Blood Pressure and Cardiovascular Reflexes

Objective:

To measure blood pressures, calculate pulse pressure and mean arterial pressure, and measure heart rate and arterial pressure in response to exercise and changes in posture, at the level of 85% proficiency for each student.

In order to achieve this objective, you will need to be able to:

1. Measure systolic and diastolic arterial pressure arterial pressure with a sphygmomanometer.
2. Calculate pulse pressure and mean arterial pressure, and estimate venous pressure.
3. Measure blood pressure, heart rate and pO_2 during exercise and during sitting, reclining and standing.

Materials

Group Supplies:

Stethoscope
Sphygmomanometer
Pulse Oximeter
Bench Stepping Apparatus

Lab Supplies:

Alcohol swabs
Millimeter ruler

Methods and Results

Indirect Measurement of Arterial Blood Pressure

1. Work in pairs to obtain brachial artery blood pressure readings. Obtain a stethoscope, alcohol swabs, and a sphygmomanometer. Clean the earpieces of the stethoscope with the alcohol swabs, and check the cuff for the presence of trapped air by compressing it against the laboratory table. (A partially inflated cuff will cause erroneous measurements.)

2. The subject should sit in a comfortable position with one arm resting on the laboratory table (approximately at heart level if possible). Wrap the cuff around the subject's arm, just above the elbow, with the inflatable area on the medial arm surface. The cuff may be marked with an arrow; if so, the arrow should be positioned over the brachial artery. Secure the cuff by tucking the distal end under the wrapped portion or by bringing the Velcro areas together.
3. Palpate the brachial artery, and lightly mark its position with a felt pen. Use the stethoscope, and place its diaphragm over the pulse point.

   The cuff should not be kept inflated for more than 1 minute. If you have any trouble obtaining a reading within this time, deflate the cuff, wait 1 or 2 minutes, and try again. (A prolonged interference with BP homeostasis can lead to fainting.)
4. Inflate the cuff to approximately 160 mm Hg pressure, and slowly release the pressure valve. Watch the pressure gauge and listen carefully for the first soft thudding sounds of the blood spurting through the partially occluded artery. The pressure at this point is the **systolic pressure**. Continue to release the cuff pressure. You will notice first an increase, then a muffling, of the sound. The pressure when the sound becomes muffled or disappears is the **diastolic pressure**. Controversy exists over which of the two points should be recorded as the diastolic pressure; so in some cases you may see readings such as 120/80/78, which indicates the systolic pressure followed by the *first* and *second diastolic end points.* The first diastolic end point is the pressure at which the sound muffles; the second is the pressure at which the sound disappears. It makes little difference here which of the two diastolic pressures is recorded, but be consistent. Make two blood pressure determinations, and record your results below.

	First trial:	Second trial:
Systolic Pressure		
Diastolic Pressure		

5. Compute the **pulse pressure** for each trial. The pulse pressure is the difference between the systolic and diastolic pressures, and indicates the amount of blood forced from the heart during systole. Pulse pressure is a good estimation of the force of contraction.

	First trial:	Second trial:
Pulse Pressure (S-D)		

6. Compute the **mean arterial pressure (MAP)** for each trial. Because the ventricles contract and relax, the flow of blood out of the heart is intermittent. During each cardiac cycle blood flows out of the heart for about **1/3** of the cycle, causing the **systolic** level of pressure. Blood does not flow out of the heart during the other **2/3** of the cardiac cycle, causing the **diastolic** level of pressure. For this reason, the following equation is needed to calculate mean arterial pressure.

	First trial:	Second trial:
$MAP = \frac{(D+D+S)}{3}$		

Estimation of Venous Pressure

1. Ask your lab partner to stand with his or her right side toward the blackboard, arms hanging freely at the sides. On the board, mark the approximate level of the right atrium. (This will be at about the location of your fourth / fifth rib.)

2. Observe the superficial veins on the dorsum of the right hand as the subject alternately raises and lowers it. Notice the collapsing and filling of the veins as internal pressures change. Have the subject repeat this action until you can determine the point at which the veins have just collapsed. Then measure, in millimeters, the distance in the vertical plane from this point to the level of the right atrium (previously marked). Record this value.

   Height of right arm relative to the right atrium at point of venous collapse: _____mm

3. Compute the venous pressure (Pv), in millimeters of mercury, with the following formula:

   P = 1.056 (specific gravity of blood) X mm (measured) / 13.6 (specific gravity of Hg)

   Venous pressure computed: _____ mm Hg

Normal venous pressure varies from approximately 3 to 9 mmHg. That of the hand ranges between 3 and 4 mmHg. How does your computed value compare?

_____

4. Because venous walls are so thin, pressure within them is readily affected by external factors such as muscle activity, deep pressure, and pressure changes occurring in the thorax during breathing. The Valsalva maneuver, which increases intrathoracic pressure, is used to demonstrate the effect of thoracic pressure changes on venous pressure.

   To perform this maneuver: take a deep breath, and then mimic the motions of exhaling forcibly, but without actually exhaling. In reaction to this, the glottis will close; and intrathoracic pressure will increase. Measure and record below the height of the right arm relative to the right atrium at the point of venous collapse while the subject is performing the Valsalva maneuver. Compute the venous pressure and record it below.

   Venous pressure: _____ mm Hg

   How does this value compare with the venous pressure measurement computed for the relaxed state?

Exercise (Bench Stepping)

You will be working in groups of four. Exercise will involve bench stepping?

All students in a group may, in turn, participate as the subject, if desired, but the bench stepping is to be performed by at least two subjects in each group. Ideally, one subject should be relatively well-conditioned, and the other subject should be relatively poor-conditioned. **Any student with a known heart problem should refuse to participate as a subject.**

For each subject, one student will measure arterial blood pressure, a second student will measure the pO_2 and HR, and the third student will pace the stepping of the subject.

Measurements of arterial blood pressure are obtained using the sphygmomanometer. pO_2 and heart rate are measured using the Nonin^{tm} Pulse Oximeter.

Bench stepping is the following series of movements repeated sequentially:

- Place one foot on the step
- Step up with the other foot so that both feet are on the platform. Straighten the legs and the back
- Step down with one foot
- Bring the other foot down

The pace for the stepping will be set by the "pacer", who will repeat "Up-2-3-4, up-2-3-4" at such a pace that each "up-2-3-4" sequence takes 2 sec (i.e., 30 cycles/min).

1. Obtain the step apparatus (20-in. height for male subject, or 16 in. for a female subject). If no step apparatus is available, use the stairs.
2. Obtain the baseline measurement of blood pressure and heart rate **while the subject is sitting**. Then, the subject is to stand quietly for 2 min before beginning to step.
3. The subject is to perform the bench stepping for as long as possible, up to a maximum of 5 min, according to the tempo called by the pacer. The subject is to be watched for and warned against crouching (posture must remain erect). If the subject is unable to keep the pace for a span of 15 sec, the test is to be terminated.
4. When the subject is stopped by the pacer, stops voluntarily because he or she is unable to continue, or has completed 5 min of bench stepping, **the subject is to sit down**. The duration of exercise (in seconds) is to be recorded, and the blood pressure and heart rate are to be measured immediately and at 1 min, 2 min and 3 min after bench stepping.
5. Record the data in Table 1, and repeat the testing with the second subject.

Table 1 Exercise

Bench Stepping	Subject 1			Subject 2		
	BP	pO_2	HR	BP	pO_2	HR
Baseline (Pre-exercise)						
Immediately after exercise						
One (1) min after exercise						
Two (2) min after exercise						
Three (3) min after exercise						
Duration of exercise (sec)						
Sum of last 3 heart rates	X	X		X	X	

The subject's *index of physical Fitness* is calculated using the formula below (see next page for interpretation):

$$\text{Index} = \frac{(\text{duration of exercise in seconds}) \times 100}{2 \times (\text{sum of the last 3 heart rates})}$$

Scores are interpreted according to the following scale:

below 55: poor	72 to 79: high average
55 to 62: low average	80 to 89: good
63 to 71: average	90 & up: excellent

Postural Changes

You will be working in groups of four. All students in a group may participate as the subject in turn, if desired, but the postural changes are to be performed by ***at least two subjects*** in each group.

1. You will obtain measurements of arterial blood pressure using the sphygmomanometer, and measurements of heart rate and pO_2 using the Nonin^{tm} Pulse Oximeter monitor
2. The subject sits quietly for 3 min, and cardiovascular measurements are made while the subject continues to sit.
3. The subject will lay down for 3 min, and cardiovascular measurements are made while the subject continues to lay down.
4. The subject will stand up, and cardiovascular measurements are made as quickly as possible.
5. The subject will continue to stand for 3 min, and cardiovascular measurements are made will the subject continues to stand.
6. Record your data in Table 2 and repeat the testing and recording procedure with the second subject.

Table 2 Postural Changes

Postural Changes	Subject 1			Subject 2		
	BP	pO_2	HR	BP	pO_2	HR
After sitting quietly for 3 min						
After lying down for 3 min						
Immediately on standing						
After standing for 3 min						

Discussion

1. Explain the significance of diastolic and systolic arterial pressures.
2. Explain the importance of determining pulse pressure and mean arterial pressure.
3. Explain the significance of central venous pressure.
4. For bench stepping, when did you detect changes in heart rate and / or arterial pressure relative to rest? Explain what most likely caused these cardiovascular changes.
5. For postural changes, when did you detect changes in heart rate and / or arterial pressure relative to rest (sitting)? Explain what most likely caused these cardiovascular changes.