Lab Activity 11

The Cardiovascular System

Student Learning Objectives

After completing this lab, you should be able to:

1. Define, explain and correctly use the key terms.
2. Measure a subject's blood pressure and heart rate both at rest and during exercise.
3. Calculate pulse pressure and mean arterial pressure during rest, exercise and recovery and rate pressure product for both rest and exercise.
4. Describe how the blood pressure response to exercise differs for aerobic and resistance exercise.

Equipment:

- Blood Pressure Cuff
- Cycle Ergometer
- Sphygmomanometer
- Stethoscope
- Stopwatch
- Tape Measure
- Dumbbells
- Heart Rate Monitor

Procedure

Heart rate and blood pressure will be measured at rest and during aerobic and resistance exercise. All students will practice measuring HR and blood pressure as described in protocols A, B and C; work with a partner and test each other. Two students should be selected to be subjects for determining the HR and blood pressure responses to aerobic and resistance exercise (Protocols D and E).

Protocols

A. Heart Rate Determination

1. Feel your partner's pulse at the radial and carotid arteries. Use the tips of the index and middle fingers: do not use the thumb. When palpating the carotid artery, press lightly. Too much pressure can stimulate the vagus nerve which causes HR to decrease. This method of determining heart rate is called *palpation*.
2. Listen to your partner's heart beat with a stethoscope. Usually the best sound is achieved by positioning the stethoscope over the apex of the heart. This is called *auscultation*.
3. Measure your partner's HR using each of the two methods described above.
4. Start the stopwatch when the heart beat is felt or heard and count the first beat as zero.
5. Continue counting beats for the time specified in Data Table 1.0. Always convert to beats per minute ($b \cdot min^{-1}$).

Data Table 1.0

Measurement Site	**Counted Beats**	**Convert to $b \cdot min^{-1}$**	**HR $b \cdot min^{-1}$**
Radial Pulse (1 min)		× 1	
Carotid Pulse (15 s)		× 4	
Auscultation (6 s)		× 10	
Method of Your Choice (10 s)		× 6	

B. Blood Pressure Determination[1]

1. Your partner should be seated with his arm and back properly supported and with both feet flat on the floor, i.e., legs should NOT be crossed.
2. Remove restrictive clothing from the arm to be used for measurement and position the arm at heart level.
3. Determine the appropriate cuff size (if using velcro cuffs) according to the following chart:

Relaxed Biceps Circumference	**Size of Cuff**
33–47 cm	Large Adult
25–35 cm	Adult
18–26 cm	Child

4. Place the appropriate cuff on the right arm approximately 1 inch (2.54 cm) above the antecubital space with the center of the air bladder over the brachial artery; the brachial artery can be located by slightly hyperextending the elbow and palpating the medial portion of the space.
5. Adjust the sphygmomanometer so that it is at approximately eye level.
6. Place the stethoscope over the brachial artery and inflate the cuff to any of the following levels:

- 160 mmHg.
- 20 mmHg above the subject's expected or known blood pressure.
- 30 mmHg above the disappearance of the subject's radial pulse.

7. Adjust the air release screw so that the mercury falls approximately 3 mmHg per heartbeat or 3 mmHg per second.
8. Listen for the following sounds (called *Korotkoff* sounds: see Box 1.0):

1st sound

- Sharp tap or thud caused by sudden vibration due to the rush of blood (systolic blood pressure: SBP).

2nd sound

- Metallic tapping sound; may be softer than 1st sound.

3rd sound

- Continuous thudding.

4th sound

- Muffling, softened flowing sound (diastolic blood pressure-one: DBP_1).

5th sound

- Last sound, followed by total silence (diastolic blood pressure-two: DBP_2); usually 7 to 10 mmHg lower than DBP_1.

Box 1.0: Korotkoff Sounds

	Sounds	120 mmHg
I	Onset of sharp rhythmical thuds.	There can be considerable inter-individual variation in sounds II and III
II	Whooshing sounds or soft metallic tapping.	
III	Soft rhythmical thuds	86 mmHg
IV	Noticeable drop in volume; muffling or tone change.	80 mmHg
V	Silence	

SBP: onset of sharp rythmical thuds (I)

DBP_1: onset of noticeable drop in volume and tonal change (IV)

DBP_2: last sound heard before silence (V)

9. Rapidly deflate the cuff after obtaining the blood pressure readings; it is painful for the subject if you maintain a partial constriction of the blood vessel.
10. Measure and record the blood pressure at least 3 times or until you feel you have obtained an accurate reading.

Note to student: Have your instructor check your accuracy by listening through a double stethoscope.

11. Record blood pressures in Data Table 2.0.

    For recording blood pressures, the American Heart Association recommends the following:

- Initially, blood pressure should be taken in both arms. If the pressures differ by more

than 10 mmHg between the right and left arm, thereafter use the arm with the higher pressure. Otherwise, ease of measurement may dictate the use of the right or left arm.

- For resting blood pressures, at least two readings should be taken with a minimum of 1 minute between readings.
- Use DBP_1 for children always.
- Use DBP_1 for adults if sounds are heard at rest below 40 mmHg.
- Use DBP_1 during exercise.
- Use DBP_2 for adults at rest if no sounds are heard below 40 mmHg.
- Always record and state the BP as SBP/DBP_1/DBP_2 mmHg.

Data Table 2.0		
SBP (mmHg)	**DBP_1 (mmHg)**	**DBP_2 (mmHg)**

C. Concurrent determination of Heart Rate and Blood Pressure

1. Determined your partner's SBP, close the air screw to stop the mercury from dropping, and count the number of beats in 6 seconds.
2. Open the air screw and determine DBP_1 and DBP_2.
3. Record HR (# of beats in 6 seconds × 10) and blood pressure in Data Table 3.0.

Data Table 3.0			
SBP (mmHg)	DBP_1 (mmHg)	DBP_2 (mmHg)	HR ($b \cdot min^{-1}$)

D. Cycle Ergometer Ride

1. Wear a heart rate monitor for comparison to check manual count.

Note to Student: The HR column in Data Tables 4.0, 5.0 and 6.0 have a column for a) manual HR measurement and b) HR measured using a monitor.

2. Females should work at a load of 0.5 to 1.0 kp (150–300 $kgm \cdot min^{-1}$) at 50 $rev \cdot min^{-1}$ for 15 minutes. Males should work at 1.5 to 2.0 kp (450 to 600 $kgm \cdot min^{-1}$) at 50 $rev \cdot min^{-1}$ for 15 minutes.
3. HR and blood pressure ($SBP/DBP_1/DBP_2$) are measured at rest, every third minute during exercise, and after 1 minute of recovery and recorded in Data Table 4.0.

Note to student: make sure you do not grip the handlebars while the blood pressure is being measured.

Data Table 4.0 Cycle Ergometer Ride					
Time (min)	**SBP (mmHg)**	**DBP_1 (mmHg)**	**DBP_2 (mmHg)**	**HR ($b \cdot min^{-1}$)**	
				a) manual	**b) monitor**
Rest					
3					
6					
9					
12					
15					
1 MinPost					

E. Constant Load Resistance Exercise

1. Wear a heart rate monitor for comparison to check manual heart rate count.
2. Sit with your left arm free to do one-arm biceps curls (or any other resistance exercise you choose).
3. Choose a weight that the subject can lift about 15 times for one set.
4. Lift at a cadence 2 seconds to lift and 2 seconds to lower the weight.

Note to Student: Make sure you exhale while lifting and inhale while lowering the weight, and do not grip tightly with the fingers if they are not involved in the lifting exercise.

5. Complete 5 sets of 15 repetitions using the same load for each set. Allow 1 minute rest between each set.
6. Measure HR, SBP and DBP during the last 30 seconds of each set and after 1 minute of recovery and record in Data Table 5.0.

Data Table 5.0 Constant Load Resistance Exercise						
Set	**Weight**	**SBP (mmHg)**	**DBP_1 (mmHg)**	**DBP_2 (mmHg)**	**HR ($b \cdot min^{-1}$)**	
					a) manual	**b)monitor**
Rest						
1						
2						
3						
4						
5						
1 Min Post						

F. Incremental Resistance Exercise

1. Wear a HR monitor for comparison to check manual heart rate count.
2. Sit with your left arm free to do one-arm biceps curls (or other resistance exercise you choose). The same exercise protocol from Protocol D should be used.
3. Choose a light weight for set one and use heavier weights for each succeeding set.
4. Lift at a cadence of 2 seconds to lift and 2 seconds to lower the weight.

Note to Student: Make sure you exhale while lifting and inhale while lowering the weight.

5. Complete 5 sets, lifting for 1 minute and resting 1 minute rest between sets.
6. Measure HR, SBP and DBP during the last 30 seconds of each set and after 1 minute of recovery and record in Data Table 5.0.

Data Table 6.0 Incremental Load Resistance Exercise						
Set	Weight	SBP (mmHg)	DBP_1 (mmHg)	DBP_2 (mmHg)	HR ($b \cdot min^{-1}$)	
					a)manual	b)monitor
Rest						
1						
2						
3						
4						
5						
1 Min Post						

Student Activities

Definitions

Define the key terms. For those terms which are measurable variables, describe in your own words what they mean (not how they are obtained or calculated). Indicate the unit(s) of measurement.

1. Diastolic Blood Pressure (DBP):

2. Diastolic Blood Pressure-One (DBP_1):

3. Diastolic Blood Pressure-Two (DBP_2):

4. Mean Arterial Pressure (MAP):

5. Rate Pressure Product (RPP):

6. Systolic Blood Pressure (SBP):

Analysis

1. Calculate the following variables for the cycle ergometer and both resistance exercises:

    a. Pulse Pressure:

    $PP = SBP - DBP_1$ (exercise) or DBP_2 (rest/recovery)

    b. Mean Arterial Blood Pressure (rest/recovery):

    $MAP = 1/3\ PP + DBP_2$

    c. Mean Arterial Blood Pressure (exercise):

    $MAP = 1/2\ PP + DBP_1$

    d. Rate Pressure Product:

    $RPP = (SBP \times HR) \div 100$

    Note: units of measurement are not used for this variable.

Note to Student: which DBP you use depends on whether the blood pressure was taken during rest, exercise or recovery.

For example: A student rode the bike for 15 minutes at a moderate intensity. His blood pressure and heart rate at rest were 118/86/78 mmHg and 74 b · min^{-1}, and his blood pressure and heart rate at minute 15 were 136/90/80 mmHg and 150 b · min^{-1}, respectively.

At rest:

PP = 118 − 78 = 40 mmHg

MAP = (40/3) + 78 = 91.3 mmHg

RPP = (118 × 74) ÷ 100 = 87.32

During exercise:

PP = 136 − 90 = 46 mmHg

MAP = (46/2) + 90 = 113 mmHg

RPP = (136 × 150) ÷ 100 = 204

2. If *Lab Activity 13 Maximal Oxygen Consumption* has been completed, calculate RPP for the incremental portion of the $\dot{V}O_2max$ test.

3. Graph the subject's blood pressure response (SBP, DBP_1 and/or DBP_2, and MAP) to the 15 minute cycle ergometer ride (rest, exercise at designated minutes and 1 minute post-exercise).

4. Graph the subject's blood pressure response (SBP, DBP_1 and/or DBP_2, and MAP) to the constant load resistance exercise and the incremental resistance exercise (rest, exercise by set/weight and 1 minute post).

5. Graph the subject's heart rate response to the 15 minute cycle ergometer ride (rest, exercise at designated minutes and 1 minute post-exercise).

6. Graph the subject's heart rate response to the constant load resistance exercise and the incremental resistance exercise (rest, exercise by set/weight and 1 minute post).

7. Graph each subject's rate pressure product (RPP) response to the 15 minute cycle ergometer ride, constant load resistance exercise and the incremental resistance exercise (rest, exercise at designated minutes or by set/weight, and 1 minute post-exercise).

Interpretation and Discussion

1. On the basis of all your graphs, compare and contrast the patterns of cardiovascular responses: a) between incremental aerobic exercise based on *Lab Activity 13 Maximal Oxygen Consumption*, your textbook and incremental resistance exercise measured in this lab and b) between steady state submaximal aerobic exercise and constant load dynamic resistance exercise.

2. Explain what RPP means (indicates) physiologically.

3. Why does DBP react differently to a continuous rythmical activity and a static or dynamic resistance activity?

4. Application

1. How may RPP be used in a practical situation?

2. Among the instructions given for taking blood pressure during the bicycle ergometer ride was the caution not to grip the handlebars when the blood pressure measurement was being taken. What is the physiological reason for this caution and how would you expect the values you graphed to change if the subject were gripping the handlebars tightly?

3. Among the instructions given for taking blood pressure during the resistance exercise was the caution to make sure that the subject was not holding his/her breath but instead was exhaling as the weight was lifted and inhaling when the weight was lowered. What is the physiological reason for this caution? How would you expect the values you graphed to change if the subject was holding his/her breath?

3. References:

1. American Society of Hypertension Public Policy Position Paper (1992). Recommendations for Routine Blood Pressure Measurement by Indirect Cuff Sphygmomanometry. *American Journal of Hypertension,* 5, 207–209.

Related Readings References

1. Plowman, S.A. & Smith, D.L. (2011) *Exercise Physiology for Health, Fitness and Performance.* (3rd ed.). Baltimore: Lippincott, Williams & Wilkins; pp. 349–342, 351–352.