Lab 1: Blood Pressure and the Sympathetic Nervous System

CONCEPTS

<u>Physiology</u>

- blood pressure
- systole
- diastole
- mean arterial pressure (MAP)
- sympathetic vs. parasympathetic nervous system
- flight or fright response
- vasoconstriction vs. vasodilation

<u>Engineering</u>

- pressure transducer
- differential amplifier
- weighted average
- oscillatory activity
- envelope
- DC vs. AC

BACKGROUND

<u>Blood pressure</u>

Blood pressure is a measure of the changing fluid pressure within the circulatory system. It varies from a peak pressure produced by contraction of the left ventricle, to a low pressure, which is maintained by closure of the aortic valve and elastic recoil of the arterial system. The peak pressure is called *systole*, and the pressure that is maintained even while the left ventricle is relaxing is called *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.

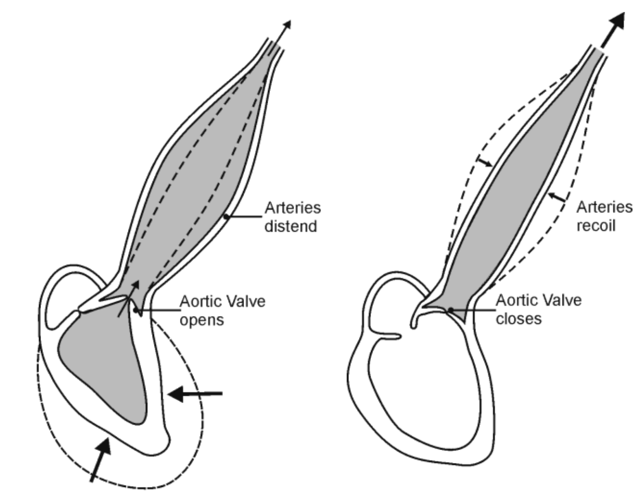
Blood pressure is traditionally reported with the *systolic* pressure stated first and the *diastolic* pressure stated second. In adults, 120/80 and below is considered normal blood pressure. High blood pressure is 140/90 or above. The seriousness of low blood pressure, as well as the health risks of 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.

Sympathetic nervous system

In this experiment, you will examine the hemodynamic changes (changes in the forces involved in blood circulation) that prepare the body for a “fight or flight” response. This response describes the physiological changes that occur when the sympathetic nervous system is activated to protect oneself from danger. This response is characterized by several physiological changes which help to achieve the following goals (as described by ChangingMinds.org):

- Our senses are sharpened.
- Energy is conserved so that we can focus our energy on “fighting”or taking “flight” (i.e., fleeing).
- Our body’s resources (oxygen, energy) are diverted toward muscles for fight or flight.
- Our body prepares to protect itself and minimize damage to itself in the case of injury/harm.

The sensitivity of blood pressure to harmful external or internal injuries makes it useful as a *vital sign*, an indicator of health, disease, excitement, and stress. You will compare blood pressures taken before and after exposure to a cold stimulus, which activates the sympathetic nervous system.



Ventricular Contraction (systole) | Ventricular Relaxation (diastole)

Figure 1

Oscillometric method of blood pressure measurement

In this lab, blood pressure is measured using the oscillometric method. This method is based on the principle that blood pumped through the arteries by the heart causes the arterial walls to flex. First, a cuff is placed around the upper arm to occlude the brachial artery. When the cuff is inflated and then slowly deflated at a constant rate, an arterial pressure pulse forms, which passes through the arm and into the cuff itself. When the cuff reaches maximum inflation, the artery becomes highly occluded which stops pulsations of the blood. As the pressure in the cuff slowly decreases, blood pressure increases and the blood is forced through the artery in short pulses. As the pressure in the cuff continues to decrease, the pulses become increasingly significant until maximum amplitude is reached.

The cuff pressure corresponding to this amplitude approximates the mean arterial pressure (MAP). At that point, the pulses will begin to decrease with any further decrease in cuff pressure. These pressure pulses form an oscillating waveform and the peak- to-peak amplitudes of this waveform create a bell shaped "envelope" (Figure 2). The systolic blood pressure (SBP) is calculated by determining the point along the envelope prior to the MAP using a known percentage of the maximum amplitude. Diastolic blood pressure is calculated using the same method but with the portion of the envelope following the MAP.

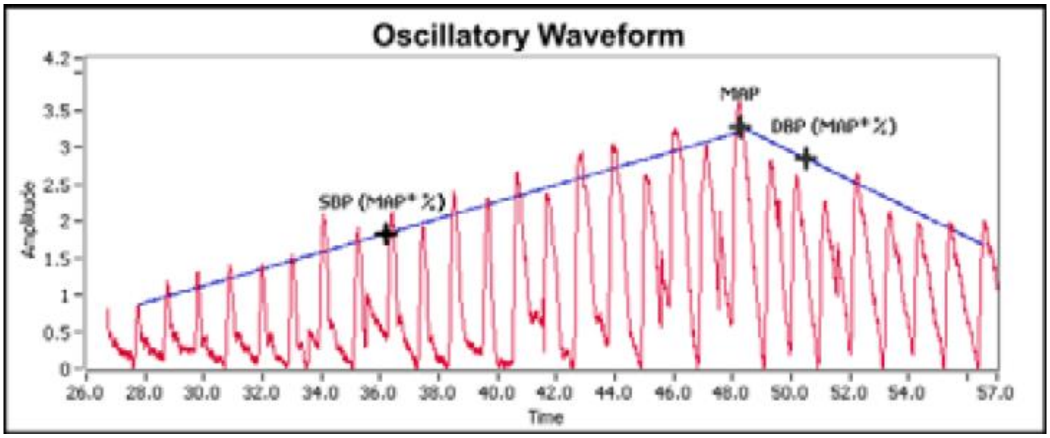


Figure 2. Oscillating waveform from blood pressure pulses.

OBJECTIVES

In this experiment, you will

- Obtain graphical representation of blood pressure.
- Compare systolic, diastolic, and mean average blood pressure before and after exposure to cold stimulus.
- Observe an example of sympathetic nervous system activation ("fight or flight" response).

MATERIALS

computer
Vernier computer interface
Logger *Pro*
Vernier Blood Pressure Sensor
ice water bath
towel (paper or cloth)

PROCEDURE

Select one or more persons from your lab group to be the subject(s).

Part I Baseline Blood Pressure

1. Connect the Blood Pressure Sensor to LabQuest. There are two rubber tubes connected to the pressure 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.

2. Open the file "07 Blood Press Vital Sign" from the *Human Physiology with Vernier* folder.
3. Attach the Blood Pressure cuff firmly around 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 with his or her forearm resting on a table surface. *The person having his or her blood pressure measured must remain still during data collection; there should be no movement of the arm or hand during measurements.*
5. Click Collect to begin data collection. Immediately pump the bulb pump until the cuff pressure reaches at least 160 mm Hg. Stop pumping. The cuff will slowly deflate and the pressure will fall. During this time, the systolic, diastolic, mean arterial pressures, and pulse will be calculated by the software. These values will be displayed on the computer screen. **Answer DA Q1.** When the cuff pressure drops below 50 mm Hg, the program will stop calculating blood pressure. At this point, you can terminate data collection by clicking Stop. Release the pressure from the cuff, but do not remove it.

Figure 2

6. Enter the pulse and the systolic, diastolic, and mean arterial pressures in the appropriate row of Table 1.
7. Store the data by choosing Store Latest Run from the Experiment menu.

Part II Blood Pressure Response to Cold

8. Prepare an ice water bath for use in the next step. The subject will be instructed to place his or her opposite hand (the one to which the Blood Pressure cuff is not attached) in the ice water bath for 15 s.

9. Collect data to examine the body's response to cold.
   a. With the cuff still attached, have the subject from Part I put the hand of his or her non-cuffed arm in the ice water bath.
   b. As soon as the subject's hand enters the ice water bath, start data collection.
   c. Pump the bulb until the cuff pressure reaches at least 160 mm Hg, then stop pumping.
   d. When data have been collected for 15 s, have the subject remove his or her hand from the ice water bath.
   e. 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.

9. Enter the systolic, diastolic, and mean arterial pressures, and the pulse in the appropriate row of Table 1.

DATA

	Table 1-- Blood Pressure Data			
Condition	**Systolic pressure (mm Hg)**	**Diastolic pressure (mm Hg)**	**Mean arterial pressure (mm Hg)**	**Pulse (beats/minute)**
Baseline				
Cold stimulus				

DATA ANALYSIS

1. Watch the meter as the cuff pressure falls. Write your observations. What physiological events or behavior correspond to these observations?

2. For each of the desired behaviors/responses that occur when the sympathetic system is activated, list 1 or 2 physiological changes that would enable the goal to be achieved.

Desired behavior / goal	**Organ/organ system**	**Physiological change**	**Possible specific reason (more direct effect)**
Sharpened senses			
Prepare muscles for running or fighting			
Conserve energy			
Reduce potential blood loss			

3. Describe the trends that occurred in the systolic pressure, diastolic pressure, mean arterial pressure, and pulse with cold stimulus. How might these be useful in a "fight or flight" response?

4. 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*.

   Sketch and annotate a diagram of the cuff pressure and the blood pressure to illustrate how this method works.