Pharmacologic & Chemical Ergogenic Aids Evaluated

HNF 610: Nutrition & Fitness
Dr. Melissa Olfert
Ergogenic Aids

- Ergogenic means work producing.
- Products are aggressively advertised toward athletes and coaches.
- Sports supplements are the largest segment of the dietary supplement industry.
- Indiscriminate use increases the likelihood of adverse side effects.
- Many fail to conform to labeling requirements.
Functional Foods and Transgenic Nutraceuticals

- Foods and their bioactive components that help to:
  - Promote well-being
  - Promote health
  - Allow for optimal body function
  - Reduce disease risk

- Transgenic nutraceuticals is an emerging field of biotechnology that uses genes introduced into a host plant or animal.
Nutrition Research

- Justification
- Subjects
- Research sample, subject, and design
- Conclusions
- Dissemination of findings
How Ergogenic Aids Might Work

- Act as central or peripheral nervous system stimulant
- Increase storage and/or availability of a limiting substrate
- Act as supplemental fuel source
- Reduce or neutralize performance-inhibiting metabolic byproducts
- Facilitate recovery
Anabolic Steroids

- Used to treat natural androgen deficiency, muscle-wasting diseases, osteoporosis, severe breast cancer, and decline in lean body mass due to age, HIV, or kidney disease
- Used by some athletes along with stimulants, hormones, and diuretics
- Many athletes are screened for steroid use.
Structure and Action of Anabolic Steroids

- Function similar to the hormone testosterone
- Anabolic steroid use usually combines with resistance training and augmented protein intake to improve strength, speed, and power.
- Increased use among young athletes
- Abnormal alterations in mood and psychiatric dysfunction also are associated with androgen use.
General Anabolic Steroid Side Effects

- Connective tissue damage
- Chronic stimulation of the prostate gland
- Possible kidney malfunction
- Injury and alterations in cardiovascular function and myocardial cell cultures
- Possible pathologic ventricular growth and dysfunction when combined with resistance training
- Impaired cardiac microvascular adaptation to exercise training
Anabolic Steroid Side Effects in Men

- Infertility
- Reduced sperm concentrations
- Decreased testicular volume
- Gynecomastia
- Chronic stimulation of the prostate gland

- Injury and functional alterations in cardiovascular function
- Possible pathologic ventricular growth and dysfunction
- Increased blood platelet aggregation
- Increased risk of stroke and acute myocardial infarction
Anabolic Steroid Side Effects in Women

- Virilization
- Deepened voice
- Increased facial and body hair
- Altered menstrual function
- Dramatic increase in sebaceous gland size
- Acne
- Decreased breast size
- Enlarged clitoris
- Long-term effects of steroid use on reproductive function remain unknown.
**\(\beta_2\)-Adrenergic Agonists**

- Popular due to their purported tissue-building, fat-reducing benefits
- Do not produce the androgenic side effects of anabolic steroids
- Clenbuterol facilitates responsiveness of adrenergic receptors to circulating epinephrine, norepinephrine, and other adrenergic amines.
β₂-Adrenergic Agonists: Negative Effects

- In rats, clenbuterol:
  - Hastened fatigue during short-term, intense muscle actions
  - Resulted in cellular deformities
  - Inhibited the longitudinal growth of bones
  - Caused acceleration of epiphyseal closure in the bones of growing animals
  - Changed the heart’s structural dimensions
  - Caused the aorta to enlarge
Human Growth Hormone (GH)

- Also known as somatotropin
- Stimulates bone and cartilage growth, enhances fatty acid oxidation, and slows glucose and amino acid breakdown
- Serious side effects:
  - Swollen feet and ankles, joint pain, carpal tunnel syndrome, and development of a diabetic or prediabetic condition
  - Gigantism and acromegaly
DHEA

- A relatively weak steroid hormone
- Synthesized from cholesterol
- Quantity produced by the body surpasses all other known steroids
- Largest concentrations in the brain
- Because it occurs naturally, the FDA has no control over its distribution or claims.
- Some believe supplementing with DHEA blunts the negative effects of aging.
Claims for DHEA:

- Blunts aging
- Facilitates weight loss
- Boosts immune function
- Inhibits development of Alzheimer's Disease
- Protects against heart disease
- Retains and even increases muscle mass

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Androstenedione

- Physically active individuals use this supplement because they believe it:
  - Directly stimulates endogenous testosterone production or forms androgen-like derivatives
  - Enables them to train harder, build muscle mass, and repair injury more rapidly
- Found naturally in meat and extracts of some plants
- Aids the liver in synthesizing other biologically active steroid hormones
Eight Research Findings Concerning Androstenedione

- Little or no elevation of plasma testosterone concentrations
- No favorable effect on muscle mass
- No favorable effect on muscular performance
- No favorable alterations in body composition
- Elevates a variety of estrogen subfractions
- No favorable effects on muscle protein synthesis or tissue anabolism
- Impairs the blood lipid profile in apparently healthy men
- Increases likelihood of testing positive for steroid use
Amphetamines

- Stimulate the central nervous system
- Effects mimic actions of the sympathetic hormones epinephrine and norepinephrine
- Increase blood pressure, pulse rate, cardiac output, breathing rate, metabolism, and blood sugar
- Increase alertness and wakefulness and augment work capacity by depressing sensations of muscle fatigue
Dangers of Amphetamines

- Chronic use leads to physiologic or emotional drug dependency.
- General side effects include headache, tremulousness, agitation, insomnia, nausea, dizziness, and confusion.
- Taking larger doses eventually requires more drug to achieve the same effect.
- The drugs suppress normal mechanisms for perceiving and responding to pain, fatigue, or heat stress.
- Prolonged intake of high doses produces weight loss, paranoia, psychosis, repetitive compulsive behavior, and nerve damage.
Caffeine

- Can be used as a drug, food, or dietary supplement
- Most widely consumed behaviorally active substance in the world
- Sixty-three plant species contain caffeine in their leaves, seeds, or fruits.
- Intestinal tract absorbs caffeine rapidly.
- Extends endurance in strenuous aerobic exercise under laboratory and field conditions, as it also does in shorter duration maximal effort
Caffeine’s Mechanism for Ergogenic Action

- Results from the facilitated use of fat as an exercise fuel
- Spares limited glycogen reserves
- Acts in either of two ways:
  - Directly on adipose and peripheral vascular tissues
  - Indirectly from stimulating epinephrine release by the adrenal medulla
Warnings about Caffeine

- Effects become less apparent when someone:
  - Consumes a high-carbohydrate diet
  - Uses caffeine habitually

- Can cause restlessness, headaches, insomnia, nervous irritability, muscle twitching, tremulousness, psychomotor agitation, and elevated heart rate and blood pressure and trigger premature left ventricular contractions

- Acts as a diuretic
Ginseng

- Used in Asian medicine to prolong life, strengthen and restore sexual functions, and invigorate the body
- Serves no recognized medical use in the United States except as a soothing agent in skin ointments
- Commercial ginseng root preparations generally take the form of powder, liquid, tablets, or capsules.
- A common claim is that Ginseng boosts energy and diminishes the negative effects of overall stress on the body.
Ephedrine

- FDA banned ephedrine in April of 2004.
- Amphetamine-like alkaloid compound
- Has been used to treat asthma, symptoms of the common cold, hypotension, and urinary incontinence and as a central stimulant to treat depression
- Exerts both central and peripheral effects
Ephedrine Side Effects

- Increased heart rate, cardiac output, and blood pressure
- Bronchodilation in the lungs
- High doses: hypertension, insomnia, hyperthermia, and cardiac arrhythmias
- Other possible side effects include dizziness, restlessness, anxiety, irritability, personality changes, gastrointestinal symptoms, and difficulty concentrating.
Alcohol

- Adolescents and adults and athletes and nonathletes abuse alcohol more than any other drug in the United States.
- Some have argued that alcohol before competition reduces tension and anxiety, enhances self-confidence, and promotes aggressiveness.
- Research does not substantiate any ergogenic effect of alcohol on muscular strength, short-term anaerobic power, or longer term aerobic activities.
Alcohol Side Effects

- Produces generalized central nervous system depression
- Impairs balance, hand-eye coordination, reaction time, and overall need to process information rapidly
- Impairs cardiac function
- Alcohol exaggerates the dehydrating effect of exercise in a warm environment.
- Acts as a potent diuretic
Buffering Solutions

- Increased acidity inhibits the energy transfer and contractile capabilities of active muscle fibers.
- Maintaining high levels of extracellular bicarbonate rapidly releases H\(^+\) from the cells and delays the onset of intracellular acidosis.
- Increasing bicarbonate (alkaline) reserves might enhance anaerobic exercise performance.
- No ergogenic effect emerges for typical resistance training exercises.
<table>
<thead>
<tr>
<th>Trial</th>
<th>Total work (kJ)</th>
<th>Peak power (W)</th>
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<tbody>
<tr>
<td>Control</td>
<td>24.6</td>
<td>728.6</td>
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<tr>
<td>Placebo</td>
<td>24.5</td>
<td>727.2</td>
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<tr>
<td>Bicarbonate</td>
<td>26.9*</td>
<td>769.4*</td>
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</tbody>
</table>

*Significantly higher than either control or placebo

![Graph showing blood lactate concentration over time](image)
Phosphate Loading

- Rationale for supplementation focuses on increasing the levels of extracellular and intracellular phosphate.
- Phosphate loading may:
  - Increase the potential for ATP phosphorylation
  - Increase aerobic exercise performance and myocardial functional capacity
  - Augment peripheral oxygen extraction in muscle tissue by stimulating red blood cell glycolysis
Glutamine

- A nonessential amino acid
- Accounts for more than one-half of the muscles’ free amino acid pool
- Counteracts the decline in protein synthesis and muscle wasting from repeated glucocorticoid use
- Modulates glucose homeostasis during and after exercise
- Plays an important role in normal immune function
Phosphatidylserine

- Part of the structural components of biologic membranes, particularly the internal layer of the plasma membrane that surrounds all cells
- Might modify the neuroendocrine response to stress
- The physiologic mechanism for any ergogenic effect remains unknown.
β-Hydroxy-β-Methylbuterate (HMB)

- A bioactive metabolite generated from the breakdown of the essential branched-chain amino acid leucine
- May decrease protein loss during stress by inhibiting protein catabolism
- Increases fatty acid oxidation
- The mechanism for HMB’s action on muscle metabolism, strength improvement, and body composition remains unknown.
Hormonal Blood Boosting

- Some athletes use recombinant epoetin (EPO), a synthetic form of erythropoietin.
- Regulates red blood cell production within the marrow of the long bones
- Can result in dangerously high hematocrit levels causing an increased likelihood for stroke, heart attack, heart failure, and pulmonary edema
- Hematocrit levels are being tested in some competitive sports.