

What Effects Does Exercise Have on You?

Suggestions for Teachers

Purpose

To explore the responses of the heart and blood pressure to exercise

Objectives

- 1) To learn how to take a pulse and blood pressure reading
- 2) To learn how heart rate responds to exercise
- 3) To learn how blood pressure responds to exercise

Materials

- 16" high bench or step
- blood pressure cuff (sphygmomanometer)
- stethoscope
- Graph paper, poster board or overhead transparencies to make heart rate and blood pressure graphs

Procedure

1. Practice taking your or a colleague's pulse before the lesson.
2. Practice taking a colleague's blood pressure before the lesson (see diagram).
3. You will find that it is easier for students to take pulse and blood pressure readings if all groups start and stop the step test at the same time ... the room must be quiet while readings are being taken.
4. You may modify the step test to fit your particular situation. For example, we have done the step test on choir risers, bleachers, and building steps. If the step test is not feasible, an alternate exercise could be substituted. However, if you do not use the step test, student numbers are not as accurate for the extension activity in Module #3.

Safety

- Students should NOT take the pulse at the carotid artery in the neck.
- You may want to get parental permission slips for students participating in the step test. This is a relatively strenuous activity in which all students may be unwilling or unable to participate. The more athletic students in your class should have no difficulty with the activity.
- Be sure to have at least one student in each group designated as a "spotter" in case the step tester stumbles.

Suggestions for Assessment

Groups can turn in the answers to their analysis questions or can write a complete laboratory report.

References and Resources

McArdle, W.D., Katch, F.I., & Katch, V.L. (1991). *Exercise Physiology* (3rd edition). New York: Lea & Febiger.

Vander, A.J., Sherman, J.H., & Luciano, D.S. (1994). *Human Physiology: The Mechanisms of Body Function* (6th edition). New York: McGraw-Hill, Inc.

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Information for Students

Background Information

The cardiovascular system is the important link between the transport of oxygen from the lungs to other parts of the body, its delivery to tissues, and its use in those tissues. It is essential for life in ALL animal species. In humans, the heart plays an important role in moving blood, loaded with oxygen, which is then consumed during cellular respiration. The response to exercise offers an excellent opportunity to observe and learn about the physiological principles of oxygen transport and utilization. In this laboratory, you will be able to study the response of the heart and/or blood pressure to exercise.

Materials

- Stopwatch
- 16" high bench or step
- blood pressure cuff (sphygmomanometer)
- stethoscope

Procedure

1. Do these activities in groups of three students. One student should volunteer to be the first experimental "subject."
2. The "subject" should be seated and at rest for a minute or two before you measure his/her pulse. Find your partner's radial pulse (on the thumb side of the inner wrist) and count it for the times directed below. Then use the multiplication factor to calculate the number of beats per minute. If you have difficulty finding the pulse in the wrist, try the other arm and or the ankles. DO NOT take the pulse from arteries in the neck area.

Count pulse for:	Record the count	Multiply by...	Beats per minute
60 seconds		x 1 =	
30 seconds		x 2 =	
15 seconds		x 4 =	
10 seconds		x 6 =	
6 seconds		x 10 =	

3. While still seated, measure the subject's blood pressure using the stethoscope and blood pressure cuff. You should measure both the systolic and diastolic pressures. The systolic pressure is the pressure inside the artery when the heart is contracting and the diastolic pressure

is the pressure inside the artery when the heart is refilling with blood. Record your findings below and calculate the subject's Mean Arterial Pressure (MAP), using the following formula:

$$\text{Mean Arterial Pressure} = \text{Diastolic Pressure} + 1/3 (\text{Systolic Pressure} - \text{Diastolic Pressure})$$

or

$$\text{MAP} = \text{DP} + 1/3(\text{SP}-\text{DP})$$

4. Add your data to the charts that your teacher has provided and to the chart below.

Measurements taken...	Heart rate (beats/min)	Mean Arterial Pressure
At rest		
After exercise		

5. Now that you are good at finding and recording the pulse rate and blood pressure, you can perform the Physical Fitness Step Test that is used to predict a person's maximum O₂ uptake and observe acute physiological changes due to exercise. The subject should do the Step Test in the following way:

- The subject steps at a rate of 22 steps per minute (female) or 24 steps per minute (male) for 3 minutes total. The other team members should "spot" for the subject in case he/she stumbles during the test.
- After exercise, the subject remains standing. Wait 5 seconds (find the pulse during this time) and then begin counting a 15-second heart rate count at the radial artery (as you did before). Be prepared to count quickly since the rate will be faster than before! At the same time, take a blood pressure reading (on the arm opposite to the one where you are measuring the pulse).
- Record your findings on the table above and calculate the ratio of the heart rate during exercise to the heart rate at rest (from the measurements you made in step #2 above) and the ratio of the MAP during exercise to the MAP at rest.

Analysis

- What happens to the resting heart rate (in beats per minute) depending upon how long you take your measurements? Why could you get different answers for different measurement times?
- Not everyone has the same resting heart rate. Add your data to a histogram of resting heart rate for everyone in the class. What might explain the variability in heart rate between individuals?
- Cardiac output is the amount of blood moved by the heart. Cardiac output depends on both the rate the heart is beating and the volume of blood the heart moves with each beat (that is, the stroke volume).

If a normal cardiac output is 6 liters/minute (when the person is at rest), use your resting heart rate to find out the stroke volume.

$$\begin{aligned}\text{Cardiac output} &= (\text{heart rate})(\text{stroke volume}) \\ 6 \text{ liters/minute} &= (\text{heart rate})(\text{stroke volume})\end{aligned}$$

What is your stroke volume? _____

4. What happens to the heart rate when you exercise? Why do you think it is important for this to occur?
5. Divide your post-exercise heart rate by your resting heart rate. How many times faster was your heart beating after exercise? (Example: If your resting heart rate=72 and your post-exercise heart rate=154, then: $154/72=2.1$... or your heart was beating more than 2 times as fast after exercise).
6. If stroke volume remains constant (doesn't change), calculate your cardiac output after exercise. (Hint: Use the stroke volume you calculated in question #3 above). Remember...

$$\text{Cardiac output} = (\text{heart rate})(\text{stroke volume})$$

What is your cardiac output after exercise? _____

7. What happens to the Mean Arterial Pressure (MAP) when you exercise? Why do you think it is important for this to occur?
8. What happened to the systolic pressure when you exercised? What happened to the diastolic pressure when you exercised? How might you explain this difference?
9. As you look at your data, what other questions come to mind about how the cardiovascular system responds to exercise? Write your questions down ... we'll be exploring your findings further in the next activity.

Going Further: Extension questions on flow, pressure, and resistance

The flow of a liquid between two points in a tube (such as the flow of blood through an artery or vein) is related to the pressure difference between the points (ΔP) and the resistance to flow. This can be represented as:

$$\text{Flow} = \frac{\text{Pressure Difference}}{\text{Resistance}}$$

Therefore, flow increases as the pressure difference increases and as resistance decreases. For our cardiovascular system, flow is cardiac output (in liters/minute) and the pressure difference is the mean arterial pressure (MAP).

Part 1

If we assume that resistance (R) is constant, what would you predict your MAP to be **after** exercise?

Example: If your resting heart rate is 70 beats/minute your heart rate after exercise is 130 beats/minute, and your resting MAP is 120 mmHg, then...

$$\text{Flow}_{\text{rest}} = 6 \text{ liters/minute (see question \#3)}$$

$$\text{Flow}_{\text{exercise}} = 11 \text{ liters/min}$$

$$\Delta P_{\text{rest}} = 120 \text{ mmHg}$$

Remembering that...

$$\text{Resistance} = \frac{\text{Pressure Difference}}{\text{Flow}}$$

Adding the data we know in our example...

$$\frac{\Delta P_{\text{exercise}}}{\text{Flow}_{\text{exercise}}} = R = \frac{\Delta P_{\text{rest}}}{\text{Flow}_{\text{rest}}}$$

$$\frac{\Delta P_{\text{exercise}}}{\text{Flow}_{\text{exercise}}} = \frac{\Delta P_{\text{rest}}}{\text{Flow}_{\text{rest}}}$$

$$\frac{\Delta P_{\text{exercise}}}{11 \text{ L/min}} = \frac{120 \text{ mmHg}}{6 \text{ L/min}}$$

$$\Delta P_{\text{exercise}} = 220 \text{ mmHg}$$

1. Now, try this with your data. Using the cardiac output you calculated in question #6, what's your predicted MAP after exercise? (show your work)

2. Finally, compare your predicted MAP to the actual MAP value you obtained earlier. Was your MAP higher or lower than you predicted?

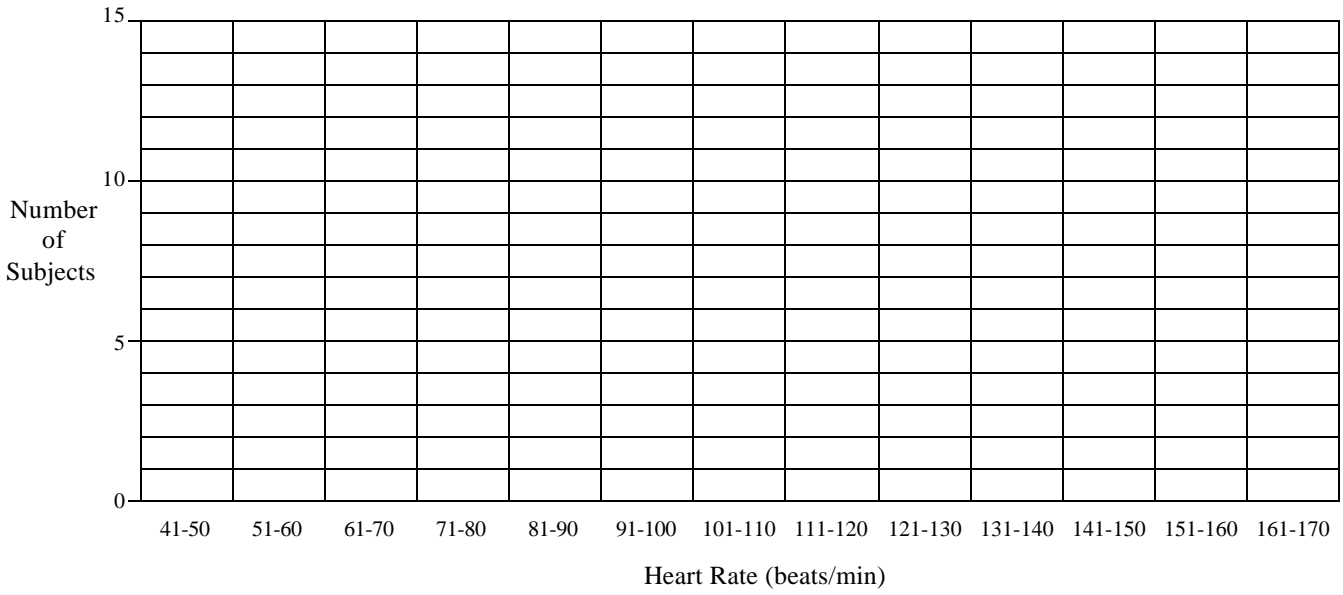
Part 2

If your prediction did not prove true, then our assumption that the resistance was the same in both cases (rest and exercise) must be incorrect. This time, use your actual MAP (the reading you obtained earlier) to determine how vascular resistance responds during exercise.

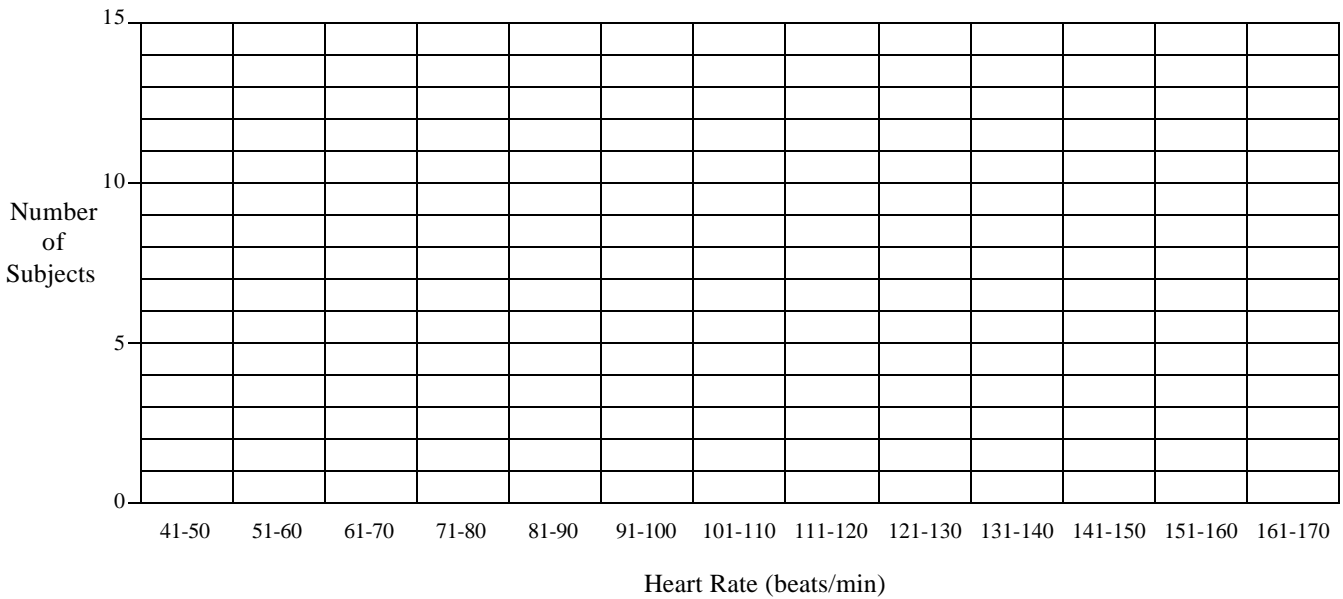
(Hint: Use the cardiac output (flow) that you calculated in question #6 along with the actual MAP you measured and the relationship between flow, resistance, and pressure difference.)

1. What is your conclusion?
2. Does resistance increase or decrease during exercise?
3. Write at least two ideas you have of how resistance can decrease quickly in the cardiovascular system. (Remember these are hypotheses. Just think about what you know and offer up some ideas).

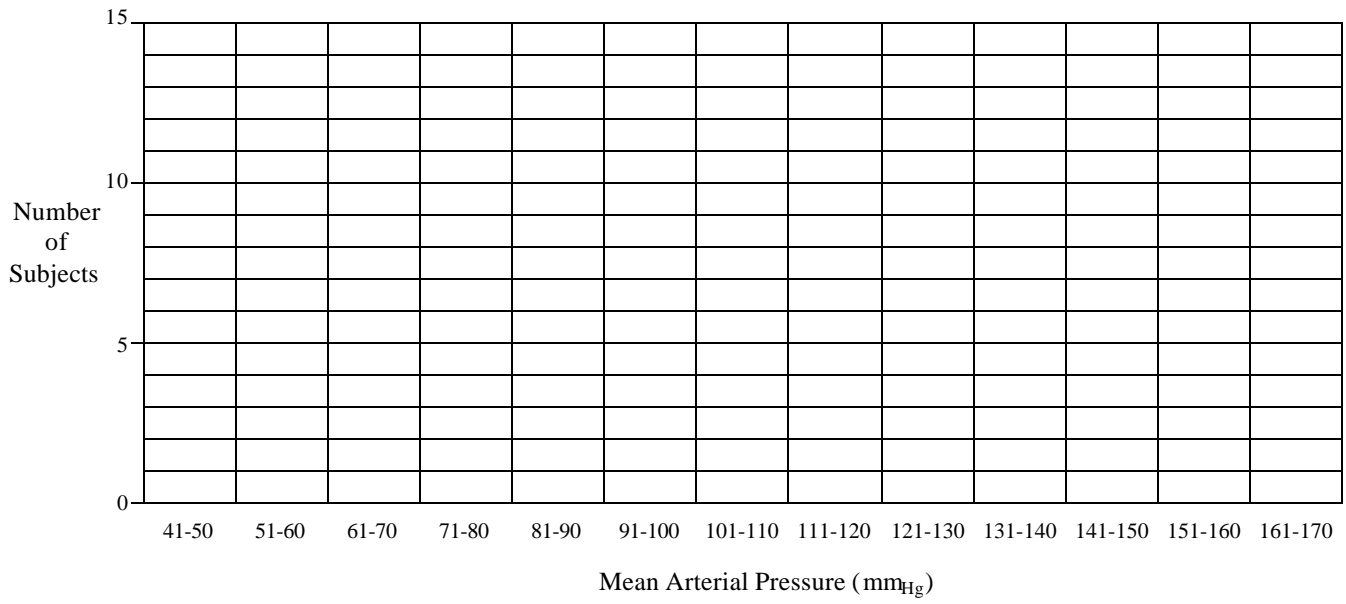
Class Data for Resting Heart Rate Measured over 15 Seconds



Class Data for Post-Exercise Heart Rate Measured over 15 Seconds



Class Data for Resting Mean Arterial Pressure (MAP)



Class Data for Post-Exercise Mean Arterial Pressure (MAP)

