

Lab 7: Electrocardiogram, Exercise and Peripheral Circulation

Overview

The arterial system functions as a pressure reservoir. Blood leaves the arterial system continuously through the capillaries, but enters intermittently from the heart. Between contractions the heart is relaxed (called diastole) and the chambers fill with blood from the veins. During this time no blood flows into the arterial system from the heart, but blood flows out through the capillaries; as a result, the arterial pressure slowly declines. When the ventricles contract (called systole) the pressure of the blood inside the ventricles increases to close the atrioventricular valves. Further contraction increases the ventricular pressure until it exceeds the arterial pressure. At this point, when the arterial pressure is at its lowest point during the cardiac cycle (called diastolic pressure) the semilunar valves are forced open, and blood flows into the artery. Blood entering the arterial system inflates the arteries a little and increases blood pressure to a maximum – the systolic pressure.

While the variation in arterial blood pressure during the cardiac cycle is smoothed out by the inherent elasticity of the major arteries, blood still exhibits pulsatile flow through the arteries and arterioles. In this lab you will measure the pulsatile flow of blood through the finger of a student volunteer and correlate it with the ECG. In addition you will examine the effects of temperature on peripheral circulation.

At rest, the distribution of blood to a particular organ may be very different from that seen during exercise. For example, the blood flow to the gut decreases during exercise, while blood flow to the skeletal muscles increases dramatically. Furthermore, the amount of blood flowing around the circulatory system may be increased several fold. In this laboratory you will record the electrocardiogram and the finger pulse from a (healthy) volunteer. These parameters will be recorded when the volunteer is at rest and immediately after exercise.

Warning: *This experiment involves exercise and an elevation of heart rate. It should not be performed by anyone who is not healthy or has a personal or family history of cardiovascular or respiratory problems.*

Equipment Required

PC computer
iWorx/214 and USB cable
AAMI cable and three ECG leads
Alcohol swabs
Plethysmograph
Ice, cold and hot water, plastic bags

Equipment Setup

1 Connect the iWorx/214 unit to the computer (described in Chapter 1).

- 2 The volunteer should remove all jewelry from their wrists and ankles.
- 3 Use an alcohol swab to clean and scrub a region of each wrist, that has little or no hair. Let the area dry.
- 4 Remove the plastic disk from a disposable electrode and apply the electrode to the scrubbed area on one wrist. Repeat for the other wrist and the right ankle.
- 5 Attach the AAMI connector on the end of the gray patient cable to the isolated Channel 1 and 2 inputs on the iWorx/214 unit.
- 6 Attach three color-coded electrode cables to the ground and Channel 1 inputs on the lead pedestal and snap the other ends onto the disposable electrodes, so that:
 - the red “+1” lead is attached to the right wrist,
 - the black “-1” lead is connected to the left wrist,
 - the green “C” lead (the ground) is connected to the right leg.
- 7 Plug the DIN connector on the end of the plethysmograph cable into Channel 3 (Figure 6-8 on page 126).
- 8 Place the plethysmograph on the volar surface (where the fingerprints are located) of the distal segment of the middle finger, and wrap the Velcro strap around the end of the finger to attach the unit firmly in place.
- 9 The volunteer should sit quietly.

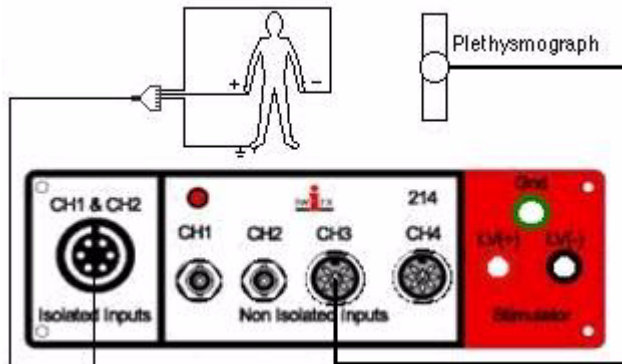


Figure 6-8: The equipment used to measure an ECG and blood flow from a volunteer.

Start the Software

- 1 Click the Windows **Start** menu, move the cursor to **Programs** and then to the **iWorx** folder and select **LabScribe**; or click on the LabScribe icon on the Desktop
- 2 When the program opens, select **Load Group** from the **Settings** menu.
- 3 When the dialog box appears, select **ahk214.iws** and then click **Load**.
- 4 Click on the **Settings** menu again and select the **ECG-Circulation-214** settings file.

5 After a short time, LabScribe will appear on the computer screen as configured by the **ECG-Circulation-214** settings.

Exercise 1: ECG and Volume Pulse in a Resting Volunteer

Aim: To measure and correlate the ECG and volume pulse in a resting individual.

Procedure

1 Remind the volunteer to sit quietly with their hands in their lap.

2 Click **Start**, and then click **AutoScale** in the Channel 1 title area; see the rhythmic ECG signal (Figure 6-9 on page 127). If the trace is upside down (R wave goes down), click **Stop** and switch the positive and negative electrodes. If a larger signal is required, the electrodes should be moved from the wrists to the skin immediately below each clavicle.

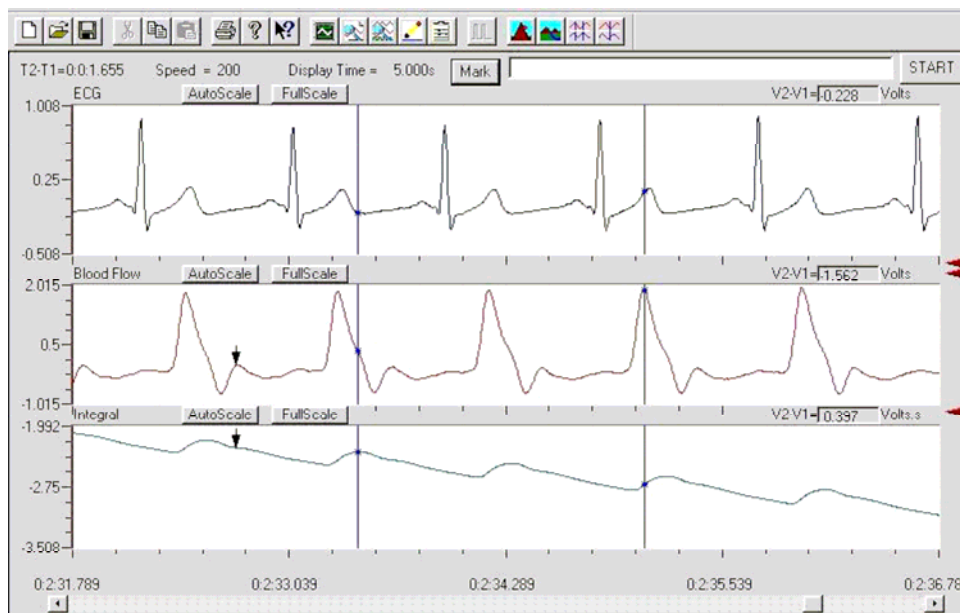


Figure 6-9: An ECG (upper trace), plethysmograph recording of blood flow (middle trace) and its integral (lower trace) shown in the Main window. The arrows on the two lower channels point to the dicrotic notch.

3 Click the **AutoScale** buttons for Channels 1 (**ECG**), 3 (**Blood Flow**), and 4 (**Integral**) and see the rhythmic signals get bigger. If the pulse wave on Channel 3 (**Blood Flow**) goes down, use the **Invert** function in the rightclick menu for Channel 3 to orient the image in the correct direction.

4 When you have a suitable trace, type "ECG & Finger Pulse" in the comment line to the right of the **Mark** button. Press the **Enter** key on the keyboard to attach the comment to the data.

5 Click **Stop** to halt recording.

6 Select **Save As** in the **File** menu, type a name for the file. Choose a destination on the computer in which to save the file (e.g. the **iWorx** or class folder). Click the **Save** button to save the file (as an *.iwd file).

Data Analysis

1 Click the **2-Cursor** icon (Figure 6-10 on page 128) so that two blue vertical lines appear over the recording window.

2 Drag the cursors left and right so that four complete heart beat cycles are located between the two blue lines.

3 Click the **Analysis** icon (Figure 6-10 on page 128) to open the **Analysis** window.

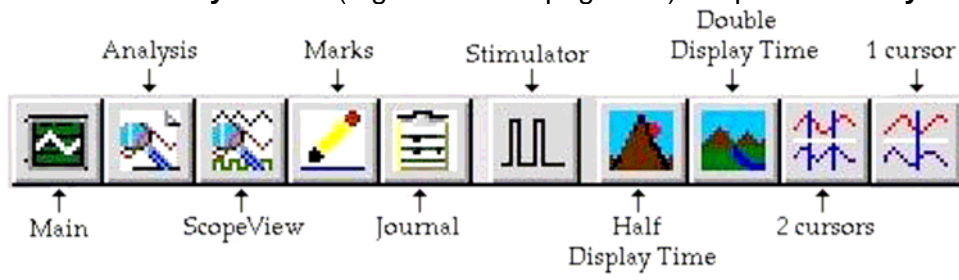


Figure 6-10: The LabScribe toolbar

4 Display the **ECG** trace (CH 1) and the **Integral** (CH 4) by clicking and deselecting Channels 2 and 3 in **Display Channel** list, on the left side of the **Analysis** window.

5 Use the mouse to click and drag one cursor to the peak of the R wave and the second cursor to the peak of the next volume pulse signal on the **Integral** channel (CH 4). Measure the time difference (**T2-T1**) between these two cursors.

6 Data can be entered into the **Journal** by either typing the titles and values directly or by using the right-click menu. Place the cursors to take measurements; then, select **Add Title to Journal** or **Add Data to Journal** from the right click menu to add the measurements to the **Journal**.

Questions

1 What produces the QRS complex in the ECG?

2 What corresponds to the peak of the volume pulse viewed on Channel 4?

3 What cardiovascular processes take place between these two events?

4 What does the time interval between the R wave and the peak of the volume pulse represent?

5 Does the falling phase of the volume pulse have a small, transient plateau, as shown in the lower trace of Figure 6-9 on page 127 (arrow)? This plateau is called the dicrotic notch. What event on the **Blood Flow** channel (CH 3) corresponds to the dicrotic notch?

6 Would you expect a transient increase in blood pressure as the elastic arteries recoil, after being stretched by blood entering from the ventricles?

Exercise 2: ECG and Volume Pulse after Exercise

Aim: To measure and correlate the ECG and volume pulse immediately after exercise.

Procedure

1 Disconnect the AAMI cable and the plethysmograph DIN connector from the iWorx/214 unit.

2 Check that the ECG leads are not tangled.

3 Remember that the ECG leads are still attached to the electrodes, so the volunteer should exercise carefully (so as not to break the leads), but vigorously enough to elevate heart rate. Try walking up and down stairs for 5-10 min.

4 Immediately after exercise, reconnect the two connectors to the iWorx/214 unit, while the volunteer sits down and relaxes. Click **Start** and record data until the subject's heart (and breathing) rate have returned to normal. During this time, type "ECG and Finger Pulse—Recovery from Exercise" in the comment line to the right of the **Mark** button. Press the **Enter** key on the keyboard. Record for at least two minutes.

5 Click **Stop** to halt recording.

6 Select **Save As** in the **File** menu, type a name for the file. Choose a destination on the computer in which to save the file (e.g. the **iWorx** or class folder). Click the **Save** button to save the file (as an *.iwd file).

Data Analysis

You should have traces for the subject while resting and immediately after exercise. For the resting condition:

1 Click the **2-Cursor** icon (Figure 6-14 on page 136), so that two blue vertical lines appear over the recording window.

2 Drag the cursors left and right so that four complete heart beat cycles are located between the two blue lines.

3 Click the **Analysis** icon (Figure 6-14 on page 136) to open the **Analysis** window.

4 Display the **ECG** trace (CH 1) by clicking and deselecting Channels 2, 3, and 4 in the **Display Channel** list on the left side of the **Analysis** window.

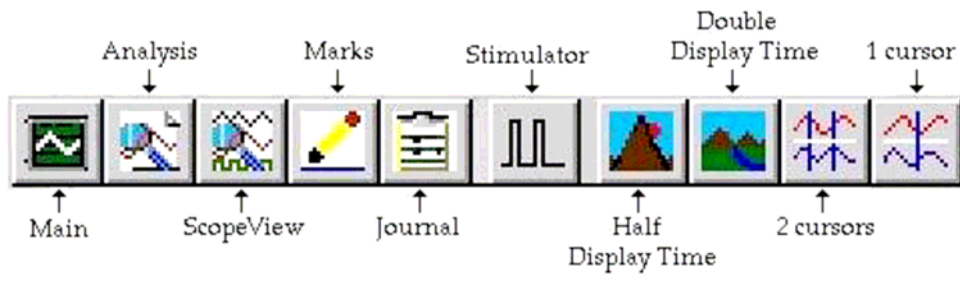


Figure 6-14: The LabScribe toolbar

5 Use the mouse to click and drag the two cursors to measure (Figure 6-15 on page 136) within each cardiac cycle (three measurements from each trace):

- P-R time interval, the time from the beginning of the P wave to the beginning of the QRS complex.
- Q-T time interval, time from the beginning of the QRS complex to the end of the T wave.
- T-P time interval, time from the end of the T wave to the beginning of the P wave,

Between cardiac cycles (three measurements from each trace):

- R-R time interval, time from peak of R wave to peak of successive R wave.

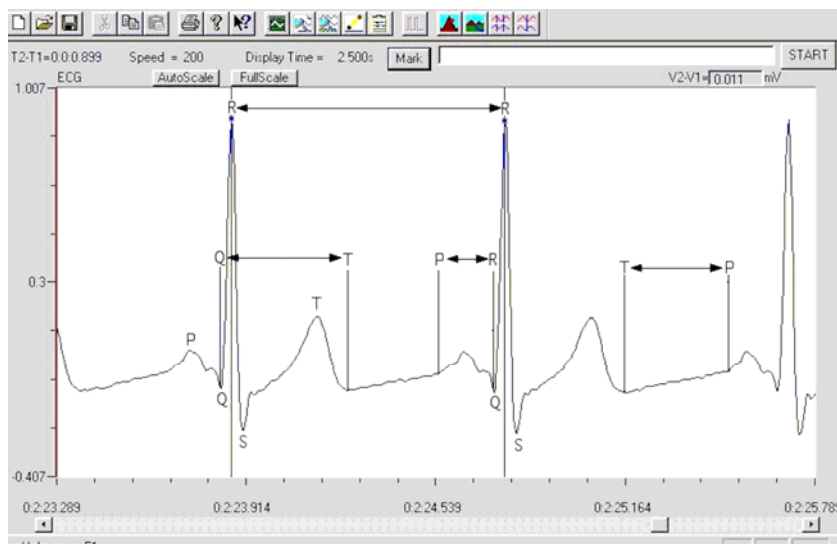


Figure 6-15: An ECG trace recorded in the Main window with labels to indicate the four time values to be measured during data analysis.

6 Data can be entered into the **Journal** by either typing the titles and values directly or by using the right-click menu. Place the cursors to take measurements; then, select **Add Title to Journal** or **Add Data to Journal** from the right click menu to add the measurements to the **Journal**.

7 Measure the listed intervals for the time immediately after, 30 seconds after, and 60 seconds after exercise. Use the first “good” ECG traces at each point.

8 Enter your data into the **Journal**.

Questions

- 1 How do the three values for the P-R interval in the resting person compare? Explain any variation that occurs.
- 2 How do the three values for the P-R interval from 0, 30 and 60 seconds after exercise compare? Are the values constant within each set of data? Explain any variation and trends for the three sets of data obtained at different intervals (0, 30, 60 seconds) after exercise.
- 3 Repeat steps 1 through 3 for the Q-T, T-P and R-R intervals.
- 4 Look at the three values for R-R interval at rest and for the three times after exercise. Are they the same? If not, why not?
- 5 Calculate the differences in the mean values of the time values obtained at rest and immediately after exercise, and tabulate in your Journal.
- 6 If the R-R interval is used to determine heart rate, can any of the other three intervals (P-R, Q-T, or T-P) fully account for this change?

More Data Analysis

- 1 Look at the finger pulse trace recorded immediately after exercise.
- 2 Use the cursors to measure the amplitude (Figure 6-16 on page 138) of the integrated signal (CH 4) every 10 seconds for the entire record, or until the signal has returned to a resting level for 30 seconds, (i.e. three or four measurements that are reasonably constant).

Questions

- 1 What is the effect of exercise on the rate of blood flow through the fingers?
- 2 Is it possible that blood flow may be affected more if the exercise is directed at the arm—rather than in the legs?

Exercise 3: The Volume Pulse

Aim: To measure the volume pulse in other individuals.

Procedure

- 1 Remove the ECG cable and leads from the volunteer. They are no longer needed.
- 2 Attach the plethysmograph to the finger of another student. Make a recording of the subject's blood flow and volume pulse. Label the recording using a mark with comments that indicate the name of the subject.

3 Record blood flow and volume pulse data for all the students in your group. Again, use marks with comments to label the data from each subject.

4 Select **Save** in the **File** menu.

5 Compare the recordings from different subjects.

Questions

1 Do the traces from all subjects have dicrotic notches displayed on the **Integral** channel (CH 4) (Figure 6-9 on page 127)?

2 Does the size of the dicrotic notch correlate with age, smoking or fitness? Does it correlate with the tightness of the plethysmograph strap?

Exercise 4: The Effect of Cold on Volume Pulse

Aim: To measure the effects of cold on volume pulse and heart rate.

Procedure

1 Attach the plethysmograph to the middle finger of the subject's left hand.

2 Click **Start** to begin recording. Type "Room Temp" in the comment line to the right of the **Mark** button. Press the **Enter** key on the keyboard. Record for about one minute.

3 Type "Cold" in the comment line. Place a bag containing a mixture of ice and cold water on the subject's left forearm. At the same time, press the **Enter** key on the keyboard. Record for about two minutes.

4 Type "Remove" in the comment line. Simultaneously remove the ice bag and press the **Enter** key on the keyboard.

5 Record for an additional two minutes; then, click **Stop** to halt recording.

6 Select **Save** in the **File** menu.

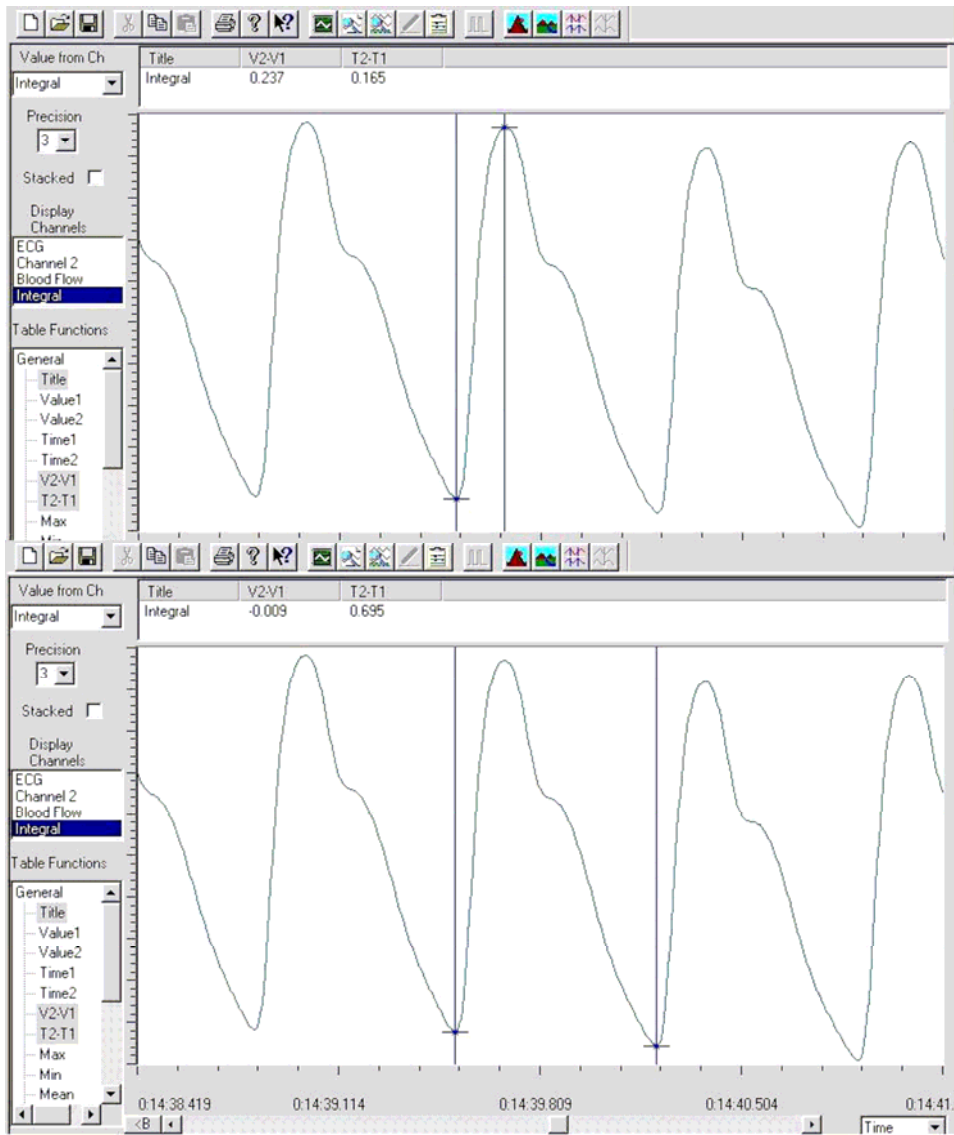


Figure 6-11: An integrated signal from the plethysmograph shown in the Analysis window with the cursors placed to measure the amplitude (V2-V1) of the signal (upper) and the time delay (T2-T1) between the two signals (lower).

Data Analysis

1 Use the two cursors to select a section of the “Room Temp” data, from the **Main** window, that contains three “good” adjacent pulses. Click the **Analysis** icon to go to the **Analysis** window.

2 On the **Integral** channel (CH 4), use the two cursors to measure (Figure 6-11 on page 130):

- the amplitude of three peaks. Place one cursor on the lowest amplitude that precedes a peak, and the second cursor on the peak. Use the **V2-V1** function to determine the amplitude of each peak. Calculate their average.
- the time interval between the two peaks. Calculate the heart rate.

3 Repeat these measurements every 10 seconds throughout the recording. Use the values (time, amplitude, heart rate) to create a table in the **Journal** that can be used to demonstrate the effects of cooling and recovery on peripheral circulation and heart rate. Note when ice was applied and removed in your **Journal** data table.

Exercise 4: The Effect of Heat on Volume Pulse

Aim: To measure the effects of heat on volume pulse and heart rate.

Procedure

- 1** Move the plethysmograph to the middle finger of the subject's right hand.
- 2** Follow the directions used in Exercise 3 to do an experiment on the right forearm of the subject with a bag of warm water. Use comments that indicate when the bag of warm water was applied and removed from the forearm.

Questions

- 1** What is the effect of heat on peripheral circulation?
- 2** Does warming the arm affect the heart rate? Explain your observations.