Lecture 4: Protein, Ergogenic Aids, Water, Electrolytes, and Hydration in Sports Nutrition
Course: Introduction to Sports Nutrition: Fuel for Fitness

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Objectives

- **To gain an understanding of the role Proteins play in the body**
  1. To understand the functions of protein.
  2. Be able to state dietary guidelines for protein.
  3. To be able to explain proteins effects on performance.
  4. To explain how creatine and carbohydrates work as an ergogenic aid.
  5. To be able to state the pros and cons of creatine.
  6. To understand the effectiveness of specific ergogenic aids.
- **To gain a basic understanding of Water, Electrolytes and Hydration in Sports Nutrition**

Outline

- Proteins
  - Functions
  - Diet Needs
  - Safety
  - Supplements
  - Effects on Performance
  - Creatine
  - Branched Chain Amino Acids
  - Glutamine
  - Chondriotin and Glucosamine
- Water, Key Electrolytes and Hydration

Protein

Proteins

- Composed of C, O, H, **N**
- Basic unit is amino acid
- Make up bones, muscles, other tissues, and components
- (9) Essential amino acid
- (11) Nonessential amino acid
- Energy yielding (4 kcal /gm)

Protein = PRO

- AA are the building block of proteins
- 22 different AA
- Third source of “E” for the body
- NOT a major or direct source of energy
- PRO must be broken down by the liver to produce glucose
- Body conserves them b/c of their key role in nutrition

Protein *

- Amino acids are the basic component of proteins
- AA contain nitrogen which build tissue
- Essential (E-AA) vs. Non Essential AA (NE-AA)
  - Essential: body not can make
  - Nonessential: body can make
- Protein sources that contain all essential: include meats, milk products, eggs, soybean, and wheat germ
- Beans, grains, vegetables may contain some EAA but may be missing one or more.

Protein

- Amino acids made up of:
  - Carbon, hydrogen, oxygen, and nitrogen
- Essential Amino Acids
  - 9 of them
    - Histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, valine
  - Must be supplied by the diet
- Nonessential Amino acids
  - Formed in the body
  - Alanine, arginine, asparagine, aspartic acid, cysteine, glutamic acid, glutamine, glycine, proline, serine, tyrosine

Protein *

- Animal protein
  - A complete protein
  - Contains all essential amino acids
  - Protein supplements - made from milk, egg, whey
- Plant protein
  - Proteins exist in smaller concentrations in plant foods
  - With proper combinations can get all protein and amino acids necessary for growth and development

Protein a Minor Source of Fuel

- During rest and low/moderate exercise
  - Provides 2%-5% of energy needs
- During endurance exercise
  - Provides 10%-15% of energy needs
- Branched-chain amino acids provide most of the energy
- Resistance exercise uses protein less
- Average diet *
  - Provides ample amount of these amino acids
  - Supplements not needed

Protein

- To maintain lean body mass need to have adequate protein and CHO calories.
- Protein sparing - CHO calories used for energy, which spares protein as an energy source
- Athletes often use protein supplements for muscle growth and repair, *mostly not indicated*.
- Sports anemia - when body uses protein to synthesize oxidative enzymes and mitochondria at the expense of hemoglobin formation

Proteins and Exercise

- When body stores of glycogen and glucose are low, protein can be used during exercise to provide energy directly into the muscle.
- Low carb diet - relies on protein for energy source
- High intensity and/or endurance exercise - loss of protein in urine, sweat

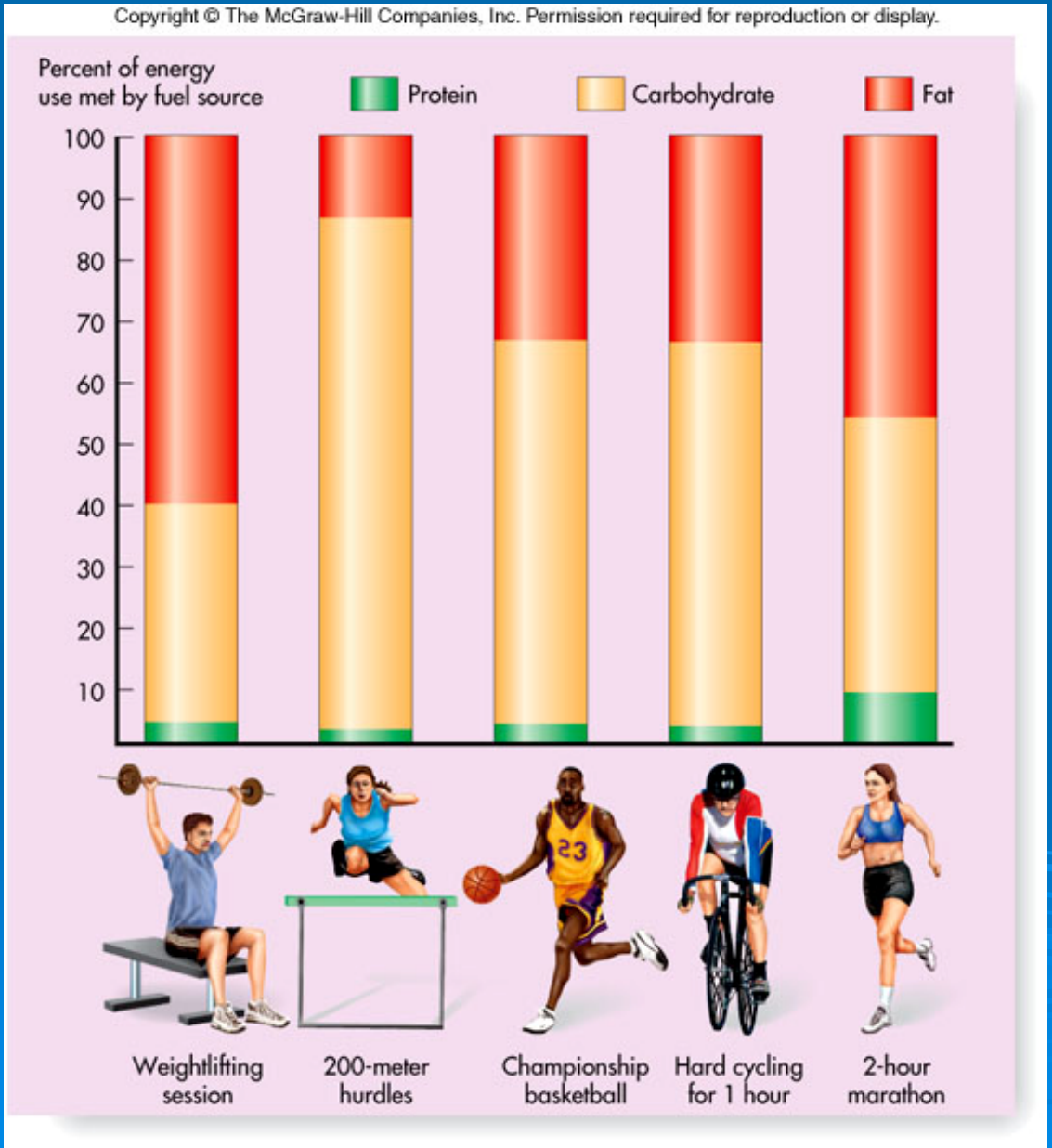
Protein

- Athletes who need to gain muscle tissue need an adequate supply of dietary protein to created a positive protein balance
- Branched Chain Amino Acids (BCAA)
  - Leucine, isoleucine, valine
- Proteins help transport nutrients into the body cells

Protein and Exercise

- Aerobic
  - Leucine is the primary BCAA in the muscle that is oxidized during exercise
  - Leucine balance returns after 24 hours
- Resistance
  - Protein breakdown in exercised muscles
  - 24-48 hours to recover (protein anabolism)
- Eccentric Exercise
  - Running downhill puts stress on muscle tissue
  - Whole body protein breakdown is increased

Fuel Use During Physical Activity



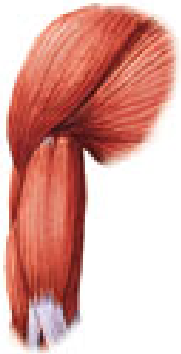
Exercise

Short-term and prolonged exercise

During exercise, sympathetic stimulation increases epinephrine and glucagon secretion and inhibits insulin secretion.

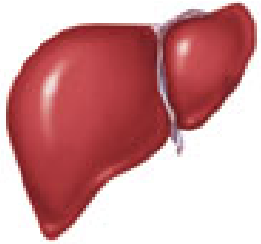
Prolonged exercise

During prolonged exercise, both GH and cortisol secretion increase.



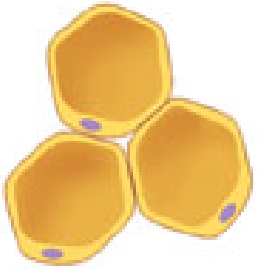
Muscle

Epinephrine increases the rate at which glycogen in muscle cells is used so that the cells do not take up as much glucose from the blood.



Liver

Epinephrine and glucagon increase glycogen breakdown in the liver, resulting in the release of glucose into the circulatory system.



Adipose tissue

Epinephrine and sympathetic stimulation also increase the breakdown of fat and the release of fatty acids from adipose tissue.

Cortisol increases protein breakdown to amino acids and increases glucose synthesis from amino acids and from some components of fat such as glycerol.

Cortisol increases the breakdown of fats and the use of fatty acids as an energy source in tissues.

GH slows the breakdown of proteins and conserves them.

Circulation

Blood glucose levels are maintained for normal nervous system function.

PRO Combination Myth *

- Mixing proteins to get a complete protein at one meal is not necessary
- Your body has a constant amino acid pool or turn over
- You can eat peanut butter for breakfast and bread for dinner and still get the essential amino acids you need

Protein

- Physiological functions
  - Protein forms the structural basis of muscle tissue
  - Protein is the major component of most enzymes in the muscle
  - Protein can serve as a source of energy during exercise
- Protein supplements are marketed to improve athletic performance
  - Bodybuilders and strength-type athletes
  - Endurance athletes

Protein Quality

- Major reasons why animal protein is called a high-quality protein, whereas plant protein is of lower quality
  - Animal protein is a complete protein because it contains all the essential amino acids
  - It contains the essential amino acids in larger amounts and in the proper proportion
- Plant proteins may provide you with all the protein and amino acids you need for optimal growth and development
  - Plant foods may be eaten in a variety throughout the day to give a balanced supply of amino acids
  - Soybean protein is comparable to animal protein

Rec'd amount of Protein

- The RDA for protein varies in different stages of the life cycle
    a. 0-0.5 years: 1 gm/lb
    b. 0.5-1 years: 0.71 gm/lb
    c. 1-6 years: 0.56 gm/lb
    d. 7-14 years: 0.45 gm/lb
    e. 15-18 years: 0.41 gm/lb
    f. 19+ years: 0.36 gm/lb

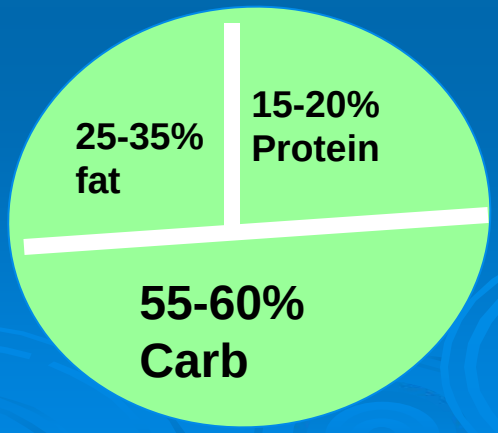
Protein Needs

- Recommend 1.0 - 1.6 gm protein/kg body weight
- Up to 1.7 gm/kg body weight for athletes beginning strength training (some resources up to 1.8 gm/kg)
- Needs are easily met by a normal diet
  - Protein supplements are not necessary
  - Excessive protein has not been shown to be beneficial

Recommended protein intake for intermittent high-intensity activities is 1.4-1.7 gm/kg

Protein Calories

- About 12-15 percent of the total daily caloric intake should be dietary protein
- 10-15 percent of the total protein requirement should consist of the essential amino acids for the average adult



Protein Needs

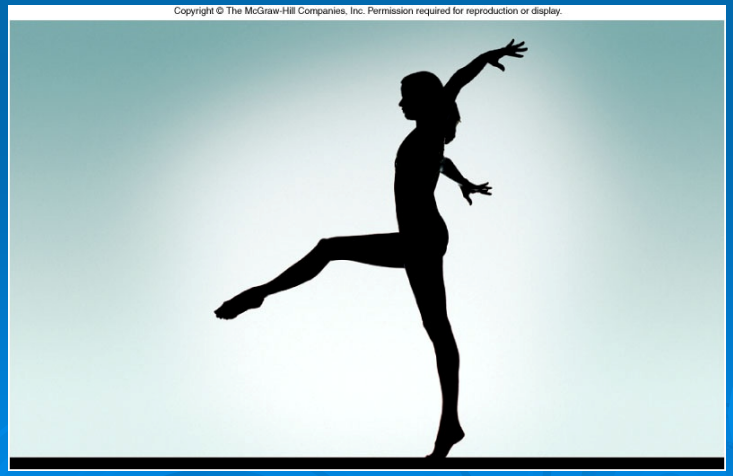
- Consume protein w/ CHO before and after workout
- Some athletes may need more protein than others depending on the type of sport
  - Gymnastics vs. Swimming vs. Ultraendurance athletes

Dietary Guidelines to Insure Adequate Protein Intake

- Eat a variety of animal and plant foods
- The 56-grams protein requirement for an adult male can be met by 45 grams of animal protein
- The same requirement would necessitate 65 grams of plant protein
- Combine plant products properly, legumes and grains, to receive all the essential amino acids – can be consumed throughout the day, not at one meal
- A mixture of 30 percent animal protein and 70 percent plant protein would be similar to the use of animal protein alone

Protein

- Protein can be formed from carbohydrates and fats, but it needs nitrogen present to do so.
- Nitrogen comes from protein



Protein Safety

- Excess protein is converted to CHO or fat
- Excess nitrogen ---> urea excreted by kidneys
- High protein diet - excessive production by ketones ---> can stress liver or kidneys
- Careful with dehydration
- Adequate amino acids can be obtained from the diet so there is still a question about the ergogenic effectiveness and health implications of supplementation with individual amino acids

Proteins and Exercise

- Protein appears to be a relatively minor source of energy and accounts for less than 5 percent of the total energy cost of the activity
- In the latter stage of prolonged endurance exercise, protein could contribute up to 15 percent of the total energy cost
- A brief session of exercise lowers the rate of protein synthesis and speeds protein breakdown

Proteins and Exercise

- Amino acids can be utilized during exercise to provide energy
  - Directly in the muscle
  - Via glucose produced in the liver
- Adequate carbohydrate intake before and during prolonged exercise will help reduce the use of body protein

Exercise Increases Protein Losses in Other Ways

- Exercise causes an elevated level of protein in the urine
  - The greater the intensity, the greater the protein loss
  - Total loss amounts to less than 3 grams per day
- Protein may be lost in the sweat (1 gram per liter of sweat in adult males)
- Protein metabolism during recovery after exercise
  - Protein synthesis is believed to predominate during the recovery period
  - Protein anabolism appears to predominate 24-48 hours after resistance exercise
- Following eccentric exercise, whole body protein breakdown is increased *(eccentric method: means the muscle is lengthening even though it is trying to shorten, for example in the down phase of the pull-up the biceps is now contracting eccentrically as it slows your rate of decent. Gravity is trying to pull you down, but your biceps are resisting.*

The Effect of Exercise Training Upon Protein Metabolism

- After resistance or endurance exercise, protein balance becomes positive
- Aerobic exercise stimulates syntheses of mitochondria and oxidative enzymes
- Resistance training promotes synthesis of the contractile muscle proteins
- Endurance training develops the potential for increased capacity for oxidation of leucine and other branched-chain amino acids, thus increasing the capacity of the muscle to derive energy from protein
- Training may decrease the production or accumulation of ammonia
- Training may help prevent muscle injury associated with eccentric exercise

Endurance-type Activities

- The use of protein as an energy source may increase during prolonged endurance exercise
- Those involved in vigorous endurance exercise are recommended to consume 1.1-1.4 g/kg/day
- Overtrained athletes should ensure adequate protein in their diets
- Female athletes may need higher values since their energy intakes are lower
- Athletes attempting to lose body weight or maintain a low weight may need more protein
- Consuming sufficient carbohydrate will decrease reliance on protein

Sports Anemia

- A normal protein intake of 1.25 g/kg would prevent its development
- It has not been shown to occur in all subjects initiating a strenuous training program, particularly in those on a balanced diet

Do Individuals In Strenuous Physical Training Need More Protein In The Diet?

- Strength-type activities
  - The current RDA may actually limit muscle growth in strength-trained individuals
  - Athletes training to increase muscle mass and strength, adolescent athletes, and those in the early stages of training should consume more protein (1.5-1.8 grams per kilogram body weight)
  - Consume additional energy, 200 more calories per day

General Recommendations Relative to Dietary Protein Intake For Athletes

- Athletes need at least the RDA of 0.8-1.0 g/kg
- Prudent recommendations
  - 1.1-1.4 g/kg for those active in aerobic exercise
  - 1.5-1.8 g/kg for those participating in strength programs
- The young athlete who wants to gain body weight through a weight-training program needs about 1.7 g/kg
- Endurance athletes need to replenish the protein that may serve as an energy source during training, approximately 1.5 g/kg

General Recommendations Relative to Dietary Protein Intake For Athletes

- Adequate energy intake, primarily in the form of carbohydrates, will improve protein balance
- The athlete should make wise selections of high-quality protein foods through a balanced diet
- The timing of protein intake may be important
- The endurance athlete needs adequate amounts of carbohydrates, as this will decrease the oxidation of amino acids and the formation of ammonia

General Recommendations Relative to Dietary Protein Intake For Athletes

- Carbohydrate provides a potent protein-sparing effect
- Protein intake should be restricted in any precompetition feedings within an hour of exercise, particularly intense exercise near 100 percent $V0_2$ max
- A carbohydrate-protein supplement after weight-training exercise may elicit hormonal responses during recovery that may be favorable to muscle growth

Are High-protein Diets or Supplements Necessary?

- Athletes in training may need more than the RDA for protein
- Supplements of intact proteins offer no advantages over protein found in other food sources
- Commercial supplements containing protein, carbohydrate, and fat may be useful adjuncts to a balanced diet
- There is little data to support an ergogenic effect of protein diets or supplements

Are High-protein Diets or Supplements Necessary?

- Strength-type activities
  - There is an absence of strong evidence that high-protein diets confer any advantage in terms of strength
  - Given the possibility of enhanced muscle repair, consuming some of the RDA following exercise may be prudent
  - It is recommended that athletes not consume protein in amounts greater than 2 g/kg

Are High-protein Diets or Supplements Necessary?

- Endurance-type activities
  - The zone diet might actually impair endurance performance
  - For weight-restricted athletes, a 30 percent protein allotment may help insure protein adequacy
  - Protein intake should be restricted within an hour of competition
  - A carbohydrate/protein drink provides no advantage in preventing muscle tissue damage over carbohydrate alone
  - There is no data to support that a protein intake of 1.1-1.4 g/kg/day will enhance sport performance

Protein Supplements

- Protein supplements have no advantage over protein found in food sources
- Canned drinks, bars, shakes, powders
- Used for convenience
- Products provide a balance of protein, CHO, and fat
- May contain vitamins and minerals

Protein Supplements: Creatine

- Creatine
  - Nitrogen containing compound - amine
  - Marketed to athletes
  - Enhances AP-PCr energy system
  - High intensity performance like speed and muscular power
  - Increase in muscle mass - may be due to water retention in the muscles
  - Improvement in anaerobic performance

Protein Supplements: Creatine

- Creatine and Safety
  - Long term studies needed – could end up finding harmful implications
  - Individuals with impaired kidney function may be at risk
  - Associated w/ GI distress - nausea, vomiting, and diarrhea
  - Dehydration and muscle cramps
  - Overdoses can be harmful
  - Strategy - 20-30 grams in 4 doses throughout the day

Creatine

- Effective supplementation protocols
  - Consume 20-30 grams in four equal doses over the course of the day
  - 3 grams per day over four weeks has been shown to be effective
- Those who have the lowest levels before supplementation will increase muscle creatine levels the most
- Combining creatine with simple carbohydrates increases creatine transport into the muscle

Creatine

- Appropriate creatine loading protocols will increase muscle total creatine
  - Free creatine
  - Phosphocreatine
- Ergogenic theory
  - Increasing creatine phosphate in the muscle will provide more substrate for generating ATP during high-intensity exercise
  - Higher levels of free creatine will help resynthesize creatine phosphate

Effect on Exercise Performance

- ATP-PCr energy system
  - Research supports a positive ergogenic effect of creatine supplementation in certain exercise endeavors, primarily characterized by repetitive, high-intensity exercise bouts with brief recovery periods
  - Additional research is needed to support its application to actual sport competition

Effect on Exercise Performance

- A beneficial effect of supplementation has been shown on osotonic strength and endurance cycle ergometer power and endurance and isometric and isokinetic tests of muscular strength, power and endurance
- 30-50 percent of studies revealed beneficial effects of creatine supplementation on field tests of anaerobic power
- Additional research is needed to support its application to actual sport competition

Creatine

- There is some evidence that creatine supplementation may be helpful in more prolonged anaerobic endurance events, but more research is needed
- There is little support that supplementation benefits exercise tasks that depend primarily on aerobic glycolysis
- Body mass
  - Will cause an increase in total body mass or lean body mass
  - Creatine supplementation may make it more difficult for weight-control athletes to lose weight for competition

Are Amino Acid, Amine, And Related Nitrogen-containing Supplements Effective Ergogenic Aids?

- Individual amino acid supplements may induce specific physiological responses in the body
  - Formation of certain chemicals in the brain needed for nerve impulse transmission
  - Secretion of hormones
- Consumption of specific amino acid mixtures or even high-protein diets may actually lead to nutritional imbalances

Findings Regarding Specific Amino Acids or Various Combinations

- Currently, there are no sound data supporting an ergogenic effect of arginine, ornithine, or lysine supplementation as a means to enhance muscular development, strength, or power via increased secretion of HGH
- No data to support an ergogenic effect of isolated arginine supplementation on aerobic endurance in healthy individuals
- Data indicates tryptophan does not appear to be an effective ergogenic in either short term or prolonged exercise tasks

Protein Supplements

- Arginine, lysine, ornithine
  - May lead to Human Growth Hormone release
- Tryptophan
  - Not an effective ergogenic in short term or prolonged exercise
- BCAA
  - No significant effect on exercise

Branched-Chain Amino Acids (BCAA)

- BCAA supplementation appears to have no ergogenic or ergolytic effect on exercise performance
- Carbohydrate appears to be the preferential fuel to consume before and during prolonged intermittent and continuous endurance exercise tasks
- Chronic BCAA supplementation might be effective as a means to help lose body fat and retain exercise performance, but more research is needed before recommending
- More research is needed on effects of BCAA supplementation and mental performance and psychological perception of effort

Balanced Diet is Best

- A balanced diet containing 12-15 percent of the Calories as protein will provide amounts of the individual amino acids necessary even for those who exercise extensively
- No data supporting advantage of oral consumption of amino acid supplements are more effective than amino acids consumed as natural components of food

Table 11-8 (*continued*)

Substance/Practice	Rationale	Reality
Growth hormone	Increase muscle mass	At critical ages may increase height; may also cause uncontrolled growth of the heart and other internal organs and even death; potentially dangerous; requires careful monitoring by a physician. Use of needles for injections adds further health risk. Banned by the International Olympic Committee.
Blood doping	To enhance aerobic capacity by injecting red blood cells harvested previously from the athlete, or alternately the athlete may use the hormone erythropoietin (Epogen) to increase red blood cell number	May offer aerobic benefit; very serious health consequences are possible, including thickening of the blood, which puts extra strain on the heart; is an illegal practice under Olympic guidelines.
Gamma hydroxybutyric acid (GHB)	Promoted as a steroid alternative for bodybuilding	FDA has never approved it for sale as a medical product; is illegal to produce or sell GHB in the United States. GHB-related symptoms include vomiting, dizziness, tremors, and seizures. Many victims have required hospitalization, and some have died. Clandestine laboratories produced virtually all of the chemical accounting for GHB abuse. FDA is working with the U.S. Attorney's office to arrest, indict, and convict individuals responsible for the illegal operations.

Substances that are promoted to athletes but have yet to show any clear ergogenic effects include pyruvic acid (pyruvate), glycerol, ribose, medium chain triglycerides, L-carnitine, conjugated linoleic acid (CLA), bovine colostrum, insulin, and amino acids not already mentioned in this section. Any use of these products is not recommended at this time. Note that these substances are defined in the glossary.

Glutamine

- Glutamine is a major means for removing excess amino groups from the muscle, delivering them to the kidney
- No studies have researched an anabolic effect of glutamine supplementation in healthy athletes
- Limited data is conflicting on muscle glycogen resynthesis following muscle glycogen depletion
- Plasma glutamine levels are decreased in athletes who participate in sport activities predisposing to overtraining
- Research provides conflicting data regarding the beneficial effects of glutamine supplementation on lymphocyte function
- Glutamine has potential utility as a dietary supplement for athletes engaged in heavy exercise training, but more data is needed

Glucosamine and Chondroitin Sulphate

- Supplements of glucosamine and chondroitin sulphate are frequently taken either separately or in combination in the belief that they maintain joint health and/or have therapeutic benefits for those suffering from arthritic disease.
- These substances are compounds that are normally present and synthesized in the body and are concentrated in cartilage.
- It is suggested that they may be 'chondroprotective', they reduce the breakdown of cartilage that is a feature of arthritic conditions. They may also have anti-inflammatory effects.

Chondriotin and Glucosamine

- Marketed to promote healthy joints in individuals who exercise
- Both may be synthesized in the body and are found in cartilage
- Studies found that chondroitin and/or glucosamine supplementation relieved pain and improved mobility better than a placebo

Chondriotin and Glucosamine

- No data that these supplements will prevent the development of joint pain or osteoarthritis in young, healthy athletes
- Tufts University recommendations
  - Supplements are believed to be safe, but may cause mild side effects
  - There may be some complications
  - A reasonable dose would be 1,500 mg of glucosamine and 1,200 mg of chondroitin daily for 2-4 months
  - Purity, safety and effectiveness are not guaranteed

Caffeine

- Caffeine negates the potential ergogenic effect of creatine
- Safety issues
  - Long term effects need to be studied
  - Individuals with impaired kidney function may be at risk
  - Consuming a large dose before an event may cause problems
  - Creatine supplementation may enhance performance in events where the amount of PCr may be a limiting factor

HMB/Choline/Inosine

- There is little evidence to support HMB supplementation as an anabolic agent for strength-trained individuals
- Research results are equivocal on choline
- Studies have revealed no ergogenic effect of inosine on aerobic endurance, but a possible decrement to performance

Review of Ergogenic Aids

- Additional research is merited with several amino acids
  - Aspartic acid salts
  - BCAA
- Creatine is effective for repetitive high-intensity, short-duration exercise tasks
- Research findings regarding the ergogenic effect of choline and HMB are ambiguous
- Inosine appears to be an ineffectual ergogenic aid

Does Excessive Protein Intake Pose Any Health Risks?

- The National Research Council recommends that individuals consume no more than twice the RDA
- The ratio of animal: plant protein for most Americans is 70:30; it would be more healthful if reversed (30:70)
- Protein in many foods is often accompanied by substantial quantities of saturated fat and cholesterol
- Increased consumption of charred meat has been associated with increased levels of cancer
- Incorporate soy foods within the diet in moderation for their health benefits

Does Excessive Protein Intake Pose Any Health Risks?

- Individuals with a personal or family history of liver or kidney problems may be susceptible to adverse reactions from excessive dietary protein
- Dehydration could occur from excessive fluid losses
- Gout may be aggravated by high-protein diets containing substantial quantities of purines, which are metabolized to uric acid that may accumulate in the joints and cause inflammation
- Individuals on a high-animal protein and low-calcium diet may be susceptible to bone fractures

Does The Consumption Of Individual Amino Acids Pose Any Health Risks?

- Amino acids taken in large doses are essentially drugs with unknown effects
- Excessive reliance on free-form amino acids may lead to a diet deficient in key vitamins and minerals
- Amino acids may interfere with the absorption of other essential amino acids; suppress appetite and food intake; precipitate tissue damage; contribute to kidney failure; lead to osteoporosis; cause gastrointestinal distress such as nausea, vomiting, and diarrhea; or create unfavorable psychological changes

Does the Consumption of Individual Amino Acids Pose Any Health Risks?

- There is little scientific support for use of amino acid supplements for their stated purposes and safety levels have not been established
- There are inadequate scientific data to support either an ergogenic or a health benefit of supplementation with individual amino acids in the apparently healthy individual

Water & Electrolyte Summary of Key Points

Water

- Intracellular water - inside the cells
- Extracellular water - outside the cells
- Intercellular water - between the cells
- Intravascular water - within the blood vessels
- Male - 60% body wt
- Female - 50% body wt
- Fat tissue - low in body water
- Muscle tissue - high in body water

Fluid Needs

- Needs of average adults
  - 9 cups per day for women
  - 13 cups per day for men
- Athletes need more
- Maintenance of body's cooling system
  - Water helps dissipate heat from working muscles
- Avoid losing more than 2% of body weight during exercise

Hydration

- Thirst: Not reliable indicator of fluid needs
- General guidelines:
  - Drink 3 C of fluids per each pound of weight loss during activity
  - Check urine color
  - Drink fluid freely 24 hours before event
  - Drink 1 ½ -2 ½ C two-three hours before event
  - Consume ½ - 1 ½ C every 15 minutes for events lasting longer than 30 min.
  - Lose no more than 2% of body weight

Hydration

- Skin Wetting
  - Wetting skin with sponge or spray bottle reduces sweat loss
  - Cools skin
- Hyperhydration
  - Drink lots of fluids before competition
- Rehydration
  - Replenish fluid loss

Electrolytes

- An electrolyte, in solution, conducts an electric current - like a nerve impulse
- Acids, bases, and salts
- Carry a positive or negative charge
- Sodium, chloride, potassium

Acids, Bases, And Salts Are Common Electrolytes

- The major electrolytes in the body fluids
  a. Sodium
  b. Potassium
  c. Chloride
  d. Bicarbonate
  e. Sulfate
  f. Magnesium
  g. Calcium

Electrolyte Functions in The Body

- They can act at the cell membrane and generate electrical current, such as in a nerve impulse
- They can activate enzymes to control a variety of metabolic activities in the cell

Sodium (Na)

- One of the principle positive ions in the body fluids
- Estimated minimum requirements for adults, 500 milligrams
- DV is 2.4 grams

Sodium

- + ion
- Adequate intake - 1500 mg
- Nerve impulse conduction
- Muscle contraction
- Acid-base balance
- Deficiency - hyponatremia; muscle cramps, loss of appetite, seizures
- Excess - hypertension

Sodium and Exercise

- Sodium concentration increases in the blood during exercise
  - This helps to maintain blood volume
  - Exercise leads to increased secretion of ADH and aldosterone, which helps conserve body water and sodium supplies

Sodium Deficiency

- Deficiency states due to inadequate dietary intake are not common
- Prolonged sweating while exercising in the heat may lead to short-term deficiencies that may be debilitating to the athletic individual
- During events over hydration can cause hyponatremia

Potassium

- + ion
- Adequate intake - 4700 mg
- In intracellular fluid
- Glucose transport into cell
- Deficiency - hypokalemia, loss of appetite, muscle cramps, apathy (rare)
- Excess - hyperkalemia

Potassium

- Excessive potassium may disturb electrical impulses, causing cardiac arrhythmias and possible death
- A potassium deficiency could adversely affect physical performance capacity but is very rare

Chloride

- Negative ion
- Nerve impulse conduction
- HCL - forms in stomach
- Deficiency - rare or caused by vomiting
- Excess - hypertension

Sports Drinks

- Glucose electrolyte solutions
  - Fluid and CHO replacement
  - CHOs - glucose, fructose, sucrose, glucose polymers and some major electrolytes
  - Accelerade, All-Sport, Gatorade, and PowerAde

Sports Drinks

- Glucose-polymer solutions
  - Provide CHOs while decreasing the osmotic concentration of the solution to minimize the effect of gastric emptying
  - Common ingredient - Maltodextrin
  - Common brand - Ultima

Sports Drinks for Endurance Exercise

- Recommended for activity > 60 minutes
  - Help maintain blood glucose level and blood volume
  - Delay “bonking”
- Supply electrolytes
- <60 minutes
  - Nutrients are easily replaced by diet

Gels and Bars

- Provide additional fuel
- Should be taken with fluids
- Expensive source of nutrients
- Ideal bars for endurance athletes
  - Contain 40 gm carbohydrate, 10 gm of protein, 4 gm fat, 5 gm of fiber
  - Fortified with vitamins and minerals
  - Toxicities possible with overuse

Table 11-6 Calorie and Macronutrient Contents of Popular Energy Bars and Gels

Product	Calories (kcal)	Carbohydrates (grams)	Protein (grams)	Fat (grams)
PowerBar Performance (chocolate)	230	45	10	2
PowerBar ProteinPlus (cookies & cream)	230	38	24	5
PowerBar PowerGel (lemon lime)	110	28	0	0
Luna Bar (cherry-covered chocolate)	180	28	10	4
Clif Bar (chocolate chip)	250	45	10	5
Clif Shot (viva vanilla)	100	24	0	0
Balance Bar (chocolate)	200	22	14	6
Balance Satisfaction (chocolate crisp)	280	47	12	6
Boulder Bar (chocolate)	210	42	10	4

Overall, choosing energy bars is preferable to choosing candy bars and packaged cakes. When used in sports situations, energy bars can be handy. Better yet, however, is to eat a variety of wholesome foods; these offer more health-protective compounds. This is also a less expensive choice, especially for day-to-day snacking. An additional concern is that micronutrient toxicity might occur if numerous bars are eaten in a day, as many are highly fortified. Vitamin A and iron are two nutrients of special concern in this regard.

Hyperhydration

- Excessive intake of water
- Intake without sodium and chloride
- During prolonged low-intensity activities
- Results in low blood sodium and low blood chloride

How Much Water Do You Need Per Day?

- The average adult needs about 1 milliliter of water per Calorie of energy intake
  a. Adult male, 3 quarts
  b. Adult female, 2 quarts

Water Weight

- Average adult male, 60 percent of body weight
- Average adult female, 50 percent of body weight
- May be as low as 40 percent in obese individuals and as high as 70 percent or more in muscular ones

Hyperthermia

- One of the major factors limiting physical performance
- One of the most dangerous factors

Hyperthermia

- When dehydration or hyperthermia is the major threat to performance, water replacement is the primary consideration
- In prolonged endurance events, carbohydrate replacement may help improve performance
- In very prolonged exercise in the heat with heavy sweat losses, electrolyte replacement may be essential to prevent heat injury
- The effects of involuntary dehydration are most severe in aerobic endurance performance

Heat Stress Indicators

- Guidelines for taking these four factors into consideration: heat stress indicators
  - WBGT Index
  - Heat index

The Effects of Involuntary Dehydration are Most Severe in Aerobic Endurance Performance

- Hypohydration of less than 2 percent of body weight usually will lead to decrements in performance
- The deterioration appears related to adverse effects on cardiovascular functions and temperature regulation
- Maximal aerobic power decreases by 4-8 percent with a 3 percent weight loss during exercise in a neutral environment

The Effects of Involuntary Dehydration are Most Severe in Aerobic Endurance Performance

- Dehydration may be a factor in the onset of gastrointestinal distress (GI)
- Other factors contributing to suboptimal performance
  - Disturbed fluid and electrolyte balance in the muscle cells
  - Adverse effects of hyperthermia upon mental processes contributing to central fatigue

Heat Exhaustion

- Heat stress causes depletion of blood volume due to fluid loss
- Body heat is dissipated through evaporation of sweat (fluid)
- Fluid loss (sweat): ~3-8 C per hour
- Humidity interferes with sweat production
- Dehydration decreases endurance, strength, performance
- Signs: Profuse sweating, headache, dizziness, nausea, weakness, visual disturbances

Heat Cramps

- Frequent complication of heat exhaustion
  - Exercising in heat
  - Significant sweating
  - Consuming water without sodium
- Painful muscle contractions
  - 1-3 minutes at a time
- Ensure adequate salt and fluid intake
- Exercise moderately at first in the heat

Heat Stroke

- High blood flow to working muscles
  - Overloads body's cooling system
  - Sweating ceases
  - Internal body temperature reaches 104º F
  - Fatality rate high
- Symptoms:
  - Nausea, confusion, irritability, poor coordination, seizures, coma
- Replace fluids
- Monitor weight change (fluid loss)
- Avoid exercising in hot humid conditions

What are the Symptoms and Treatment of Heat Injuries

- Symptoms of impending heat injury are variable
  - (1) Weakness
  - (2) Feeling of chills
  - (3) Piloerection
  - (4) Nausea
  - (5) Headache
  - (6) Faintness
  - (7) Disorientation
  - (8) Muscle cramping
  - (9) Cessation of sweating
- Continuing to exercise in a warm environment when experiencing any of these symptoms may lead to heat injury

How Fast May an Individual Dehydrate While Exercising?

- Maximal sweat rate for a trained athlete is about 2-3 liters per hour
- 150-pound runner could lose 3 percent of their weight in 1 hour
- Football players may lose 11-13 pounds over a day with multiple daily workouts
- There are age and gender differences in sweating
- Excessive dehydration may not only impair one's physical performance, but possibly one's health

Sweat

- The major electrolytes found in sweat
  - Sodium
  - Chloride
- Other minerals lost in small amounts
  - Potassium
  - Magnesium
  - Calcium
  - Iron
  - Copper
  - Zinc

Sweat

- Small quantities are present in sweat, but are easily restored with a balanced diet
- Nitrogen
- Amino acids
- Water-soluble vitamins

Sweat

- If the electrolytes are not replaced daily, a deficiency may occur over time
  - Prolonged sweating has been shown to decrease the body content of sodium and chloride by 5-7 percent
  - Potassium levels dropped about 1 percent

Which Is Most Important to Replace During Exercise — Water, Electrolytes, or Carbohydrate?

- Fluid replacement preparations
  - Glucose-electrolyte solutions (GES)
    - Ingredients
      - Water
      - Carbohydrates; glucose, glucose polymers, sucrose, or fructose
      - Major electrolytes
        - Sodium
        - Chloride
        - Potassium
        - Phosphorus

Glucose Polymer and Electrolytes

- Glucose-polymer solutions provide carbohydrates while decreasing the osmotic concentration of the solution to help minimize the effect upon gastric emptying
  - Water
  - Carbohydrate
  - Electrolytes

Does Skin Wetting Help Improve Performance When Exercising in the Heat?

- Wetting techniques have been shown to decrease sweat loss
- They have not been shown to cause any major reductions in core temperature or cardiovascular responses
- Some researchers theorize that these techniques may be potentially harmful

Does Rehydration Improve Performance When Exercising in the Heat?

- It is the most effective way to enhance performance
- Wrestling studies
  - Some studies show no effect of rehydration was found
  - Some studies reported partial improvement in endurance performance after rehydration
  - Rehydration is recommended for wrestlers

Fluid Ingestion During Prolonged Endurance Exercise

- Rehydration minimizes the rise in core temperature
- It reduces stress on the cardiovascular system by minimizing the decrease in blood volume
- It helps maintain an optimal race pace for a longer period
- Water ingested during exercise may appear in plasma and sweat within 10-20 minutes

What Environmental Conditions May Predispose An Athletic Individual To Hyperthermia?

- Environmental factors that are important determinants of the heat stress imposed on an active individual
  - Air temperature, 80 F or above
  - Relative humidity
    - With humidity levels from 90-100 percent, heat loss via evaporation nears zero
    - Caution should be used when the relative humidity exceeds 50-60 percent, especially with warmer temperatures
- Air movement
- Radiation

How Should Carbohydrate Be Replaced During Exercise in the Heat?

- Types of fluid available to replace carbohydrate and water
  - Glucose-electrolyte solutions (GES)
  - Glucose polymer solutions (GPS)
- Recent research suggests that an appropriate amount of carbohydrate in solution may maintain body temperature as effectively as water, and help improve performance during prolonged exercise

General Findings Relative to GES and GPS Intake During Prolonged Exercise Under Warm Conditions

- GES and GPS solutions between 5 to 10 percent seem to empty from the stomach as effectively as water
- They may also be absorbed more readily from the intestinal tract
- GES and GPS seem to be equally effective
- Solutions higher than 10-12 percent may significantly delay gastric emptying and possibly cause gastrointestinal distress
- Sports drinks containing carbohydrate as an energy source are more effective than plain water in improving prolonged endurance performance

Electrolyte Replacement During Most Exercise is Not Necessary

- During very prolonged bouts of physical activity, electrolyte replacement may be necessary
  - Types of activities
    (1) Marathons
    (2) Ultramarathons
    (3) Ironman-type triathlons
    (4) All-day tournaments

Hyponatremia & Electrolyte Replacement

- Symptoms: Epileptic-like seizures, Death
- A solution with small amounts of salt may be recommended to prevent the development of hyponatremia in prolonged exercise events
- Athletes involved in ultraendurance events should consume adequate salt in their diet the days before competition

Electrolyte Losses

- Heavy daily sweat losses do not lead to an electrolyte deficiency
- If electrolytes are not adequately replaced because of a poor diet, a deficiency may occur over 4-7 days of very hard training, especially in hot conditions
- Exercising individuals who experience heavy daily sweat losses need both adequate fluids and sodium to ensure adequate rehydration

Are Salt Tablets or Potassium Supplements Necessary?

In general, the use of salt tablets to replace lost electrolytes is not necessary

Oral Rehydration Solutions

- Currently, there is no general agreement on the optimal formulation of an oral rehydration solution for all individuals
- Guidelines for maintaining body fluid balance before competition
  - Be well trained and acclimated
  - Be adequately hydrated the day before and the morning of competition
  - 10-17 oz. of cold fluid 15-30 minutes before exercising
  - A 6-8 percent concentration of carbohydrate may be added
  - Minimize the consumption of alcohol the evening before and avoid caffeinated beverage 1-4 hours before competition

Guidelines for maintaining body fluid balance, improving performance in the heat, and preventing heat-related illnesses during competition

Body Fluid Balance

- Cold water, about 40-50 F (4.4-10 C) is effective when carbohydrate intake is of little or no concern
- For longer duration events, carbohydrate may provide an important source of energy
- The fluid should contain small amounts of electrolytes, 400-1,100 milligrams of sodium and 120-225 milligrams of potassium per liter
- The fluid should be palatable
- Rehydrate with 6-8 ounces of cold fluid during exercise at 10- to 15-minute intervals
- Start rehydrating early in endurance events because thirst does not develop until about 1-2 percent of body weight has been dehydrated

Glycerol

- Glycerol combined with water may be an effective ergogenic aid for prolonged exercise under warm environmental conditions
- Research regarding the effects of glycerol-induced hyperhydration, compared to water-induced hyperhydration, on body water levels are equivocal
- Research on the effects of glycerol-induced hyperhydration on performance are also equivocal

Glycerol

- Results of glycerol-induced hyperhydration may be equivocal because of methodology differences
- Glycerol supplementation may be ergolytic for some athletes
- Recommended supplementation protocol
  - Mix 36 milliliters of glycerol with 955 milliliters of water per 100 pounds of body weight
  - 150-pound runner would need to consume 1.5 quarts to hyperhydrate

Sodium Bicarbonate

- Disadvantages of sodium bicarbonate supplementation
  - Gastrointestinal distress
  - Excessive doses could lead to alkalosis

Thank You!!