Chapter 10: Nutrients, Physical Activity, and the Body’s Responses

PowerPoint Lectures for
Nutrition: Concepts and Controversies, eleventh edition
Frances Sizer and Ellie Whitney

Lectures by Judy Kaufman, Ph.D.
Fitness

Fitness depends on a certain minimum amount of **physical activity** or **exercise**.

- Exercise is a vigorous, structured, and planned type of physical activity.
- In this chapter, both words will be used interchangeably.
Benefits of Fitness

Compared with unfit people, physically fit people enjoy:

• More restful sleep
• Improved nutritional health
• Improved body composition
• Improved bone density
• Enhanced resistance to infectious diseases
• Lower risk of some cancers—too little physical activity is associated with a 30-40% increase in breast, colon, kidney, pancreatic, and uterine cancer
• Lower risk of cardiovascular disease
Benefits of Fitness

- Lower risk of type 2 diabetes
- Reduced risk of gallbladder disease (women)
- Lower incidence and severity of anxiety and depression
- Stronger self-image
- Longer life and higher quality of life in the later years
- Stronger circulation & lung function
Physical Activity Guidelines for Americans

- **Every day**—Choose an active lifestyle and engage in flexibility activities.
  Integrate activity into your day: walk a dog, take the stairs, stand up whenever possible. Stretching exercises lend flexibility for activities such as dance, but minutes spent stretching do not count toward aerobic or strength activity recommendations.

- **5 or more days/week**—Engage in moderate or vigorous aerobic activities.
  Perform a minimum of 150 min of moderate-intensity aerobic activity each week by doing activities like brisk walking or ballroom dancing; or, 75 min per week of vigorous aerobic activity, such as bicycling (>10 mph) or jumping rope; or a mix of the two (1 min vigorous activity 2 min moderate).

- **2 or more days/week**—Engage in strength activities.
  Perform muscle-strengthening activities that are moderate to high intensity and involve all major muscle groups.

- **Do seldom**—Limit sedentary activities.
  Limit TV or movie watching, leisure computer time.

*For most men and women, aged 18 to 64 years.

Physical Activity Guidelines

- Some physical activity is better than none

- **Aerobic activity**
  - makes your heart & lungs work harder than normal to deliver oxygen to tissues
  - brisk walking.... what else?

- **Resistance training**
  - develops muscle strength, power, endurance & mass

- **Intensity**
  - the degree of effort required
### Table 10-1: Guidelines for Physical Fitness for Healthy Adults, Age 18 to 65

<table>
<thead>
<tr>
<th>Type of Activity</th>
<th>Aerobic</th>
<th>Strength</th>
<th>Flexibility</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aerobic</strong></td>
<td>Aerobic activity that uses large-muscle groups and can be maintained continuously</td>
<td>Resistance activity that is performed at a controlled speed and through a full range of motion</td>
<td>Stretching activity that uses the major muscle groups</td>
</tr>
<tr>
<td><strong>Frequency</strong></td>
<td>5 to 7 days per week</td>
<td>2 or more nonconsecutive days per week</td>
<td>2 to 7 days per week</td>
</tr>
<tr>
<td><strong>Intensity</strong></td>
<td>Moderate (equivalent to walking at a pace of 3 to 4 miles per hour)</td>
<td>Enough to enhance muscle strength and improve body composition</td>
<td>Enough to develop and maintain a full range of motion</td>
</tr>
<tr>
<td><strong>Duration</strong></td>
<td>20 to 60 minutes</td>
<td>8 to 12 repetitions of 8 to 10 different exercises (minimum)</td>
<td>2 to 4 repetitions of 15 to 30 seconds per muscle group</td>
</tr>
<tr>
<td><strong>Examples</strong></td>
<td>Running, cycling, swimming, in-line skating, rowing, power walking, cross-country skiing, kickboxing, jumping rope; sports activities such as basketball, soccer, racquetball, tennis, volleyball</td>
<td>Pull-ups, push-ups, weight lifting, pilates</td>
<td>Yoga</td>
</tr>
</tbody>
</table>

*a For those who prefer vigorous-intensity aerobic activity such as walking at a very brisk pace (4.5 miles per hour) or running (at a pace of 5 miles per hour or more), a minimum of 20 minutes per day, 3 days per week is recommended.

To be physically fit, you need to develop enough **flexibility**, **muscle strength**, **muscle endurance**, and **cardiorespiratory endurance** to allow you to meet the demands of everyday life with some to spare, and you need to have a reasonable body composition.
How Do My Muscles Gain Strength and Size?

- Stretching enhances flexibility
- Weight training develops muscle strength and endurance
- **Aerobic** activity improves cardiorespiratory endurance
How Do My Muscles Gain Strength and Size?

Muscle cells respond to an overload of physical activity by gaining strength and size, a response called **hypertrophy**.

**Hypertrophy**: increase in muscle size in response to use.

Muscles adapt to activities they are called upon to perform repeatedly.

- Swim to be a better swimmer
- Bike to be a better biker
How Do My Muscles Gain Strength and Size?

- Resistance training: physical activity that develops: muscle strength, power, endurance & mass.
  - free weights
  - weight machines
  - own body weight
  - other objects
### Table 10–3

#### A Sample Balanced Fitness Program

<table>
<thead>
<tr>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday or Sunday</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-min warm-up(^a)</td>
<td>5-min warm-up(^a)</td>
<td>5-min warm-up(^a)</td>
<td>5-min warm-up(^a)</td>
<td>5-min warm-up(^a)</td>
<td>Active leisure</td>
</tr>
<tr>
<td>Resistance training: chest,</td>
<td>Resistance training: legs,</td>
<td>Resistance training: chest,</td>
<td>Resistance training: legs,</td>
<td></td>
<td>pursuits: Sports,</td>
</tr>
<tr>
<td>back, arms, and shoulders 15–45</td>
<td>core (abdomen/lower back) 15–45</td>
<td>back, arms, and shoulders 15–45</td>
<td>core (abdomen/lower back) 15–45</td>
<td></td>
<td>walking, hiking,</td>
</tr>
<tr>
<td>min(^b)</td>
<td>min</td>
<td>min</td>
<td>min</td>
<td></td>
<td>biking, swimming</td>
</tr>
<tr>
<td>Stretching: 5 min</td>
<td>Stretching: 5 min</td>
<td>Stretching: 5 min</td>
<td>Stretching: 5 min</td>
<td>Stretching: 5 min</td>
<td></td>
</tr>
</tbody>
</table>

\(^a\) The warm-up consists of a slower or less-intense version of the activity ahead and may count toward the week’s total activity requirement if it is performed at moderate intensity.

\(^b\) Lower-intensity exercise requires more time; higher-intensity exercise requires less time.

How Do My Muscles Gain Strength and Size?

Bodies are shaped by the activities they perform.
Weight training can emphasize either muscle strength or endurance.

- **Muscle strength** – combine high resistance (heavy weight) with a low number of repetitions
- **Muscle endurance** – combine less resistance (lighter weight) with more repetitions
Weight training reduces the risk of cardiovascular disease, improves mobility, and helps maximize and maintain bone mass.
Aerobic training enhances the ability of the heart and lungs to deliver oxygen to the tissues more efficiently.

Removes waste from body's cells.

The heart becomes stronger, breathing becomes more efficient, and the health of the entire body improves.
How Does Cardiorespiratory Training Benefit the Heart?

- **(VO₂ max)** the maximum rate of oxygen that an individual consumes.
  - improves w/regular aerobic exercise.

- As the heart muscle becomes stronger, its **cardiac output** increases. The volume of blood discharged by the heart each minute.

- The heart’s **stroke volume** also increases, i.e. the heart pumps more blood per beat.

- Resting heart rate slows b/c more blood is moved w/fewer beats.

- Working muscles push blood more efficiently through veins on their return trip to the heart and lungs.
1. The respiratory system delivers oxygen to the blood.

2. The circulatory system carries oxygenated blood throughout the body.

3. The muscles and other tissues obtain oxygen from the blood and release carbon dioxide into it.

4. The blood carries the carbon dioxide back to the lungs.

Air ($O_2$, $CO_2$), other gases
The Active Body’s Use of Fuels

Physical activity is supported by different mixtures of glucose, fatty acids, and to a small extent amino acids, depending on the intensity and duration of its activities and depending on the body’s prior training.
Glucose Use and Storage

- Glucose is supplied by dietary carbohydrate or made by the liver.
- It is stored in both liver and muscle tissue as glycogen.
- Total glycogen stores affect an athlete’s endurance.
Glucose Use and Storage

Maximum endurance time:
- High-fat diet: 57 min
- Normal mixed diet: 114 min
- High-carbohydrate diet: 167 min

© Bonnie Kamin/PhotoEdit
Glycogen stores are limited to less than 2,000 calories of energy.

Fat stores are theoretically unlimited and can provide more than 70,000 calories and fuel hours of activity.
What is the difference between aerobic & anaerobic?
<table>
<thead>
<tr>
<th>Aerobic</th>
<th>Anaerobic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen is needed to get</td>
<td>-Does not require oxygen to provide energy.</td>
</tr>
<tr>
<td>energy from energy yielding</td>
<td>-Uses glucose only</td>
</tr>
<tr>
<td>nutrients</td>
<td>-Uses less energy per glucose molecule</td>
</tr>
<tr>
<td>Uses every last calorie</td>
<td>-Lungs, heart, blood vessels can't deliver</td>
</tr>
<tr>
<td>from glucose molecule + fatty</td>
<td>oxygen quickly to meet the demand.</td>
</tr>
<tr>
<td>acids</td>
<td>-high intensity activities</td>
</tr>
<tr>
<td>Moderate physical activity,</td>
<td></td>
</tr>
<tr>
<td>such as easy jogging,</td>
<td></td>
</tr>
<tr>
<td>uses glycogen slowly.</td>
<td></td>
</tr>
</tbody>
</table>
Anaerobic Use of Glucose

Blood glucose or glycogen stores

Glucose enters here

Glucose fragments

Some quick energy

Lactate

Oxygen required here

Fatty acid fragments enter here

Anaerobic part of metabolism

The first few steps of glucose breakdown yield a small amount of energy.

Aerobic part of metabolism

Glucose fragments and fatty acid fragments are broken down completely to yield a large amount of energy.

Many more steps yield more energy.
Lactate is produced by the anaerobic breakdown of glucose during intense activity.

- Lactate travels from muscles to liver where it is converted back to glucose.
- When rate of lactate production exceeds the rate of clearance, intense activity can be maintained for only one to three minutes.
Glucose use during physical activity depends on the *duration* of the *activity* and its intensity.

- First 10 minutes – glycogen used by muscles
- First 20 minutes of moderate activity – about 1/5 of available glycogen used up
- A person who exercises for longer than 20 minutes begins to use less glucose and more fat for fuel
Activity Duration Affects Glucose Use

- Glycogen depletion occurs after ~2 hours of vigorous exercise.
- After that, vigorous activity can continue for a short time as the liver converts lactate and some amino acids into glucose.
- Finally, hypoglycemia occurs which brings the nervous system almost to a halt, making intensive activity impossible.
- This is what marathon runners call “hitting the wall.”
4 strategies can help to maintain blood glucose to support sports performance

1. Eat a high-carbohydrate diet (~70% of energy)
2. Take glucose (usually in sports drinks) during activity
3. Eat carbohydrate-rich foods after performance
4. Train the muscles to maximize glycogen stores
Those who compete in endurance activities require fluid and carbohydrate fuel.
Glucose during Activity

- Glucose ingested before and during endurance or intense intermittent activities (lasting more than 45 minutes) makes its way to the working muscles and adds to the glycogen stores.

- For activities less than 45 minutes, glucose probably won’t help (or harm) performance.
Carbohydrate loading is a technique to maximize muscle glycogen before a competition

- Can nearly double the muscle glycogen concentrations
- Can benefit an athlete who keeps going 90 minutes or longer
Eating high-carbohydrate foods within 2 hours after physical activity also enlarges glycogen stores.

- Crackers
- Orange juice
- Toast
- Cereal
- Sports drinks
Highly trained muscles use less glucose and more fat than do untrained muscles to perform the same work, so their glycogen lasts longer.
Athletes who eat high-fat diets may burn more fat during endurance activity, but the risks to health outweigh any possible performance benefits.

The intensity and duration of activity, as well as the degree of training, affect fat use.
“Spot Reducing” does not work; muscles do not own the fat that surrounds them.

Fat cells release fatty acids into the blood for all the muscles to share.

- A tennis player has same fat fold measurement in both arms but one may have better-developed muscles than the other.
The body handles protein differently during activity than during rest.
In the hours after physical activity, muscles speed up the rate of protein synthesis.

Physical activity, with a slight overload, calls into action protein-dismantling and protein-synthesis in individual muscle cells.
Physical activity itself triggers the building of muscle proteins
Proteins contributes about 10 percent of the total fuel used, both during activity and rest.

Athletes use a little more protein as fuel than non-athletes.
A carbohydrate-rich diet spares protein from being used as a fuel.

Some amino acids will be converted to glucose if your diet is low in carbohydrates.
Endurance athletes who train for over an hour a day, engaging in aerobic activity of moderate intensity and long duration, may deplete their glycogen stores by the end of their training and become more dependent on body protein for energy.

Anaerobic strength training does not use more protein for energy but does need more protein to build muscle.
The protein needs of both endurance and strength athletes are higher than those of sedentary people, but not as high as the protein intakes many athletes consume.
The extent of training affects the use of protein.

In strength athletes the higher the degree of training, the less protein a person uses during activity at a given intensity.
# How Much Protein Should an Athlete Consume?

## Table 10–6

<table>
<thead>
<tr>
<th></th>
<th>RECOMMENDATIONS (g/kg/day)</th>
<th>PROTEIN INTAKES (g/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reference Male (70 kg)</td>
<td>Reference Female (55 kg)</td>
</tr>
<tr>
<td>DRI recommended intake</td>
<td>0.8</td>
<td>56</td>
</tr>
<tr>
<td>Recommended intake for power (strength or speed) athletes</td>
<td>1.2–1.7</td>
<td>84–119</td>
</tr>
<tr>
<td>Recommended intake for endurance athletes</td>
<td>1.2–1.4</td>
<td>84–98</td>
</tr>
<tr>
<td>U.S. average intake</td>
<td>102</td>
<td>70</td>
</tr>
</tbody>
</table>

*Daily protein intakes are based on a 70-kilogram (154-pound) reference man and a 55-kilogram (121-pound) reference woman. Other individuals must calculate their recommended intakes using the numbers of column 1. (For kg divide lb by 2.2.)*

Many vitamins and minerals assist in releasing energy from fuels and transporting oxygen.
Do Nutrient Supplements Benefit Athletic Performance?

- Nutrient supplements do not enhance the performance of well-nourished athletes or active people.

- Active people eat more food; if they choose correctly, they will get more nutrients.
Active people who eat well-balanced meals do not need vitamin or mineral supplements.

- Vitamin E and iron will be discussed because many athletes take supplements and iron is special to female athletes.
During prolonged, high-intensity activity, the muscle’s consumption of oxygen increases tenfold or more, enhancing the production of free radicals.

Vitamin E is an antioxidant and some athletes take megadoses of vitamin E to prevent oxidative damage to muscles.

There is little evidence that vitamin E supplements can improve performance.
Physically active young women are especially prone to iron deficiency because of:

- Habitually low intakes of iron-rich foods
- High iron losses through menstruation
- High demands of muscles for iron
Early in training, athletes may develop low blood hemoglobin.

- **Sports anemia** – an adaptive, temporary response to endurance training.
Foods like these are packed with the nutrients that active people need.
Physically active people lose fluids and must replace them to avoid dehydration.

A water loss of 7% is likely to lead to collapse.
Heat stroke – a dangerous accumulation of body heat with a loss of fluid.

- Symptoms
  - Clumsiness
  - Confusion
  - Dizziness
  - Stumbling
  - Sudden cessation of sweating (hot, dry skin)
  - Body temp above 104°F
  - Nausea
  - Headache
Hypothermia can occur in cold weather.

- Loss of body heat
Endurance athletes can lose 1.5 quarts or more of fluid during each hour of activity. During activity thirst becomes detectable only after fluid stores are depleted.
### Fluid Needs during Physical Activity

#### Table 10–8

**Suggested Hydration Schedule for Physical Activity**

The amount of fluid required for physical activity varies by the person’s weight, genetics, previous hydration level, degree of training, environmental conditions, and other factors.

<table>
<thead>
<tr>
<th>Timing</th>
<th>Recommendation (ml/kg body weight)</th>
<th>Common Measure</th>
<th>Example: 70-kg Athlete</th>
<th>Example: 55-kg Athlete</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥4 hours before activity</td>
<td>5 to 7 ml/kg</td>
<td>≈1 oz/10 lbs</td>
<td>≈1½ to 2 c</td>
<td>≈1 to 1½ c</td>
</tr>
<tr>
<td>2 hours before activity</td>
<td>If heavy sweating is expected, additional 3 to 5 ml/kg</td>
<td>≈0.6 oz/10 lbs</td>
<td>≈1 c (9 ounces)</td>
<td>≈1 c (7 ounces)</td>
</tr>
<tr>
<td>During activity</td>
<td>Limit dehydration to ≲2% body weight</td>
<td>—</td>
<td>Varies&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Varies&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>After activity</td>
<td>—&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Drink ≥2 c for each pound of body weight lost&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Varies</td>
<td>Varies</td>
</tr>
</tbody>
</table>

---

<sup>a</sup>A personal hydration plan, based on prior measures of fluid loss (weight) during the activity, is recommended. Thirst lags behind fluid loss and should be quenched immediately.<br>

<sup>b</sup>Research to develop recommendations is ongoing.<br>

<sup>c</sup>Hydration is most rapidly achieved with divided doses to provide 2 c every 20 to 30 min after exercise until the total is consumed.<br>

Active people need extra fluid, even in cold weather.
Water is the best drink for most physically active people, but endurance athletes need drinks that supply glucose as well as fluids.
The body adapts to compensate for sweat losses of electrolytes.

Athletes are advised to use foods, not supplements, to make up for these losses.
**Sodium Depletion**

- **Hyponatremia** – a dangerous condition of sodium depletion

- Can occur when endurance athletes drink such large amounts of water over the course of a long event that they over hydrate, diluting the body’s fluids to such an extent that the sodium concentration becomes too low
To prevent hyponatremia, sports drinks are more helpful than water.

In the days before the event, athletes should not restrict salt in their diets.
Caffeine-containing drinks within limits may not impair performance, but water and fruit juice are preferred.

Alcohol can impair performance in many ways and is not recommended.
Many different diets can support an athlete’s performance.
# Food Feature: Choosing a Performance Diet

### 2600 Calories

**Breakfast:**
- 1 c shredded wheat,
- 1 c 1% low-fat milk,
- 1 small banana,
- 1 c orange juice.

**Lunch:**
- 1 turkey sandwich on whole-wheat bread,
- 1 c 1% low-fat milk

**Snack:**
- 2 c plain popcorn,
- A smoothie made from:
  - 1 1/8 c apple juice,
  - 1 1/8 frozen banana.

**Dinner:**
- Salad:
  - 1 c spinach, carrots, and mushrooms,
  - 1/2 c garbanzo beans,
  - 1 tbs sunflower seeds,
  - 1 tbs ranch dressing,
  - 1 c spaghetti with meat sauce,
  - 1 c green beans,
  - 1 slice Italian bread,
  - 2 tsp soft margarine,
  - 1 1/4 c strawberries,
  - 1 c 1% low-fat milk.

**Total cal:** 2,600
- 62% cal from carbohydrate
- 23% cal from fat
- 15% cal from protein

### Modifications

**The regular breakfast plus:**
- 2 pieces whole-wheat toast,
- 1/2 c orange juice,
- 4 tsp jelly.

**The regular lunch plus:**
- 1 turkey sandwich
- 1/2 c 1% low-fat milk
- Large bunch of grapes.

**The regular snack plus:**
- 1 c popcorn.

**The regular dinner plus:**
- 1 corn on the cob,
- 1 slice Italian bread,
- 2 tsp soft margarine,
- 1 piece angel food cake,
- 1 tbs whipping cream.

**Total cal:** 3,300
- 63% cal from carbohydrate
- 22% cal from fat
- 15% cal from protein

All vitamin and mineral intakes exceed the recommendations for both men and women.
## Food Feature: Choosing a Performance Diet

### TABLE 10-7 High-Carbohydrate Eating Patterns for Athletes

<table>
<thead>
<tr>
<th>FOOD GROUP</th>
<th>1,500 cal</th>
<th>2,000 cal</th>
<th>2,500 cal</th>
<th>3,000 cal</th>
<th>3,500 cal</th>
<th>4,000 cal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk (c)</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Fruit (c)</td>
<td>2½</td>
<td>3</td>
<td>3½</td>
<td>4½</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Vegetable (c)</td>
<td>1½</td>
<td>2½</td>
<td>1½</td>
<td>2½</td>
<td>33½</td>
<td></td>
</tr>
<tr>
<td>Grain (oz)</td>
<td>7</td>
<td>11</td>
<td>16</td>
<td>18</td>
<td>20</td>
<td>24</td>
</tr>
<tr>
<td>Oils (tsp)</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>6</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>Meat (oz)</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Percent</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>carbohydrate:</td>
<td>58%</td>
<td>58%</td>
<td>63%</td>
<td>64%</td>
<td>60%</td>
<td>62%</td>
</tr>
</tbody>
</table>

*A way to add more energy to the diet without adding much bulk is to snack on milkshakes or “complete meal” liquid supplements (see the text).

*bSoft margarine, oil, or the equivalent.
Food Feature: Choosing a Performance Diet

**300-calorie meal**
1 large apple
4 saltine crackers
1 1/2 tbs reduced-fat peanut butter

**500-calorie meal**
1 large whole-wheat bagel
2 tbs jelly
1 1/2 c low-fat milk

**750-calorie meal**
1 large baked potato
2 tsp soft margarine
1 c steamed broccoli
1 c mixed carrots and green peas
5 vanilla wafers
1 1/2 c apple or pineapple juice
### Food Feature: Choosing a Performance Diet

#### Table 10-8 Commercial and Homemade Meal Replacers Compared

<table>
<thead>
<tr>
<th></th>
<th>COST (U.S.)</th>
<th>ENERGY (cal)</th>
<th>PROTEIN (g)</th>
<th>CARBOHYDRATE (g)</th>
<th>FAT (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-ounce commercial liquid meal replacer&lt;sup&gt;a&lt;/sup&gt;</td>
<td>about $2 per serving</td>
<td>360</td>
<td>15 (17% of calories)</td>
<td>55 (61%)</td>
<td>9 (22%)</td>
</tr>
<tr>
<td>12-ounce homemade milkshake&lt;sup&gt;b&lt;/sup&gt;</td>
<td>about 50¢ per serving</td>
<td>330</td>
<td>15 (18% of calories)</td>
<td>53 (63%)</td>
<td>7 (19%)</td>
</tr>
</tbody>
</table>

<sup>a</sup>Average values for three commercial formulas.

<sup>b</sup>Home recipe: 8 oz fat-free milk, 4 oz fat-free or low-fat frozen yogurt, 3 heaping tsp malted milk powder. For even higher carbohydrate and calorie values, blend in 1/2 mashed banana or 1/2 c other fruit. For athletes with lactose intolerance, use lactose-reduced milk or soy milk and chocolate or other flavored syrup, with mashed banana or other fruit blended in.
The large majority of legitimate research has not supported the claims made for ergogenic aids. Training serves an athlete better than any pills or powders.
Caffeine

- Caffeine seems to provide a physical boost during endurance sports.
- Little or no effect for athletes in short-duration sports.
Carnitine is a nonessential nutrient often marketed as a “fat burner.”

Carnitine supplementation neither raises muscle carnitine levels nor enhances exercise performance.
Chromium Picolinate

- **Chromium picolinate** promises to burn fat from the body.

- Chromium is an essential trace mineral involved in lipid and carbohydrate metabolism.

- Majority of studies showed no effect on body fatness, lean body mass, strength or fatigue.
Creatine

Power athletes often use creatine supplements in the belief they enhance stores of the high-energy compound creatine phosphate in muscles.

Creatine may enhance performance of high-intensity strength activities such as weight lifting or competitive swimming.

But creatine does not benefit endurance activity.

No long-term studies for safety.
Conjugated Linoleic Acid

- **Conjugated linoleic acid (CLA)** arises from the essential fatty acid linoleic acid.
- In human beings, may provide a small increase in lean body mass and reductions in body fat, but no improvements in strength.
- Too early to know if CLA is worth the cost and is safe.
Amino Acid Supplements

To build protein, all the essential amino acids must be in the blood prior to physical work for maximum gains.

The best source for these amino acids is food, not supplements.

- All amino acids are in a well-balanced diet.
- Supplements may not provide the ideal balance.
- Only a few grams of amino acids are needed and heavy doses from supplements are not needed.
- Supplements can lead to digestive disturbances.
Specialty drinks and candy bars, packed with vitamins, minerals, and other healthy-sounding goodies, appeal to athletes. They may taste good but fall short of providing “complete” nutrition and often are high in fat and sugar.

These meal replacers may be useful as a pregame meal or a snack but are inferior to nutritious foods for meeting the high needs of athletes.
Anabolic steroid hormones produce muscle size and strength far beyond that attainable by training alone, but are very dangerous.
## Hormone Preparations

### Mind
- Extreme aggression with hostility ("steroid rage"); mood swings; migraines headaches; anxiety; dizziness; drowsiness; unpredictability; insomnia; psychotic depression; personality changes; suicidal thoughts; epilepsy

### Face and Hair
- Swollen appearance; greasy skin; severe, scarring acne; mouth and tongue soreness; yellowing of whites of eyes (jaundice)
- In females, male-pattern baldness and increased growth of facial and body hair; in males, baldness

### Voice
- In females, irreversible deepening of voice

### Chest
- In males, breathing difficulty; breast enlargement and development
- In females, breast atrophy; loss of female body contour

### Heart
- Heart disease; elevated or reduced heart rate; heart attack; stroke; hypertension

### Abdominal Organs
- Nausea; vomiting; bloody diarrhea; pain; edema; liver tumors (possibly cancerous); liver damage, disease, or rupture leading to fatal liver failure; kidney stones and damage; gallstones; frequent urination; possible rupture of aneurysm or hemorrhage

### Blood
- Increased red blood cells; blood clots; increased LDL cholesterol; reduced HDL cholesterol; increased triglycerides; high risk of blood poisoning; those who share needles risk contracting diseases; septic shock (from injections); glucose intolerance

### Reproductive System
- In males, permanent shrinkage of testes; early puberty in adolescents; prostate enlargement with increased risk of cancer; sexual dysfunction; loss of fertility; excessive and painful erections
- In females, loss of menstruation and fertility; increased libido; early puberty in adolescents; permanent enlargement of external genitalia; thickening of uterine lining; fetal damage; if pregnant

### Muscles, Bones, and Connective Tissues
- Weight gain; altered body composition; increased susceptibility to injury with delayed recovery times; cramps; tremors; seizure like movements; injury at injection site
- In adolescents, failure to grow to normal height

### Other
- Fatigue; edema; increased risk of liver and uterine cancer; sleep, breathing disorders
Steroid alternatives, such as the officially banned “andro” (androstenedione) or DHEA, produce unpredictable results.

Illegal to sell and banned by many sports organizations including the International Olympic Committee.

These products may be as risky as steroid drugs and provide no competitive edge in sports.
A potent thyroid hormone known as TRIAC has been recalled by the FDA.

- TRIAC has caused heart attacks and strokes
The scientific response to ergogenic claims is “let the buyer beware.”

Touted heavily in bodybuilding and health magazines even though none have been scientifically shown to be effective.