Chapter 3

Cardiorespiratory Endurance
The ability of the body to perform prolonged, large-muscle, dynamic exercise at moderate to high levels of intensity

This is a key health-related component of fitness

Having an understanding of the body processes involved in cardiorespiratory endurance exercise can help you design a safe and effective fitness program for many individuals
The Cardiorespiratory System

- Consists of the heart, the blood vessels, lungs and the respiratory system

- **Its functions**
  - Delivery of oxygen and other nutrients
  - Removal of carbon dioxide and other metabolic waste
    - Lactic acid, creatine kinase
  - Thermoregulation-surface to volume ratio
  - Maintenance of acid–base balance and overall body fluid balance
  - Immune function
The Cardiorespiratory System

**Immediate effects**

- Increased levels of neurotransmitters; constant or slightly increased blood flow to the brain.
- Increased heart rate and stroke volume (amount of blood pumped per beat).
- Increased pulmonary ventilation (amount of air breathed into the body per minute). More air is taken into the lungs with each breath and breathing rate increases.
- Reduced blood flow to the stomach, intestines, liver, and kidneys, resulting in less activity in the digestive tract and less urine output.
- Increased energy (ATP) production.
- Increased blood flow to the skin and increased sweating to help maintain a safe body temperature.
- Increased systolic blood pressure; increased blood flow and oxygen transport to working skeletal muscles and the heart; increased oxygen consumption. As exercise intensity increases, blood levels of lactic acid increase.

**Long-term effects**

- Improved self-image, cognitive functioning, and ability to manage stress; enhanced learning, memory, energy level, and sleep; decreased depression, anxiety, and risk for stroke.
- Increased heart size and resting stroke volume; lower resting heart rate. Risk of heart disease and heart attack reduced significantly.
- Improved ability to extract oxygen from air during exercise. Reduced risk of colds and upper respiratory tract infections.
- Increased sweat rate and earlier onset of sweating, helping to cool the body.
- Decreased body fat.
- Reduced risk of colon cancer and certain other forms of cancer.
- Increased number and size of mitochondria in muscle cells; increased amount of stored glycogen; improved ability to use lactic acid and fats as fuel. All of these changes allow for greater energy production and power output. Insulin sensitivity remains constant or improves, helping to prevent type 2 diabetes. Fat-free mass may also increase somewhat.
- Increased density and breaking strength of bones, ligaments, and tendons; reduced risk for low-back pain, injuries, and osteoporosis.
- Increased blood volume and capillary density; higher levels of high-density lipoproteins (HDL) and lower levels of triglycerides; lower resting blood pressure; increased ability of blood vessels to secrete nitric oxide; and reduced platelet stickiness (a factor in coronary artery disease).
The Heart

- The heart has the following characteristics:
  - 4 chambers
  - Size of a fist
  - Located just beneath the sternum
  - The sinoatrial (SA) node: is a bundle of specialized cells located in the right atrium that initiates the heartbeat.
The Heart

- It’s function is to pump blood through 2 separate circulatory systems
  - Pulmonary circulation
    - Right side of the heart pumps blood to the lungs
  - Systemic circulation
    - Left side of the heart pumps blood through the rest of the body

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The Circulatory System

- Heart
  - Pumps blood

- Arteries and arterioles
  - Carry blood away from the heart

- Capillaries
  - Exchange of nutrients with tissues

- Veins and venules
  - Carry blood toward the heart

- Systemic circuit
  - Pumps oxygenated blood to the whole body via arteries
  - Returns deoxygenated blood to the right heart via veins

- Pulmonary circuit
  - Pumps deoxygenated blood to the lungs via pulmonary arteries
  - Returns oxygenated blood to the left heart via pulmonary veins
Blood Pressure

*The forces that circulating blood exerts on the arterial walls*

\[ \text{BP} = \text{Cardiac Output} \times (\text{HR} \times \text{SV}) \times \text{Total Peripheral Resistance (TPR)} \]
Blood Pressure

- There are two specific pressures measured
  - **Systolic blood pressure (SBP):** Heart’s contraction
    - is the highest pressure within the vascular system generated during cardiac contraction
  - **Diastolic blood pressure (DBP):** Heart’s relaxation
    - is the lowest pressure within the vascular system when the heart is relaxed
Hypertension

- **Hypertension**: occurs when too much force or pressure is exerted against the wall of the arteries.

- **Risk factor for cardiovascular disease (CVD)**.
  - **Primary hypertension**: no known cause
  - **Secondary Hypertension**: caused by known endocrine disorders (Aldosterone)

- **Optimal**: 120 mmHg / 80 mmHg

- **Hypertension**: 140 mmHg / 90 mmHg

- **Hypotension**: < 90 mmHg / < 60 mmHg
The Respiratory System

Functions:

- Provides a means of gas exchange between the environment and the body \((\text{Supplies } O_2 \text{ to the body and Carries } CO_2 \text{ away})\)

- Plays a role in the regulation of acid-base balance during exercise
The Respiratory System

- Pressure changes brought about by the contraction and relaxation of the diaphragm and rib muscle allow air to be drawn from the atmosphere into the throat.

- Eventually flow from the bronchi to air sacs called **alveoli**.

- Gas exchange occurs at the alveoli and allows oxygen to return to the heart and systemic system while removing carbon dioxide.
Energy Production

- **Metabolism** is the sum of all chemical processes necessary to maintain the body.
- **Metabolic rate** is the efficiency at which your body uses energy.
- The body converts chemical energy from food into substances the cells can use as fuel:
  - Carbohydrates
    - Glucose and/or Glycogen
  - Protein
  - Fats
- **ATP** (*adenosine triphosphate*) is the basic form of energy used by cells.
Three Energy Systems

- The 3 energy systems create ATP and help fuel cellular activity
  - **Immediate Energy System (explosive)**
    - 10 or fewer seconds
    - ATP stores and creatine phosphate (CP)
  - **Nonoxidative Energy System (anaerobic)**
    - 10 to 120 seconds
    - Creates ATP by breaking down glucose and glycogen
  - **Oxidative Energy System (aerobic)**
    - Any activity greater than 120 seconds
    - Oxygen required to create ATP
    - Mitochondria
    - Maximal oxygen consumption or $\text{VO}_2\text{max}$

The energy systems can also be used in combination during exercise, based upon the intensity and duration of the activity.
EPOC

- Exercise
- Post
- Oxygen
- Consumption

- Concept that you burn calories after you exercise because your body requires energy to repair damaged cells. The more intense the exercise, the longer recovery time.
Three Energy Systems

1. ATP-PCr system
2. Glycolytic system
3. Oxidative system
Benefits of Cardiorespiratory Endurance Exercise

- Improved cardiorespiratory functioning
- Improved cellular metabolism
- Reduced risk of chronic disease
  - Cardiovascular diseases
  - Type 2 diabetes
  - Osteoporosis
- Better control of body fat
- Improved psychological and emotional well-being
Immediate and long-term effects of regular cardiorespiratory endurance exercise
Assessing Cardiorespiratory Fitness

The following are considered simple assessment tests to estimate for maximal oxygen consumption (within ± 10-15% of the results of a lab test):

- The 1-mile walk test
- The 3-minute step test
- The 1.5-mile run-walk test
- 12 minute swim test

*Lab 3.1 provides detailed instructions for each test*
Lab 3.1

- http://www.mhhe.com/socscience/hhp/fahey/labs/lab03_1.htm
Checking Your Pulse

- **Count beats**
  - for 10 seconds and multiply the result by 6 to get rate in beats per minute
  - Or 15 seconds and multiply the results by 4 to get the rate in beats per minute

*FIGURE 3.4 Checking your pulse.* The pulse can be taken at the carotid artery in the neck (top) or at the radial artery in the wrist (bottom).
• Mets

1 = Basal metabolic rate at rest

There are a number of activities you can do to increase it:
  park further from class
  ride bike to class
  skateboard
  housework- vacuum etc.
  Yard work/construction
Developing a Cardiorespiratory Endurance Program

- Setting realistic goals
  - What is your goal? Write it down now.

- Set your starting frequency, intensity, and duration
  - Applying the FITT equation
    - Frequency (3-5x/wk)
      - Are you here yet?
    - Intensity (Target Heart Rate)
      - What is your goal?
    - Time (30-60 min)
    - Type of activity: What is your main type?
- Warm up and cool down:
  - What is warm up?
  - What is cool down?
  - When should you stretch?
- Choose suitable activities
- Adjust your program as you improve.
  - What does this mean?

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Target Heart Rate Determining

- Estimate your maximum heart rate (MHR)
  - 220 – your age = MHR

- Multiply your MHR by selecting an appropriate range of 65% - 90%
  - People who are unfit should start at 55% of MHR

- Example: 19-year-old
  - MHR = 220 – 19 = 201
  - 65% training intensity = 0.65 X 201 = 131 bpm
  - 90% training intensity = 0.90 X 201 = 181 bpm
### Table 3.3

<table>
<thead>
<tr>
<th>AGE (years)</th>
<th>TARGET HEART RATE RANGE (bpm)*</th>
<th>10-SECOND COUNT (beats)</th>
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<tbody>
<tr>
<td>20–24</td>
<td>127–180</td>
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<td>97–140</td>
<td>16–23</td>
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Ratings of perceived exertion (RPE) is a method where exercisers rate the intensity of their physical activity on a scale from 6 to 20. Exercisers may use this subjective scale to estimate how near they are to their target heart rate zone.
How do people use rating of Perceived Exertion (RPE)?

Max tests primarily
The FITT Principle

Frequency: 3–5 days per week

Intensity: 55/65–90% of maximum heart rate, 40/50–85% of heart rate reserve plus resting heart rate, or an RPE rating of about 12–18 (lower intensities—55–64% of maximum heart rate and 40–49% of heart rate reserve—are applicable to people who are quite unfit; for average individuals, intensities of 70–85% of maximum heart rate are appropriate)

Time (duration): 20–60 minutes (one session or multiple sessions lasting 10 or more minutes)

Type of activity: Cardiorespiratory endurance exercises, such as walking, jogging, biking, swimming, cross-country skiing, and rope skipping
Building Cardiorespiratory Fitness

- Your fitness improves when you overload your body

- **Initial stage (3–6 weeks):** 3–4 days per week, low end of target heart rate zone, ~30 minutes

- **Improvement stage (4–6 months):** 3–5 days per week, middle to upper end of target heart rate zone, 25–40 minutes
Maintaining Cardiorespiratory Fitness

- **Maintenance Stage**
  - Improvements to fitness are not indefinite
  - There comes a time when your fitness levels will reach a limit
  - **By the 4\textsuperscript{th} – 6\textsuperscript{th} month**, you may reach an acceptable level of fitness and wish to maintain this by continuing every 3\textsuperscript{rd} day
  - Reaching this level requires setting new goals or adjustments to maintain motivation
  - **Cross-training** can help boost enjoyment and prevent injuries
Exercise Safety and Injury Prevention

- Hot Weather and Heat Stress Considerations
  - Be aware of hot weather concerns when exercising under stressful conditions, resulting in the following:
    - Dehydration
    - Heat cramps
    - Heat exhaustion
    - Heatstroke
      - Medical emergency; the victim should be transported to the hospital
Hot activities

- What about HOT yoga?
- Exercising when it is very humid?
- Exercising when it is Hot and Humid together?

- The risk for developing heat illness is extremely high when the Wet-Bulb Globe Temperature is greater than 82°F (28°C)
The WetBulb Globe Temperature (WBGT) is a measure of the heat stress in direct sunlight, which takes into account: temperature, humidity, wind speed, sun angle and cloud cover (solar radiation).
The WetBulb Globe Temperature (WBGT) is a measure of the heat stress in direct sunlight, which takes into account: temperature, humidity, wind speed, sun angle and cloud cover (solar radiation). This differs from the Heat Index, which takes into consideration temperature and humidity and is calculated for shady areas. If you work or exercise in direct sunlight, this is a good element to monitor. Military agencies, OSHA and many nations use the WBGT as a guide to managing workload in direct sunlight.
# Examples

<table>
<thead>
<tr>
<th>Temp F</th>
<th>Dwpt F</th>
<th>RH %</th>
<th>Sky %</th>
<th>Wind mph</th>
<th>HeatIdx F</th>
<th>WBGT F</th>
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</table>
- **Heat cramps**
  - **Causes:** Sodium losses and dehydration
  - **Prevention:** Proper hydration and liberally salt food

- **Heat exhaustion**
  - **Causes:** Failure of cardiovascular system’s due to dehydration
  - **Treatment:** Move to cooler environment, oral/intra venous saline

- **Heatstroke:** (>40 °C=104 f) *medical attention*
  - **Cause:** Failure of the body’s thermoregulatory system
  - **Treatment:** Rapidly cool body *in cold water or ice bath*
Cold Weather Considerations

- In extreme cold weather, problems can arise based upon a drop in body temperature
- Be aware of the following concerns when exercising in cold environments:
  - Hypothermia
  - Frostbite
  - Wind chill concept
Hypothermia and Frostbite

- **Hypothermia**
  - Ability of the hypothalamus to regulate body temperature is lost if body core temperature drops below 34.5 °C (94.1 °F)
  - Hypothermia causes heart rate to drop, from impaired cardiac conduction through the SA node
  - Decreased respiratory rate and volume

- **Frostbite**
  - Exposed skin can freeze quickly
  - This can lead to gangrene and loss of tissue
Exercise Injuries

- Consult a physician for serious injuries and those that do not improve within a reasonable amount of time
  - Head and eye injuries (concussion)
  - Possible ligament injuries
  - Broken bones
  - **Internal disorders**: chest pain, fainting, elevated body temperature, intolerance to hot weather

- Managing minor exercise injuries include using the following acronym called **RICE**
  - Rest
  - Ice
  - Compression
  - Elevation
What do you do if you cut yourself (finger etc?)

- Raise it above your heart if possible
Preventing Injuries

- Train regularly and stay in condition
- Gradually increase the intensity, duration, or frequency
- Avoid or minimize high-impact activities, alternate them with low-impact
- Get proper rest
- Drink plenty of fluids
- Warm up and cool down
- Achieve normal range of motion in your joints
- Use proper body mechanics
- Don’t exercise when you are ill or overtrained
- Use proper equipment
- Don’t return to normal exercise program until athletic injuries have healed

REST DAY