Blood Pressure and Exercise

LabQuest **8**

Constant pressure is required to pump blood through the circulatory system. This ensures the delivery of oxygen and nutrients to and the removal of carbon dioxide and waste products from tissues. Positive pressure is created by forceful contraction of the left ventricle of the heart, measured as *systole*. It is maintained during relaxation of the ventricle by closure of the aortic valve and recoil of arteries, measured as *diastole* (see Figure 1).

Mean arterial pressure (MAP) is not a simple average of the two pressures, because the duration of diastole is twice that of systole. MAP is used by emergency room and intensive care unit personnel as a measure of the adequacy of blood supplied to vital tissues (such as the brain, heart, and kidneys) when the blood pressure is dangerously low.

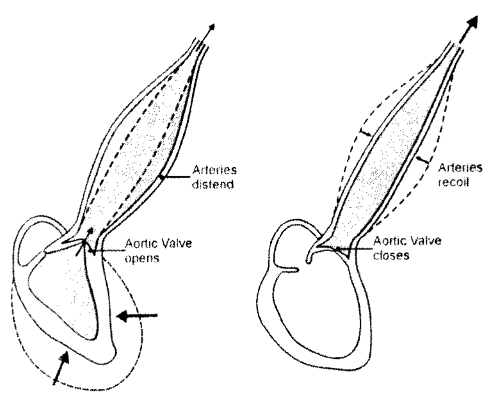
$$\frac{(systole + 2(diastole))}{3} = MAP$$

The mean arterial pressure is directly proportional to *cardiac output* and inversely proportional to *total peripheral resistance*, where:

> *Cardiac output* is the amount of blood pumped out of the heart with each beat (called the *stroke volume*) multiplied by the number of beats per minute. C.A.= s.v. **x** b.p.m.
>
> *Total peripheral resistance* depends on blood viscosity, length of the arterial system, diameter and elasticity of the blood vessels, and the pressure entering versus leaving the arterial system (systolic pressure minus the pressure in the venous system).

Blood pressure is traditionally reported with the *systolic* pressure stated first and the *diastolic* pressure stated second. In adults, 120/80 and below is considered normal blood pressure. High blood pressure is 140/90 or above. The seriousness of low blood pressure, as well as the health risks of high blood pressure (also called *hypertension*), have been elucidated over the past several decades. High blood pressure is a major risk factor for a number of health problems including strokes and congestive heart failure. Diet and exercise are beneficial, but many people require medication for optimal blood pressure control.

In this experiment, you will examine your blood pressure using the Vernier Blood Pressure Sensor. You will compare blood pressure readings taken before and after exercise and measure changes in systolic, diastolic, and mean arterial pressures. You will also consider the effect that exercise has on cardiac output and peripheral vascular resistance.



Ventricular Contraction (systole)   Ventricular Relaxation (diastole)

Figure 1

OBJECTIVES

In this experiment, you will

- Obtain graphical representation of blood pressure.
- Compare changes in systolic, diastolic, and mean arterial pressures with exercise.
- Use blood pressure readings and pulse to infer changes in cardiac output and peripheral vascular resistance with exercise.

MATERIALS

LabQuest	Vernier Blood Pressure Sensor
LabQuest App	watch with second hand

PROCEDURE

Select one person from your lab group to be the subject.

Part I Baseline Blood Pressure

1. Connect the Blood Pressure Sensor to LabQuest and choose New from the File menu.
2. Attach the Blood Pressure Sensor to the blood pressure cuff if it is not already attached. There are two rubber tubes connected to the cuff. One tube has a black Luer-lock connector at the end and the other tube has a bulb pump attached. Connect the Luer-lock connector to the stem on the Blood Pressure Sensor with a gentle half turn.
3. Attach the Blood Pressure cuff to the upper arm, approximately 2 cm above the elbow. The two rubber hoses from the cuff should be positioned over the biceps muscle (brachial artery) and not under the arm (see Figure 2).
4. Have the subject sit quietly in a chair and avoid moving his or her arm or hand during blood pressure measurements.
5. Start data collection. Immediately begin to pump until the cuff pressure reaches at least 160 mm Hg. Stop pumping.
6. Immediately feel for the radial pulse (place two or three fingers over the radial artery in the wrist proximal to the thumb) in the arm without the Blood Pressure cuff. Count the beats over 20 s. Multiply by 3 to obtain the number of beats per minute. Record this value in Table 1.

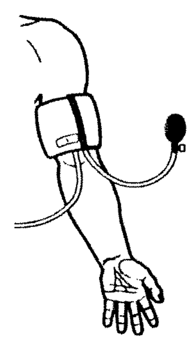


Figure 2

7. When the blood pressure readings have stabilized (after the pressure drops to 50 mm Hg), the program will stop calculating blood pressure. At this point, you can stop data collection. Release the pressure from the cuff, but do not remove it.
8. Tap the Meter tab and record the systolic, diastolic, and mean arterial pressures in Table 1.

Part II Blood Pressure After Exercise

9. With the blood pressure cuff still attached to his/her arm, the subject from Part I of the experiment should run in place for 2 minutes. At the end of 2 minutes, the subject should sit

10. Start data collection. Immediately begin to pump until the cuff pressure reaches at least 170 mm Hg and then stop pumping.

11. Immediately feel for the radial pulse (place two or three fingers over the radial artery in the wrist proximal to the thumb) in the arm without the Blood Pressure cuff. Count the beats over 20 s. Multiply by 3 to obtain the number of beats per minute. Record this value in Table 2.

12. When the blood pressure readings have stabilized (after the pressure drops to 50 mm Hg), the program will stop calculating blood pressure. At this point, you can stop data collection. Release the pressure from the cuff, and remove the cuff from the subject's arm.

13. Tap the Meter tab and record the systolic, diastolic, and mean arterial pressures in Table 2.

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DATA

Table 1–Baseline Blood Pressure			
Systolic pressure (mm Hg)	Diastolic pressure (mm Hg)	Mean arterial pressure (mm Hg)	Pulse (bpm)

Table 2–Blood Pressure After Exercise			
Systolic pressure (mm Hg)	Diastolic pressure (mm Hg)	Mean arterial pressure (mm Hg)	Pulse (bpm)

DATA ANALYSIS

1. Describe the trends that occurred in the systolic pressure, diastolic pressure, mean arterial pressure, and pulse with exercise. Assume that the stroke volume increased from 75 mL/beat to 100 mL/beat. Use this information and the change in pulse with exercise to calculate the change in *cardiac output* (stroke volume × heart rate) that occurred per minute.

2. *Pulse pressure* is the difference between systolic pressure (peak pressure during active contraction of the ventricles) and diastolic pressure (the pressure that is maintained even while the left ventricle is relaxing). Describe the change in pulse pressure seen with exercise. Which component of the blood pressure is most responsible for this change?

3. A change in pulse pressure can be seen in a variety of medical conditions. What would you expect to happen to the pulse pressure in the following examples?

   (a) In atherosclerosis there is a hardening of the arterial walls.

   (b) A damaged aortic valve does not seal properly and allows blood to flow back into the ventricle during diastole.

4. When blood pressure is taken, the first sound of Korotkoff is heard when the cuff pressure equals the ______________ blood pressure, and the last sound is heard when the cuff pressure equals the ________________ blood pressure.

5. Suppose a person's blood pressure is 165/110. What is his/her,

   a. systolic pressure? b. diastolic pressure?

   c. pulse pressure? d. mean arterial pressure?

6. What condition does the person in question 2 have? Explain the dangers of this condition.

EXTENSION

Blood pressure is traditionally obtained by using a stethoscope to listen to the brachial artery. The pumping of air into the blood pressure cuff acts to stop the blood flow through this artery. As the pressure is released, the blood again is allowed to flow. When the blood begins to flow, pulsations can be heard through the stethoscope. The pressure in the cuff at that time can be noted, and corresponds closely to the systolic blood pressure. As pressure continues to be released from the cuff, the pulsations of the artery become less audible. The pressure at which they disappear has been found to approximate the diastolic pressure. These sounds are known as *Korotkoff Sounds*.

With a stethoscope, obtain the blood pressure of a classmate by listening for the appearance and disappearance of pulsations as the pressure in the cuff is released. Compare this to the blood pressure you obtained with the Vernier Blood Pressure Sensor or with either of the two electronic *sphygmomanometers* in class.

Manually measured b.p.= **Electronically measured b.p.=**