Lab #3: Blood Pressure and Plethysmography

Materials Required: iWorx ETH-256 Bioamplifier with NI USB-6009 Interface; LabScribe Software; Blood pressure cuff (with sensor and analog gauge); Stethoscope; Finger pulse plethymosgraphic pickup.

Introduction:

Peripheral blood pressure measurements are a standard assessment tool in medicine. There are several reasons for this. First, these measurements are generally reliable and take little time; second, they can be performed with good accuracy by almost anyone, with a little training; and third, they are an important long-term metric in evaluation of a patient's health. Excessive deviation from an established history of normal blood pressure readings may signal impending disease, which can then be investigated and treated early in its course. In this experiment you'll learn to accurately take blood pressure using a pressure cuff and stethoscope. You'll also measure the effect of moderate exercise on blood pressure.

Plethysmography is the measure in the change of volume of organs due to blood pressure variations. Such changes do not indicate absolute pressure or flow, but rather are indicative of general pressure *changes* in relation to vascular and tissue *compliance*. However, plethysmography can also be used for rough, qualitative comparison of circulation between corresponding limbs, and can also be used to assess changes in flow. In this experiment you'll observe and record blood pressure waves using plethysmography, and you'll also learn how automated blood pressure measurements can be taken using this technology.

Auscultation: Korotkoff Sounds

Auscultation means listening to sounds within the body. In 1905, Dr. Nikolai Korotkoff reported these sounds, which result when the flow of blood through an artery is constricted. In a typical blood pressure measurement, a pressure cuff is placed on the upper arm. When the cuff is inflated above the systolic pressure, the cuff uniformly compresses the tissues in the upper arm to this pressure, and as a result the flow in the brachial artery is halted. No sounds are produced, as no blood is flowing.

The cuff pressure is then slowly lowered; as its pressure falls below systolic, blood begins to flow in short spurts through the artery. This produces a Korotkoff Type I sound, a "snapping" or "thudding" sound. The sphygmomanometer reading at this point is the *systolic* reading. The sound is due to the turbulent flow ("squirting") of blood through the constricted artery, where normally there would be silent laminar movement.

As the pressure in the cuff is bled off further, Type II sounds (loud blowing) will be heard. The cuff pressure is then between systolic and diastolic.

About 10 mm Hg above diastolic, the sounds change in character to a soft thud (Type III) and soft blowing (Type IV), and then as the pressure in the cuff drops *below* diastolic, silence is heard (Type V sound). The diastolic pressure is recorded at the transition between Type IV and Type V sounds, at the exact point where the Type IV sounds disappear.

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To accurately measure blood pressure in this way requires a quiet environment, since the Type IV sounds are very weak. (A noisy environment will produce positive bias in the diastolic measurement).

Certain medical conditions can lead to erroneous readings. Advanced diabetes often results in hardened arteries, which don't compress as easily as the surrounding tissues, leading to auscultory results that are higher than actual blood pressure. The fifth sound may be very difficult to identify in a pregnant patient (and in this case, the observer listens for the fourth sound to report diastolic pressure).

Comparison of right and left arm readings can help validate the measurements. In normal individuals, a small variance (< 10 mm Hg) may be present between arms. The pressure can also be measured in either leg. An appropriately-sized cuff can be placed either on the thigh or lower leg, and the stethoscope can be placed either in the popliteal space (behind the knee) or at the posterior tibial artery. In the latter case, the sounds will be very low in amplitude, and the observer will have to listen very carefully!

It's important to remember that the position of the blood pressure reading corresponds to the location of the cuff, *not* the stethoscope.

It's important to never use more pressure than necessary when inflating the cuff. For normal adults, start with the pressure at or below 150 mm Hg, and only go above this value if you can't hear the onset of the Type I sounds.

Always perform readings as quickly as you can while maintaining accuracy. Never leave a cuff in place for more than three minutes.

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Lab Procedure:

1. With your team members at rest, record their blood pressures using the auscultory method.

   For each team member, record both left and right arm readings. (If your team has three or more members, each person on the team should record the readings from the remaining two (or more) members, so that each person gets several chances to practice taking pressure readings.) Report these in tabular form.

2. Set up iWorx to measure the pulse and blood pressure. This will take a few steps:

   a) Connect the blood pressure cuff transducer to Channel 1, and the finger pulse plethysmograph pickup to Channel 2.

   b) Set the ETH-256 bioamplifier as follows (these are suggested starting settings, you may need to "tweak" as you go):

   Ch1: HPF=DC, GAIN=X1, LPF=50 Hz
   Ch2: HPF=0.3 Hz, GAIN=X5, LPF=150 Hz.

   c) Start LabScribe, and calibrate Channel 1 to the blood pressure cuff.

   * Place the cuff on a non-moving, solid object such as a table leg.
   * Pump up the cuff to 50 mm Hg.
   * Read the dc voltage reported by LabScribe.
   * Repeat for 100 mm Hg, 200 mm Hg and determine what output voltage corresponds to each 100 mm Hg change in pressure.
   * Calibrate LabScribe. The instructor's data looked like this:

Pressure, mm Hg	Cuff Output Voltage
50	-1.074 V
100	-2.13 V
200	-4.25 V

   * You will need to invert Channel 1.
   * The calibration screen will look something like this:

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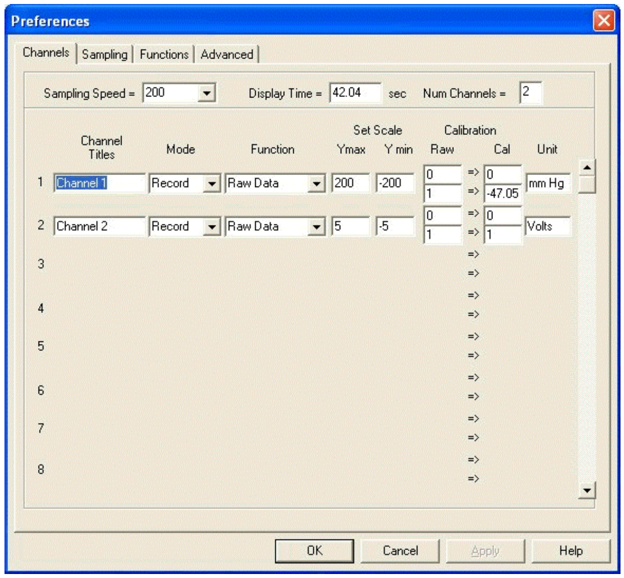

Figure 1: Setup for pressure calibration on Channel 1

d) There's no calibration for the pulse plethysmograph, since it only reports relative pressure changes.

3. Measure the blood pressure of each group member using iWorx:

a) Place the pressure cuff on the upper arm, and the finger sensor on the volar surface of the index finger.

b) Start recording, and pump up the cuff appropriately.

c) Slowly lower the pressure in the cuff while observing the signal from the plethysmograph. When the signal re-appears, the cuff pressure is equal to the systolic pressure.

d) This method will *not* measure diastolic pressure. (Why not?)

e) You should see a pattern like this on the iWorx display:

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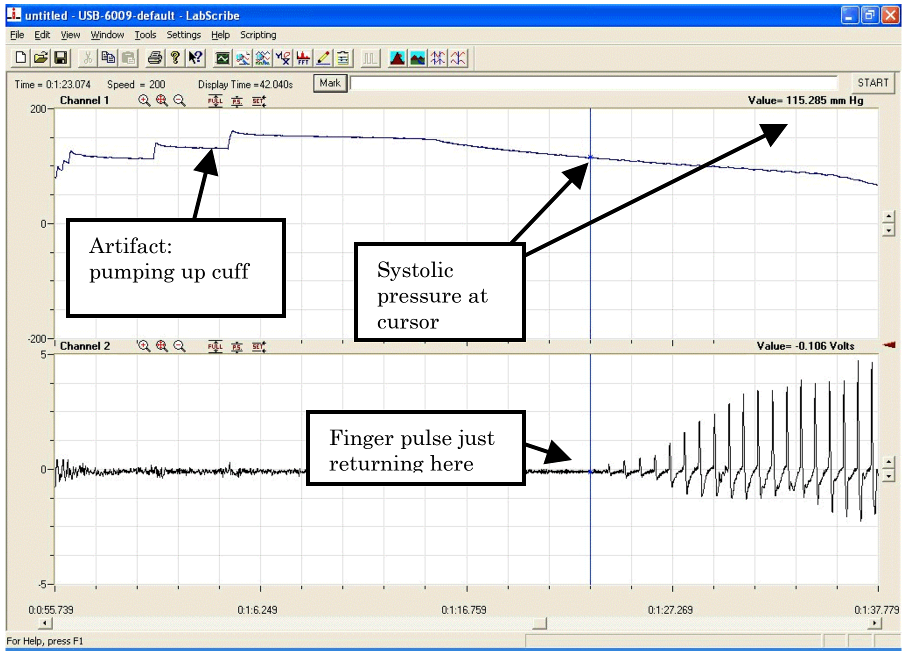

Figure 2: iWorx display of blood pressure using plethysmographic pickup

4. Using the cursors, you can measure the pulse rate of the individual. Record this as part of the baseline data for that person.

5. Measure the effect of moderate exercise:

   a) Have an individual perform a medium level of exercise for two minutes. (The easiest way to achieve this is to use the stairs a few times, or briskly walk a couple of times around the perimeter of the building).

      WARNING: Persons with preexisting health problems should not do this!

   b) Repeat the blood pressure and pulse rate measurements using both auscultory and iWorx. (You'll have to work quickly to get consistent results. The practice from Step #1 will pay off here!)

Data to Include in your Report

The data from each step in the experiment should be included. You may wish to unify the data from Steps 3 and 5, since these are both recorded using iWorx and demonstrate the effect of physical exercise.

Don't forget to fully explain the calibration procedure you performed in Step 2! Document all equipment settings and measurements used in the process, as well as any troubleshooting you had to perform.

Remember that a quantitative conclusion is required in your report. This conclusion should be based on the numerical (quantitative) data recorded during the experiment.

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