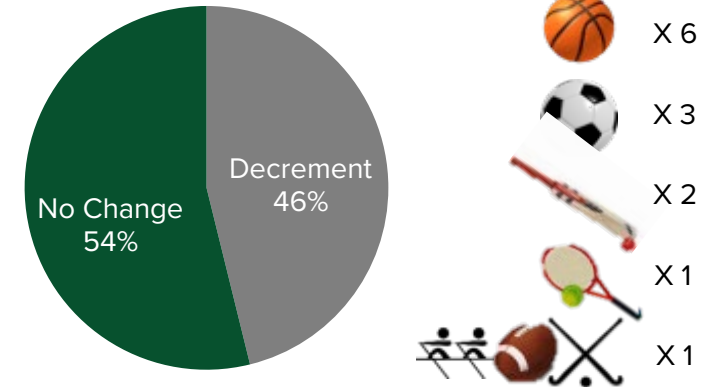
COGNITIVE FUNCTION

Percentage of Studies with Cognitive Function Decrements

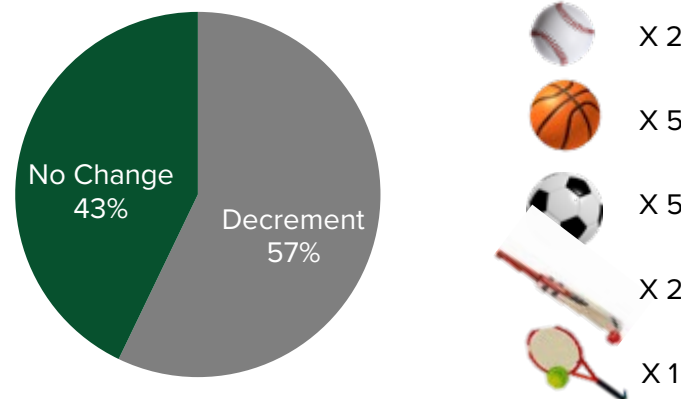
Cognition



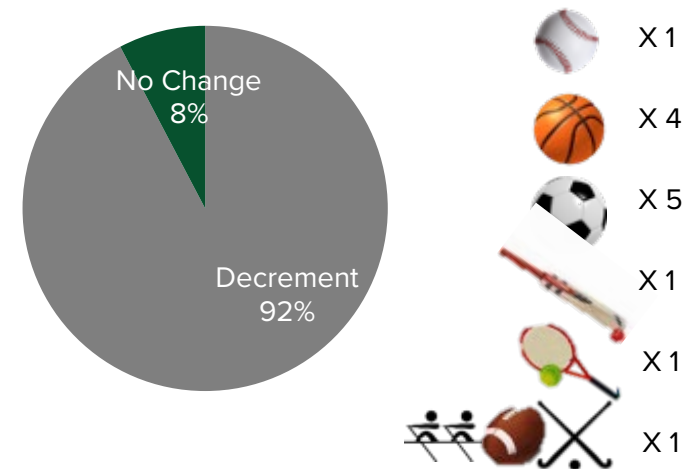
Skill



Physical Performance*



RPE and Fatigue



*sport-specific lateral movements, sprinting, jumping/anaerobic power, high intensity running

DEHYDRATION & COGNITIVE PERFORMANCE

The exact mechanism causing performance decrements with hypohydration are unclear. However, there have been a few studies that suggest that dehydration could cause physiological events that impact the brain's function or psychological distractions caused by the symptoms of dehydration. It is likely a combination of both.

Physiological

↓ cerebral blood flow

↓ brain volume

↑ blood-brain barrier permeability



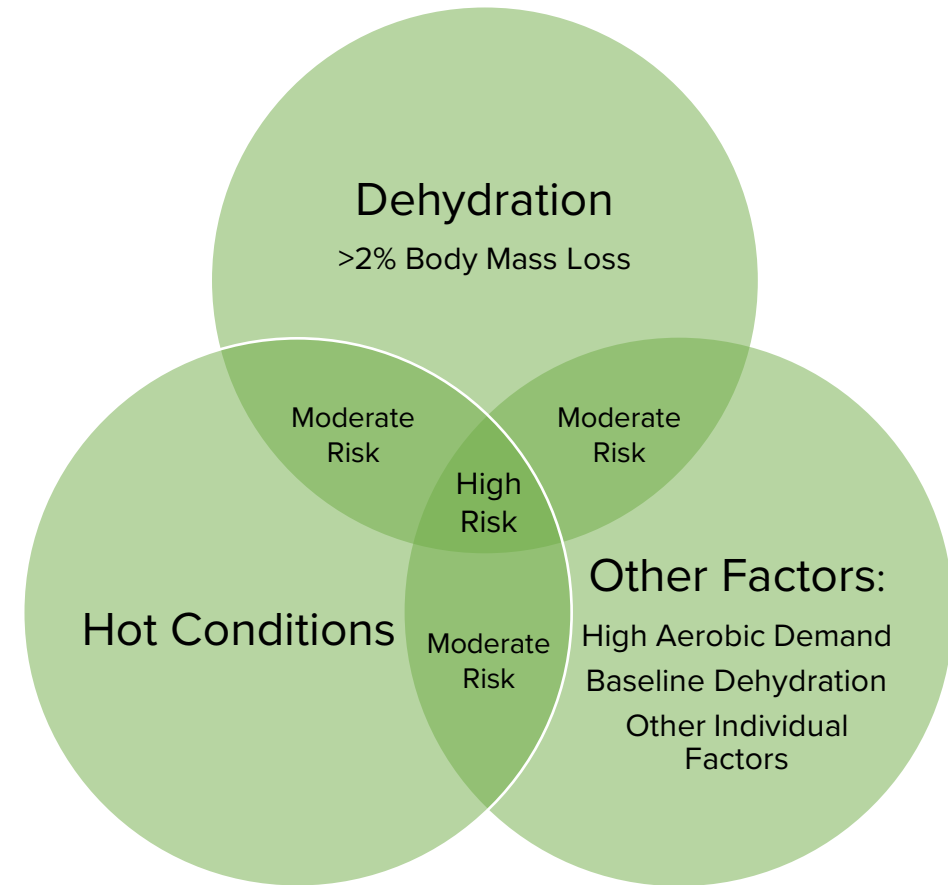
Psychological

The symptoms of thirst, headache, and fatigue or negative mood cause a distraction that impacts cognitive tests



Practical Application for Cognitive Performance in Sports

- Athletes and practitioners should strive to understand individual fluid losses during team sport play and provide customized hydration replacement plans.
- When cognitive domains are critical, athletes should keep sweat losses under about 2% body mass loss, especially when environmental conditions are hot and humid.
- To do this, athletes should be given access to fluid and ample opportunities to drink.



Venn diagram showing the risk of hypohydration in team sports



NUTRITION AND COGNITION

Ingredients and Cognition – Exercise/Sport

**Carbohydrate /
Mouth rinse**

Omega-3

Caffeine

Polyphenols

BCAAs

L-Tyrosine

SSE#119



CARBOHYDRATE (CHO)

Background

- The primary fuel source desired by the brain is glucose and glycogen, but lactate, ketones, and medium chain triglycerides may also serve as a fuel source.
- During certain situations (e.g., cognitive processes, ↑ neuronal activity, prolonged activity), the glucose stored as glycogen in the brain may be degraded.
- The brain has a limited energy reserve capacity unlike skeletal muscle.
- The brain comprises ~2% of body weight, but uses ~20% of energy from glucose.

Relevance to sport/exercise

- CHO may play a role with central fatigue.
- Additionally, some studies have demonstrated there have been improvements with CHO electrolyte solutions on skill performance, mood states, and motor skills.



CARBOHYDRATE & COGNITIVE PERFORMANCE

Background

- One of the most scientifically supported ingredients for cognitive/motor skill performance in athletes.
- A CHO mouth rinse (i.e., rinsing and spitting out CHO) has been demonstrated in some studies to improve cognitive and physical performance.
- CHO in the mouth appears to activate regions of the brain and may influence motor output (possibly independent of taste or sweetness).

Relevance to sport/exercise

- Hypoglycemia may impact cognitive performance.
- CHO ↓ perception of effort.
- Substrate delivery (maintenance or increase) to the brain during prolonged exercise.
- Glucose has > effect on cognition with ↑ task difficulty.
- ↑ brain activity (in reward centers).



CARBOHYDRATE MOUTHRINSE & PERFORMANCE

Purpose


Explore the effects of CHO receptors in the mouth on time trial (TT) exercise performance



Methods

- n=9 (24.0 ± 3.8y)
- 1-h cycling TT
- 25-ml solution of either 6.4% CHO or water (placebo) for each 12.5% completion time (5 s rinse)

Findings

- Faster performance time and mean power output (during first 3 quarters) during 60-min TT with CHO
-  HR or RPE between trials

Improved performance may be related to increased central drive or motivation

A man in a grey athletic shirt and shorts is running on a treadmill. He is wearing a white head-mounted device and a metabolic cart with a nasal cannula. The treadmill is a COSMED T20 model. The background features a green and white wall with the Gatorade Sports Science Institute logo.

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FUNCTIONAL NUTRIENTS AND COGNITION

Background

- Found in many different products including but not limited to: coffee, tea, soft drinks, and chocolate products.
- Has central nervous system effects.
- Widespread intake in the US (>80% of adults).
- One of the most scientifically supported ingredients for cognitive/motor skill performance in athletes.



Relevance for Brain/Cognition

- Crosses the blood-brain barrier easily.
- Wide range of caffeine used in research (0.5 - 6 mg/kg).
- More evidence for improved alertness, vigilance, reaction time and attention.
- Less consistency for memory, judgement, and decision making.
- Habituation and withdrawal are two potential confounders.

Background

- Found in various foods such as fish, walnuts, and flax seeds.
- Large amounts usually found in algae and fish.
- Fish oil contains both docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA).

Relevance for brain/cognition

- Omega-3 PUFAs are important for the brain in terms of growth and development.
- Plays a variety of different roles including synaptic function and cognition (e.g., plasticity).
- Research has explored the effects of omega-3 fatty acids on different aspects of cognition.

FISH OIL & ATHLETES

Background

- ~25 years of research on athlete health and performance.
- Some mechanisms for beneficial effects of fish oil alteration of brain function/mood may be associated with:
 - ↑ DHA into neuronal membranes
 - Change in membrane fluidity
 - Speed of signal transduction and neurotransmission

Relevance for sport/athletes

- ↓ Fatigue
- ↓ Pain
- ↑ Vigor
- ↑ Attention
- ↑ Mood
- Improved Reaction Time
- Preliminary evidence that Omega-3 may be protective for concussions, but more research necessary.

BRANCHED CHAIN AMINO ACIDS (BCAAS)

Background

- Comprised of the amino acids Leucine, Isoleucine, and Valine.
- Involved in a number of different processes in the brain (e.g., protein synthesis, synthesis of 5-HT, dopamine and noradrenaline).
- Postulated to limit central fatigue, but evidence is very limited.

Relevance for athletes/sport

- Some evidence of a benefit on mental performance and RPE.
- No benefit seen with exercise performance/capacity across a number of different exercise tests.
- ↑ ammonia production and limiting tyrosine across blood-brain barrier may be a reason for lack of efficacy.
- Evidence is mixed and discrepancies may be associated with study methodology.

Background

- Amino acid found in a number of foods including but not limited to: cheese, fish, chicken, yogurt, and soy.
- Oral intake noted to increase adrenaline, noradrenaline, and dopamine.
- May be efficacious with preventing declines in cognitive function in certain conditions.

Relevance for athletes/sport

- Beneficial effects with tyrosine have been observed in populations that are sleep deprived, chronically stressed, or military settings – which may be relevant to athletes.
- Limited benefit during prolonged exercise - more research necessary.



Background

- Possess antioxidant and anti-inflammatory properties.
- Largest group = flavonoids.
- Flavonoids broken down into 6 different groups.
- Some foods that fall under these groups include cocoa, coffee, berries, and soy.
- Higher concentration of active substances in supplements vs. foods.

Relevance for Brain/Cognition

- Polyphenol cognitive/brain effects include:
 - ↑ neurogenesis
 - Neuroprotection from neurotoxins
 - Improving the cerebrovascular system
- May positively influence memory and learning, but the effects on mood and cognitive function are not as clear.



ADDITIONAL NUTRIENTS - LIMITED RESEARCH

- **L-Theanine** - Constituent found in tea; linked to attention.
 - **Sage** - Some work on alertness and memory; no research in athletes.
 - **Ginkgo Biloba** - Conflicting results; no work in athletes.
 - **Cocoa Flavanols** - Some evidence of improved cerebral oxygenation.
 - **Ginseng** - Mixed results on cognitive parameters; insufficient support for cognitive enhancement.
 - **Beetroot Juice** - May ↑ cognitive performance; may mitigate decline in reaction time.
- More research needed on:
 - Dosing
 - Which cognitive domain is influenced
 - Sports science related studies
 - Well-conducted studies



KEY TAKEAWAYS

- ✓ Cognitive function is more than just memory and fast thinking.
- ✓ Athletes need cognitive function for performance.
- ✓ Hypohydration may reduce aspects of cognitive performance.
- ✓ Nutrition plays an integral role with the brain and cognitive function.
- ✓ Beyond caffeine and carbohydrates, few efficacious supplemental dietary strategies exist to improve cognition in an exercise context.



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