#6 - Cardiovascular III – Heart Sounds, Pulse Rate, Hemoglobin Saturation, and Blood Pressure

Objectives:

- Observe slide of artery and vein cross-section
- Auscultate heart sounds using a stethoscope
- Measure pulse rate
- Understand the theory of operation of the pulse oximeter
- Take pulse and SpO\textsubscript{2} measurements under a variety of physiological conditions
- Interpret pulse and SpO\textsubscript{2} data in a chart format
- Measure blood pressure using a sphygmomanometer
- Understand the origin of Korotkoff sounds
- Compare pulse and blood pressure measurements under different body conditions
- Calculate pulse pressure, stroke volume, and cardiac output using data collected
- Display blood pressure and pulse data in graph form

I. Observation of Artery and Vein Slide

Obtain the artery and vein cross-section slide. Locate the artery (thick-walled, more obvious vessel) and the vein (thin-walled, collapsed). Identify the following structures:

**Artery:**
- tunica interna
  - endothelium
- tunica media
  - smooth muscle
- tunica externa
  - connective tissue
- lumen

**Vein:**
- tunica interna
  - endothelium
- tunica media
  - smooth muscle
- tunica externa
  - connective tissue
- lumen

*Get your instructor to check your microscope before storage and initial the lab report.*

![Figure 1. Artery and vein (from AP Revealed).](image)
II. Auscultation of Heart Sounds

A. Introduction
During the cardiac cycle, two major sounds result from the turbulent blood flow created as valves close. These sounds are commonly described as lubb-dupp sounds. Lub is the first sound (S₁) which is produced when the atrioventricular (AV) valves close. Dupp is the second sound (S₂) which is associated with the closure of the semilunar (SL) valves. These sounds can be easily auscultated using a stethoscope.

B. Procedure
1. Obtain a stethoscope and identify the earpieces and the diaphragm (Figure 2). Use alcohol swabs to carefully clean the earpieces before using. Allow the alcohol to dry. Note that the earpieces of the stethoscope are angled. When putting on the stethoscope, the earpieces should be angled in a forward direction.

2. Place the diaphragm of the stethoscope on the left side of your own chest at the level of the fifth intercostal space and listen carefully for the lubb-dupp sounds. The lubb sound is louder and more prolonged, while the dupp sound is shorter and sharper.

III. Pulse Rate Measurement

A. Introduction
In peripheral locations of the body, pulse rate can be used as a reflection of heart rate. As blood is forced out of the left ventricle, it momentarily expands the elastic arteries. Blood moves through the arterial system in this pulsing manner. This temporary expansion can be palpated by lightly compressing a large artery against a bone or muscle. The average resting pulse of an adult is 60-100 beats per minute (bpm).

B. Procedure
1. Place the fingertips of the first two fingers (do not use the thumb) of one hand over the radial artery that runs along the medial wrist of your partner (Figure 3). Recall that the radius bone runs along the lateral aspect of the arm and lines up with the thumb. Count the pulse for 1 minute. Repeat the count two more times and then calculate the average pulse. Record your data in Table 1.

2. Repeat the procedure from step 1 finding the carotid pulse using the common carotid artery. The carotid arteries supply blood to the head and neck. To find the pulse at the common carotid artery, run two fingers up the neck lateral to the trachea until the pulse is
felt. Take care to only press on one side at a time to prevent a decrease in blood flow to the head. Record your data in Table 1.

IV. Hemoglobin Saturation

A. Introduction

Blood oxygen saturation (SpO₂) level is a measurement of the amount of oxygen present in blood compared to the maximum amount of oxygen the blood could contain. SpO₂ is typically expressed as a percentage. Oxygen is carried in the blood stream bound to hemoglobin protein molecules within red blood cells. Each hemoglobin protein can hold a maximum of four oxygen molecules. Hemoglobin bound to four oxygen molecules (oxyhemoglobin) has a different configuration than hemoglobin that is not bound to oxygen (deoxyhemoglobin). The result is that well oxygenated blood appears bright red and less oxygenated blood appears dark red in color.

Equipment:

A pulse oximeter (Figure 4) can detect both pulse rate and SpO₂. The sensor portion of the pulse oximeter is placed on a thin region of the body such as a fingertip, toe, or ear lobe. The instrument projects two different wavelengths of light through the tissue. As the surge of blood from a heart beat swells the arteries, the sensor picks up color differences caused by the increased volume. At the same time, the sensor registers the subtle color changes caused by varying amounts of oxyhemoglobin and deoxyhemoglobin. The color difference can be used to determine the percent of oxygen saturated hemoglobin (SpO₂) present in the blood. (Note: dark nail polish can affect the passage of light through the tissue.) A normal range of SpO₂ in healthy people at rest is 95%-100%. A SpO₂ below 92% indicates inadequate oxygen levels in the blood typically caused by respiratory distress. Both pulse and SpO₂ measurements are digitally displayed (Figure 4).

B. Oxygen Delivery – The distribution of oxygen to tissues and organs throughout the body is closely matched to the metabolic activity of the region. The heart beat is the driving force of circulation and oxygen delivery. However, the flow rate of blood and oxygen to a specific area is determined by the diameter of blood vessels supplying those tissues. When the arteries that supply a tissue or organ constrict and narrow, less blood is delivered to that area. When arteries relax and widen, blood can more easily flow to those tissues. Homeostatic mechanisms regulate vessel diameter to maintain appropriate levels of oxyhemoglobin within tissues.

C. How to use the pulse oximeter – Disinfect the pulse oximeter sensor with an alcohol pad before and after use. Make sure the sensor is firmly attached to the pulse oximeter. Place the sensor on the subject’s finger and press the ON key. In a few seconds, the SpO₂, pulse rate (in beats per minute), and pulse strength bar will appear on the screen.
D. Effect of various conditions on pulse and SpO₂ – Measure each subject’s pulse and SpO₂ under the conditions listed below.

1. Resting
2. Arm (with finger sensor) held over the head
3. Deep breathing (slow, relaxing breaths)
4. Breath holding
5. Elbow and forearm in cold water (immerse arm elbow first into ice bath keeping hand with pulse oximeter attached well above the waterline)
6. Elbow and forearm in warm water (hand above water)
7. Tensing arm muscles (with finger sensor) for 1 minute
8. Directly following relaxing muscle after tensing

E. Record results
1. Record the pulse rate and SpO₂ values in Table 2 in the lab report section (Column 1, and Column 3).
2. Calculate the change in pulse and SpO₂ for each condition by subtracting the values obtained during the resting condition (Box A or B) from the experimental values. Record the changes in columns 2 and 4 in Table 2. A negative number indicates a decrease from the resting condition.

V. Blood Pressure Measurement

A. Introduction

Blood pressure (BP) can be defined as the pressure exerted by the blood as it pushes against the walls of the blood vessels. It is most commonly measured in the brachial artery of the arm. In the arteries particularly, blood pressure typically rises and falls as the heart contracts and relaxes. Systolic blood pressure is the pressure measured at the moment the ventricles contract, and diastolic blood pressure is

![Figure 5. Sphygmomanometer](https://www.mcgraw-hill.com/)

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the pressure measured when the ventricles relax. Blood pressure measurements vary widely within the population, but values within the range of 110-130 / 75-85 mm Hg are considered normal.

The *sphygmomanometer* (usually called a blood pressure cuff) is the most commonly used instrument to measure blood pressure. Typical sounds called *Korotkoff sounds* can be detected for determination of systolic and diastolic pressures (Figure 6a).

The procedure for using the sphygmomanometer involves placing the cuff around the arm and inflating the pressure high enough to completely block blood flow through the brachial artery. At this point, there are no sounds heard when listening with the stethoscope because there is no blood flowing through the artery (Figure 5b). As the pressure is gradually released and the blood vessel first opens, blood will spurt through the artery, even though it is still partially closed. The turbulence created by the spurting blood causes the first Korotkoff sound heard. The pressure at which the first sound is heard corresponds to *systolic* blood pressure (Figure 6c).

As the pressure continues to decline, the sounds may become even louder because of greater blood turbulence, but eventually the sounds completely disappear as the artery fully opens, and the blood flows freely without turbulence. The pressure at which the sounds first stop represents the *diastolic* blood pressure (Figure 6d).
B. Procedure
Discuss with your partner who should act as the subject. Anyone with health concerns (heart issues, asthma, pregnancy) should not be the subject but can serve as recorder. Obtain a sphygmomanometer and identify the cuff, pressure gauge, rubber squeeze bulb, and metal dial (Figure 5).

Measure the subject’s blood pressure and pulse rate under the following conditions, using the exact sequence listed:

A. After sitting quietly for 5 minutes
B. After laying down for 5 minutes
C. Immediately upon standing
D. After exercising for 5 minutes

1. Take a manual pulse and record it in Table 3.

2. Wrap the cuff around the subject’s arm, just above the elbow. Make sure that the inflatable portion of the cuff is on the anterior medial side of the arm.

3. Clean the earpieces of the stethoscope with an alcohol swab before use. Place the diaphragm of the stethoscope along the medial elbow.

4. Hold the rubber squeeze bulb so that the attached rubber tubing leads away from you. Turn the metal dial in a clockwise direction until it is completely closed.

5. Pump the cuff up to about 150 mm Hg and listen carefully – you should not hear any sound at this point since the brachial artery is now closed, and there is no blood flowing through the blood vessel.

6. Gradually release the pressure so that the needle on the pressure gauge descends very slowly. Listen very carefully for the first sound that you hear, and note the pressure at which this first sound occurs – this pressure corresponds to systolic blood pressure. Record the systolic pressure in Table 3.

7. Continue to slowly release the pressure. The sound may become louder for a short time due to more blood turbulence, but eventually the sound will muffle. Listen very carefully until the sound totally disappears. Record the diastolic pressure in Table 3.

8. Use the formulas provided below to calculate pulse pressure, stroke volume (SV), and cardiac output (CO). Use Table 4 in the lab report to show your calculations and results.

\[
\text{Pulse Pressure} = \text{Systolic BP} - \text{Diastolic BP} \\
\text{Stroke Volume} = \text{Pulse Pressure} \times 1.7 \\
\text{Cardiac Output} = \text{Stroke Volume (SV)} \times \text{Heart Rate (HR)}
\]
9. Use your data from Table 4 to complete the graph found in your lab report. Follow the format of this sample graph including the colored lines as described on page 11. Answer the related questions in the lab report.

Figure 7. Graphing BP and pulse.
Blank on purpose
I. Artery and Vein slide
a) Draw using the 10x objective.
b) Label:
Artery:

tunica interna (with endothelium)
tunica media (with smooth muscle)
tunica externa (with connective tissue)
lumen

Vein:

tunica interna (with endothelium)
tunica media (with smooth muscle)
tunica externa (with connective tissue)
lumen

Microscope Check: ____________

III.B. Pulse (heart) rate measurement

Table 1. Pulse (heart) Rates (beats per minute = bpm)

<table>
<thead>
<tr>
<th>Pulse Point</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radial</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carotid</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
IV. D. and E. Hemoglobin saturation and pulse (heart) rate

Table 2. Hemoglobin Saturation

<table>
<thead>
<tr>
<th>Condition</th>
<th>Column 1</th>
<th>Column 2</th>
<th>Column 3</th>
<th>Column 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pulse rate (bpm)</td>
<td>Pulse change</td>
<td>SpO₂</td>
<td>SpO₂ change</td>
</tr>
<tr>
<td>1. Resting</td>
<td>Box A</td>
<td></td>
<td>Box B</td>
<td></td>
</tr>
<tr>
<td>2. Arm over head</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Deep breathing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Breath holding</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Elbow in cold water</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>6. Elbow in warm water</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Tensing muscle</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Relaxing muscle</td>
<td></td>
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</tr>
</tbody>
</table>

Data analysis for hemoglobin saturation - Refer to Table 2 to answer these questions about the observed changes to pulse (heart) rate and SpO₂.

1. Which condition caused the greatest change and what was that change?
   for Pulse (heart) rate - condition: ___________________________ change: ___________
   for SpO₂ - condition: ___________________________ change: ___________

2. Given your responses to question 1, explain why one value is more stable and the other more variable (think about how they work together).
V. B. Blood pressure and pulse (heart) rate

<table>
<thead>
<tr>
<th>Condition</th>
<th>Systolic Pressure</th>
<th>Diastolic Pressure</th>
<th>Pulse (heart)Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitting 5 minutes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laying down 5 minutes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exercise 5 minutes</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Calculate pulse pressure, stroke volume and cardiac output with results from Table 3

<table>
<thead>
<tr>
<th>Condition</th>
<th>Pulse Pressure</th>
<th>Stroke Volume</th>
<th>Cardiac Output (convert to Liters)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SBP - DBP</td>
<td>Pulse pressure $\times$ 1.7</td>
<td>SV $\times$ HR</td>
</tr>
<tr>
<td>Sitting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laying down</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exercise</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(NEXT PAGE)
Display the results from Table 3 (pulse rate and BP) on the graph on the next page – Draw a vertical line in red at the center of each column to represent blood pressure. Plot the pulse by drawing a straight blue line from each pulse point to the next. Refer to the Figure 7 as a model.
**QUESTION:**

Based on your data in the graph, draw conclusions about the relationships between exercise, pulse rate, and blood pressure.