ERGOGENIC AIDS THAT WORK
Ergogenic Aids

Mechanism of Action

Ergogenic Benefit

Recommended Use & Potential Side Effects

Indirect Performance Enhancing Supplements
adjective, ər-gə-ˈ je-nik

“enhancing physical performance”
-Merriam-Webster

For purposes of this presentation, only those dietary supplements recognized by the International Olympic Committee (IOC) will be included. The IOC, being a regulating body, is a trusted resource in the evaluation of nutritional supplements for individuals and athletes.
In review of the literature, a team of scientists working with the International Olympic Committee (IOC) has identified a short list of supplements that do show benefits on athletic performance:

- Caffeine
- Creatine
- Beta-Alanine
- Nitrate
- Sodium Bicarbonate

The IOC is a regulating body and a trusted resource in the evaluation of nutritional supplements for individuals and athletes.

CAFFEINE
Caffeine (1,3,7 – trimethylxanthine) is a natural alkaloid.

Present in the leaves, fruits, and seeds of a variety of plants such as coffee and tea.

Most well-studied and widely used supplement.

Pioneering work by Dr. Dave Costill & colleagues at Ball State University, late 1970’s

### Time to Exhaustion (80% VO2 max)

- **5 mg/kg** (~330 mg)
  - 96 min
- **0 mg/kg**
  - 75 min

### Work Completed (over 2 h)

- 250 mg pre-cycle
- 250 mg x 7 during cycle
  - 20% increase in work completed
Caffeine enhances aerobic endurance, muscle endurance, power, jumping, speed and overall awareness.

- Improved reaction time, concentration and self-perceived energy levels
- Enhanced endurance performance
- Enhanced glycogen resynthesis
- Improved performance in repeated high-intensity exercise bouts (i.e. team sports)
- Little to no effect on strength-based activities
- Velocity is enhanced and velocity loss attenuated over consecutive repetitions

Initial hypothesis during for improved endurance performance: metabolic
- Increased lipolysis, sparing muscle glycogen

Upon further research, it appears caffeine impacts the CNS and PNS by acting as an adenosine receptor antagonist
- Increased central drive in the CNS, decreased perception of effort and pain in the PNS

Following ingestion, appears in blood stream within 15 to 45 minutes, with peak levels appearing around 1 hour
Some individuals do not experience performance benefits associated with caffeine ingestion.

Recent research has emerged examining polymorphisms of certain genes:

- CYP1A2
- AD0RA2A

Further research is necessary, but clear that some individuals do not respond to caffeine ingestion.
Moderate to high doses (5-9 mg/kg) improve performance but are associated with increased heart rate, lactate, GI upset, nervousness, mental confusion, insomnia.

Low doses of ~200 mg or ~1.5 to 3 mg/kg body mass are effective and should be used initially.

Consumption can take place before, during and late into exercise.

Coffee and other caffeinated beverages, capsule/tablet, gels, gums, bars and dissolvable mouth strips are all effective for delivery.

The ergogenic effects of caffeine are generally independent of habitual caffeine use, training status, dietary intake, gender, hydration status and exercise modality, but results in the heat are less clear.

Caffeine is not a diuretic during exercise.
CREATINE
Creatine is synthesized in the kidney, liver, pancreas, and, to a lesser extent, the brain.

Synthesis is from the amino acids glycine, arginine, and methionine.

The total body creatine pool includes creatine and phosphocreatine (PCr).

Skeletal muscle is the primary site of storage accounting for up to 90% of total body pool.

Total body creatine pool can be increased by ingestion of foods high in creatine (meat and fish) or nutritional supplementation.

Creatine + ATP $\xrightarrow{\text{Creatine Kinase}}$ Phosphocreatine (PCr) + ADP

PCr is an important energy source for high intensity, short duration muscle contraction.

Creatine is essential for the regeneration of PCr.

The creatine kinase (CK) phosphocreatine (PCr) system serves as an energy buffer in cells with high and fluctuating energy requirements.
Short-term benefits following 5-7 day loading include increased

- **Power production**
- **Sprint performance**
- **Work performed (i.e. multiple sets of maximal effort)**

Chronic training with elevated creatine levels

- **Increases lean mass gains**
- **Improves strength**
- **Improves power**

Less common improvements noted in endurance performance:

- **Reduced lactate at same relative workload**
- **Decreased oxygen cost**
### RECOMMENDED USE

<table>
<thead>
<tr>
<th>Loading phase</th>
<th>Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 g/d for 4 weeks OR 20 g/d for 5 days</td>
<td>5 g/d</td>
</tr>
</tbody>
</table>

**To cycle or not to cycle?**

Cycling is not recommended

Creatine supplementation attenuates endogenous production

**Consideration:** Consuming carbohydrate with creatine enhances uptake
• 3 oz of raw beef equals approximately 0.4 g of creatine
• 3 to 6 g per 2.5 lbs of raw meat (estimated)
• Cooking affects creatine in meat by reducing total content
• Consideration: Athletes or individuals attempting to lose or maintain weight should consider the additional calories associated with consumption of large amounts of meat or fish for creatine

• Creatine monohydrate, most common form on the market, in solution increases whole body creatine to a greater extent than meat

• Other forms (ethyl ester, etc.) have not been found to increase muscle creatine to a greater extent and in some cases have been reported to result in less muscle creatine

After several decades of research, there is no persuasive evidence suggesting that oral creatine supplementation causes muscle cramps or adversely affects renal function or thermoregulation. The only potential side effect is weight gain.
Like caffeine, some individuals will not respond to supplemental creatine ingestion

Why?

• Individuals with a greater proportion of type II muscle fibers are more likely to have higher concentrations of creatine in muscle

• Unfortunately, all tests to determine muscle creatine content are invasive and/or expensive

• Most individuals are likely to benefit from supplementation
BETA-ALANINE
- Endogenously produced in liver
- Total body beta-alanine can be increased by ingesting meat, including poultry, or through supplementation
- Rate limiting pre-cursor to carnosine (beta-alanine alone has little to no ergogenic benefit)
- Beta-alanine is a pre-cursor to carnosine
- Carnosine has numerous physiological functions and is formed by the amino acids L-histidine and beta-alanine
- The ergogenic benefits are due to carnosine’s intracellular proton buffering capacity
- Ingestion of carnosine does not result in increased muscle concentration due to lack of a specific enzyme in the muscle which results in carnosine being metabolized prior to reaching the muscle
- However, beta-alanine allows carnosine to be increased in the muscle
• Improved exercise capacity in high-intensity events lasting 60 to 240s
• Allows for greater training volume in short event (i.e. lifting weight, sprinting)
• May benefit, though modest, in longer events (> 4 min) up to 10 minutes
• Attenuates neuromuscular fatigue
• Chronic loading of 4 to 6 g/d (~65 mg/kg body mass) divided in doses of 2 or less for minimum of 2 weeks produces benefit
• Greater benefit after 4 weeks
• Single bolus not recommended due to acute paraesthesia (i.e. skin tingling) and no performance benefit

• Paraesthesia (i.e. tingling) typically experienced in the face, neck, and back of hands
• Dose dependent with higher doses resulting in greater effect
• Time released formulations reduce paraesthesia
• No long-term (> 1 yr) safety data
NITRATE
Nitrate ($\text{NO}_3^-$) is a naturally occurring anion in the body involved in the biosynthesis of nitric oxide (NO) which has many physiological functions in the body.

- Green leafy and root vegetables are rich in nitrate.
- Ingestion of nitrate rich foods contributes to the formation of nitric oxide.
Nitric Oxide: regulation of blood flow, muscle contractility and mitochondrial respiration

![Diagram showing the mechanism of action of nitric oxide]

- L-Arginine
- Nitrate
- Nitrite
- Nitric Oxide
ERGOGENIC BENEFITS

- Reduced oxygen cost of submaximal exercise
- Improved muscle efficiency
- Increase time to exhaustion during high-intensity continuous and intermittent exercise
- Unknown if nitrate is ergogenic for highly trained athletes
5-7 mmol nitrate (~0.1 mmol/kg body mass)
- Typically peaks within 2 to 3 hours and remains elevated for 6 to 8 hours
- Consume ~3 hours prior to competition
- A daily dose is required to keep NO elevated
- Adaptations to training are unclear
- No known side effects at recommended dose
SODIUM BICARBONATE
The study of alkalosis to enhance performance goes as far back as 1930.

Sodium bicarbonate (NaHCO₃) has been purported to be the most effective ergogenic aid.

Sodium bicarbonate increases the level of bicarbonate in the blood which is a natural buffer.

\[ H^+ + HCO_3^- \rightleftharpoons H_2CO_3 \rightleftharpoons CO_2 + H_2O \]
- Maintains pH between intracellular and extracellular space
- Maintenance of muscle function
• Enhanced performance in exercise or event in which there is a reliance on anaerobic glycolysis
• Benefit for events between 30-120 seconds
• Recent review highlighted no difference in effect size in medium (2 to 10 minutes) and long (>10 minute) exercise
• Benefits realized in high intensity intermittent exercise (team sports)
• Evidence suggests more beneficial for untrained
Recommended Use
0.2 to 0.4 g/kg body mass ingested 1-2 hours before training or competition
Try it first during training!

Potential Side Effects
Gastrointestinal distress including:
- Pain
- Diarrhea
- Vomiting
- Gas
- Nausea

The IOC characterizes some supplements as “indirect performance enhancing” due to their effect on return to performance (injury recovery), soreness, or training capacity.
In addition to performance enhancing benefits, creatine also play a vital role in recovery

- Reduced delayed onset muscle soreness
- Improved cognitive processing
- Enhanced recovery from mild traumatic brain injury (mTBI) (i.e. concussion)

Supplementation for recovery is the same as for performance
Components of cell membranes, important for cardiovascular and neurological health

- Docosahexaenoic Acid (DHA) and Eicosapentaenoic Acid (EPA)
- The body can produce DHA and EPA from ALA; however, that process is limited and inefficient
- Fatty fish are rich dietary sources
- Most individuals are deficient, and several studies have highlighted deficiency in college athletes

Benefits may include:

- Enhanced muscle protein synthesis
- Improved cognitive processing
- Enhanced recovery from mTBI
- Enhanced recovery from exercise (may be due to anti-inflammatory properties of EPA)
- Recommended dose is 2 g/d; though optimal ratio is unknown. 2 g/d DHA is recommended for enhanced mTBI recovery

- Essential fat-soluble vitamin
- Obtained from exposure to sun
- Low vitamin D levels are often observed in athletes
- Measure status with a blood test
- Vitamin D is associated with numerous important biological actions relevant to the athlete including regulating bone health, immune function, cell cycle and skeletal muscle homeostasis
- RDA = 600 IU/day
Collagen is the primary protein in connective tissue (tendons and ligaments)

Gelatin is made from animal collagen and used in jellies and gummies to produce the gelatinous texture

Increased collagen production has been observed following consumption of gelatin + vitamin C

Additionally, decreased joint pain has been observed

Recommended amounts: 15 g gelatin with 50 mg vitamin C
Some foods have anti-inflammatory properties which may reduce the symptoms associated with muscle soreness and enhance recovery

- **Curcumin**, the bioactive ingredient in the spice turmeric, has anti-inflammatory properties
- **Tart cherries** also have bioactive ingredients purported to promote recovery

Recommended dose: 250-350 mL (30 mL concentrate) tart cherry juice twice daily

KEY TAKEAWAYS

✔ Caffeine, creatine, beta-alanine, nitrate, and sodium bicarbonate are direct performance enhancing supplements that may provide benefit if used appropriately and with the right type of exercise activity.

✔ Ensure the athlete has a sound nutritional base before adding supplements, even those with benefits.

✔ No supplement should be tested on competition day and/or game day. Care should be taken to ensure an athlete does not experience any side effects and that the desired benefit is realized.

✔ Indirect performance enhancing supplements may provide additional support by enhancing those periods of recovery, allowing for better health and enhanced recovery.