Nutritional Supplements
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Credit: Ty Wadsworth, MD
Objectives

• Review use of supplements by athletes

• Review (proposed) mechanism of action for common supplements

• Review safety and efficacy of selected supplements
# BJSM Reviews
## A-Z of supplements
### 2009-2013

Table 1: An example of most supplements that will be covered in the BJSM supplement series

<table>
<thead>
<tr>
<th>Amino acids</th>
<th>Androstenedione</th>
<th>Antioxidants</th>
<th>Arnica</th>
<th>Bee pollen</th>
<th>Boron</th>
<th>Buffers</th>
<th>Caffeine</th>
<th>Calcium</th>
<th>Carbohydrate</th>
<th>Carnitine</th>
<th>Carbohydrate</th>
<th>Carnitine</th>
<th>Chondroitin</th>
<th>Chromium picolinate</th>
<th>Cissus</th>
<th>quadrangularis</th>
<th>Citrulline</th>
<th>CLA</th>
<th>Coenzyme Q10</th>
<th>Colostrum</th>
<th>Copper</th>
<th>Creatine</th>
<th>Curcumin</th>
<th>Cytochrome C C</th>
</tr>
</thead>
<tbody>
<tr>
<td>DHEA</td>
<td>Dihydroxyacetone</td>
<td>Dimethylglycine</td>
<td>Echinacea</td>
<td>Electrolytes</td>
<td>Ephedra (Ma Huang)</td>
<td>Fatty acids &amp; MCTs</td>
<td>Ferulic acid</td>
<td>Fish oils</td>
<td>Flavonoids</td>
<td>Folic acid</td>
<td>Gamma-butyrolactone</td>
<td>Gamma-oryzanol</td>
<td>Gamma-aminobutyric acid</td>
<td>Garlic</td>
<td>Gingko biloba</td>
<td>Ginseng</td>
<td>Glandulars</td>
<td>Glucosamine</td>
<td>Glutamine</td>
<td>Glutathione</td>
<td>Glycerol</td>
<td>Green tea</td>
<td>Guarana</td>
<td>HMB</td>
</tr>
<tr>
<td>Hydroxycut</td>
<td>Inosine</td>
<td>Inositol</td>
<td>Iron</td>
<td>KIC</td>
<td>(alphaketoisocaproate)</td>
<td>Lecithin</td>
<td>Leptin</td>
<td>Linoleic acid</td>
<td>Magnesium</td>
<td>Melanin</td>
<td>Melatonin</td>
<td>Minerals</td>
<td>MSG</td>
<td>MSM</td>
<td>N-Acetylcyesteine</td>
<td>Nitric oxide</td>
<td>stimulators</td>
<td>Octacosanol</td>
<td>Omega 3, 6, 9 fatty acids</td>
<td>Ornithine</td>
<td>Oxygenated waters</td>
<td>Phloegenzym</td>
<td>Phosphate salts</td>
<td>Phosphatidyserine</td>
</tr>
</tbody>
</table>
Nutritional Supplements

• Common use by athletes
  • 1994 meta-analysis, 10,274 athletes, 15 sports
  • Prevalence of 46%.
    • more common among elite, followed by college, and then high school athletes
    • use by women was greater than men
    • use by athletes greater than the general population
Nutritional Supplements

• Why Use?

• To prevent or treat a perceived nutrient deficiency, especially when requirements for a nutrient are increased by their exercise program.

• To provide a more convenient form of nutrients in situations where every-day foods aren’t practical- particularly to address nutritional needs/goals around an exercise session.

• To provide a direct ergogenic (performance-enhancing) effect

• Because they believe every top athlete is consuming it and they can’t afford to miss out.

Nutritional Supplements

• 2001 NCAA athlete survey

• 53% of all athletes surveyed (from multiple sports) had used nutritional supplements

• most common creatine, protein products
Nutritional Supplements

- $22 Billion Dollar Market
- Over 300 products available, over 200 of which claim to increase muscle mass or performance
Nutritional Supplements

- Historical
  - Greek Olympians
    - Dung of a wild boar used as restorative by ancient chariot racers after crashes.
  - Runners at mushrooms for endurance
  - Zulu warriors drank a fermented beverage made from grape skins called “dop” to enhance their prowess in battle.
- Aztec athletes
  - Ate human heart for strength
Sports Supplements

- Modern Olympians

  - Thomas Hicks ran to victory in the Olympic marathon of 1904 in Saint Louis with the help of raw egg, injections of strychnine, and doses of brandy administered to him during the race.

  - “Icteric Ben” Johnson, many others.
Elite Athletes

- Bob Goldman, MD, in a 1995 survey of Olympic and other elite athletes
  - 195 out of 198 would use a performance-enhancing substance if it could not be detected and would guarantee they win the race
  - If it were later discovered that substance would cause death in 5 years, more than half surveyed said they would still use the substance.
Caveats

- Nearly unregulated
- Sometimes adulterated (5-20%)
- All that work have potential adverse effects
- Never try anything for the first time before competition.
Carbohydrate

- Claimed Effects: Replaces/ spares glycogen stores
- Evidence: Supports in activities lasting longer than 60 minutes
- Side effects: Diarrhea in 5-10% who use fructose
- Fructose, ribose not superior to sucrose
- Legality: Legal
Creatine

- Claimed Effects: Increases creatine phosphate pool; increases muscle energy, endurance, strength and lean muscle mass

- Potential use for age related sarcopenia/ muscular dystrophy

- Dietary sources: meat, fish

- Evidence: Supports anaerobic performance, no apparent benefit in aerobic performance; insufficient data on long-term use.

- Side effects: weight gain, muscular cramping, possibly increases risk for heat illness.

- Legality: Legal
Creatine

- **Dose:**
  - Body normally uses 2 g of creatine daily. The liver, kidneys, and pancreas produce about 1 g
  - Loading dose 20 g/day for 5-7 d, followed by a 2-5 g daily dose
  - “Slow load” of 3 g/day for 28 days can be used
  - No safety data on pediatric use
    - Metz, et al found similar use rates in grades 6-12 to those of college athletes.
Sodium Bicarbonate

- **Claimed Effects:** Buffers lactic acidosis, delay fatigue

- **Evidence:** May be effective in both short-term and long-term high intensity exercise

- **Dose:** 0.3 mg/kg

- **Side effects:** diarrhea, abdominal cramps, bloating, acid-base disturbance (metabolic alkalosis) (~10% of athletes do not tolerate)

- **Legality:** Legal
Glycerol

- Claimed Effects: Improves hydration and endurance; osmotic properties result in H$_2$O retention; “hyperhydration”

- Evidence: Limited, mixed, some support, overall equivocal

- Dose: 1-1.5 gm/kg in 1.5 liters - 60-120 min prior to activity

- Side effects: Mild gastrointestinal (bloating, nausea, diarrhea), mild headaches (increased intra-cranial pressure)

- Increases the risk of voiding during competition

- Legality: Legal (oral)?? 2011 WADA - Prohibit diuretics and Masking agents - including plasma expanders. Testing?
Multivitamins

• Claimed Effects: Increase energy, endurance and aerobic capacity, enhances recovery

• Evidence: No benefit unless pre-existing deficiency
  
  • Regular exercise may increase requirements for Riboflavin and pyridoxine.

• Useful for vegans, junk food junkies, eating disordered, inadequate calorie intake (therefore insufficient vitamin content)

• Side effects: None at RDA, some toxicities at high doses

• Legality: Legal
Vitamin D

- Claimed Effects: Improved muscle performance

- Evidence: Early 20th Century Russian and German studies suggest exposure to Ultraviolet Light B had a positive impact on athletic performance. Unclear if this was due to Vitamin D.

- Vitamin D deficiency is associated with fatigue, muscle, bone, joint pain, weakness, and more.....

- Side effects: None at RDA, some toxicities at high doses

- Legality: Legal

- Deficient: <20 ng/ml (50 nmol/l)
- Insufficiency: <30 to 32 ng/ml (75–80 nmol/l)
- Sufficient: ≥30 to 32 ng/ml (75–80 nmol/l)
- Optimal: 40–70 ng/ml (100–175nmol/l)
- Toxicity: >150 ng/ml (375 nmol/l)
Caffeine (and Guarana)

- **Claimed Effects:** Increases muscle contractility and aerobic endurance, enhances fat metabolism
- **Evidence:** Supports
- **Side effects:** Mild
- **Legality:** Legal to urine level of 12 to 15 μg caffeine per mL; consumption of ~7mg/kg (16 oz Starbucks=320 gm; just over 3 cups for 150-lb athlete)

Guarana is a climbing plant in Brazil - Guaranine is chemically similar to caffeine
# Caffeine Content

<table>
<thead>
<tr>
<th>Food or drink</th>
<th>Serving</th>
<th>Caffeine (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instant coffee</td>
<td>250 ml cup</td>
<td>60 (12–169)</td>
</tr>
<tr>
<td>Brewed coffee</td>
<td>250 ml cup</td>
<td>80 (40–110)</td>
</tr>
<tr>
<td>Short black coffee/espresso</td>
<td>1 (80–100 ml)</td>
<td>107 (25–214)</td>
</tr>
<tr>
<td>Starbucks Breakfast Blend coffee Venti size</td>
<td>600 ml</td>
<td>415 (300–564)</td>
</tr>
<tr>
<td>Iced coffee—commercial brands</td>
<td>500 ml bottle</td>
<td>30–200</td>
</tr>
<tr>
<td>Frappuccino</td>
<td>375 ml cup</td>
<td>90</td>
</tr>
<tr>
<td>Tea</td>
<td>250 ml cup</td>
<td>27 (9–51)</td>
</tr>
<tr>
<td>Chocolate—</td>
<td>dark 60 g</td>
<td>10–50</td>
</tr>
<tr>
<td>Coca Cola</td>
<td>375 ml can</td>
<td>49</td>
</tr>
<tr>
<td>Red Bull energy drink</td>
<td>250 ml can</td>
<td>80</td>
</tr>
<tr>
<td>Smart Drink—Brain fuel</td>
<td>250 ml can</td>
<td>80</td>
</tr>
<tr>
<td>Spike Shotgun energy drink</td>
<td>500 ml can</td>
<td>350</td>
</tr>
<tr>
<td>Fixx energy drink</td>
<td>600 ml can</td>
<td>500</td>
</tr>
<tr>
<td>Ammo energy shot</td>
<td>30 g</td>
<td>170</td>
</tr>
<tr>
<td>PowerBar caffeinated sports gel</td>
<td>40 g sachet</td>
<td>25</td>
</tr>
<tr>
<td>PowerBar double caffeinated sports gel</td>
<td>40 g sachet</td>
<td>50</td>
</tr>
<tr>
<td>PowerBar ActiCaf performance bar</td>
<td>65 g bar</td>
<td>50</td>
</tr>
<tr>
<td>Jolt caffeinated gum</td>
<td>1 stick</td>
<td>33</td>
</tr>
<tr>
<td>No doz</td>
<td>1 tablet—Australia</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>1 tablet—USA</td>
<td>200</td>
</tr>
</tbody>
</table>
Protein

- **Claimed Effects:** Optimizes muscular growth and repair

- **Evidence:** Supports; increased need for protein with activity

- **Side effects:** None unless underlying medical condition (hepatic, renal disease risk probably overestimated) Excess converted to fat. Excess may lead to increased urinary excretion of Calcium

- **Legality:** Legal
Protein

• Do athletes need protein supplements?
  - Some do
    • Females with low total caloric intake
    • Adolescent athletes with high training demands superimposed on growth needs.
    • Athletes with limited time to eat balanced diet due to educational, training, work or other demands
    • Vegans may be deficient in lysine, threonine, tryptophan, or methionine
Protein

Do athletes need protein supplements?

- RDI = 0.8-0.9 g/kg/d
- Endurance athletes may need up to 1.5 g/kg/d
- Anabolic training may need 1.8-2.2 g/kg/d
- Typical American diet provides 1.2 g/kg/d
Protein

- Emphasize dairy source proteins enriched in leucine
- Consume protein in doses of 20-25 g/serving
- Equally spaced protein meals throughout the day
- Consume protein immediately after exercise to maximize incorporation into muscle.
Amino Acid Supplements

- Specific amino acid supplements and combinations have been evaluated
  - Arginine, Ornithine, Lysine
  - Branched-Chain AA’s
    - Leucine, isoleucine, valine
    - Aspartate
Arginine, Ornithine, Lysine

- Claimed Effects: Stimulate growth hormone release; Aid recovery of muscles after exercise
- Evidence: No significant increase in GH secretion and no strength benefits when taken orally.
- Side effects: Diarrhea at large doses
- Legality: Legal
Branch-Chain Amino Acids

- Leucine, isoleucine, and valine - Essential AA’s


- Evidence: Mixed; may help performance at altitude and in heat; may induce significant and preferential losses of visceral adipose tissue in calorie-restricted athletes in training

- Side effects: None at doses used; large doses may cause ↓ performance due to ↑ ammonia produced by exercising muscle.

- Legality: Legal
BCAA

- Small studies (8-30 subjects)
- BCAA vs. placebo
  - Higher testosterone
  - Lower cortisol, CPK
  - Improved self-reported DOMS sx, muscle fatigue
- Dose: 2-4 g/hour ingested during exercise and recovery.
Good evidence that caffeine can improve single-sprint performance, while caffeine, creatine and sodium bicarbonate ingestion have all been demonstrated to improve multiple-sprint performance.

Current evidence does not support the ingestion of ribose, branched-chain amino acids or β-hydroxy-β-methylbutyrate, especially in well trained athletes.
Anabolic/Androgenic Steroids

• Claimed Effects: Increase protein synthesis, muscle mass, aggressiveness.

• Evidence: Effective
Anabolic/Androgenic Steroids

- Reversible side effects
  - Sexual effects
    - Increased or decreased libido
    - Decreased sperm production
    - Testicular atrophy (sometimes does not reverse)
  - Cutaneous effects
    - Acne
    - Hirsutism
    - Edema
  - Psychiatric effects
    - Euphoria
    - Nervousness
    - Aggression
    - Personality disorders
  - Other
    - Increased transaminases
    - Nausea
    - Increased urination
Anabolic/Androgenic Steroids

- Serious and irreversible side effects
  - Hypertension from mineralocorticoid effects
  - Dysplastic changes in collagen fibrils, resulting in severe tendon ruptures
  - Liver tumors (hepatocellular carcinoma, hepatic adenoma, hepatic cholangiocarcinoma)
  - Psychosis (ie. “steroid rage”)
  - Gynecomastia (typically irreversible)
  - Irreversible hirsutism, clitoral hypertrophy and deepening of voice in women
  - Premature closure of growth plates, causing shorter stature in adolescents

- Legality: Illegal
Androstenedione

- Claimed effects: Increase strength, lean muscle mass and motivation: immediate precursor of testosterone and estrone
- Evidence: Refutes, no benefits
- Side effects: possible prostate stimulation
- Legality: Banned by WADA, NCAA
DHEA

- Claimed effects: Increases endogenous steroid production
- Evidence: No benefit in healthy athletes
- Side effects: acne (50%), increased facial hair (18%), and increased perspiration (8%) breast tenderness, weight control, good alteration, headache, oily skin, and menstrual irregularity in some women. Possible prostate stimulation
- Legality: Banned by WADA, NCAA
EPO, Blood doping

• Claimed effects: Increases aerobic capacity
• Evidence: Supports
• Side effects: Polycythemia, CVA, transfusion reaction, death
• Legality: Illegal
Human Growth Hormone

- **Claimed effects:** Anabolic effect on muscle growth, increases fat metabolism, hastens muscle repair/recovery

- **Evidence:** Supports both endurance and resistance exercise

- **Side effects:** glucose intolerance, acromegaly, myopathy, hypothyroidism

- **Legality:** Illegal
Amphetamines

- Claimed effects: Improve concentration, decrease fatigue and appetite
- Evidence: Mixed, some positive, likely some benefit in concentration and reaction time, psychological effects mimic ergogenesis
  - some trials suggest increased Vigor, Elation, Friendliness, Arousal and Positive Mood and decreased confusion on POMS.
- Side effects: Significant, dangerous, including dysrhythmias, hyperthermia, increased risk for heatstroke, hypertension, addiction
- Legality: Illegal without TUE.
Summary

- Sound nutrition and training techniques are effective

- Most supplements provide no benefit, and those that do give minimal benefit

- Most supplements that are legally available are harmless

- Most athletes are better served spending the $$ on a healthy, balanced diet.
Bibliography


