Experiment HH-1: The Electrocardiogram and Peripheral Circulation

Background

The cardiac cycle involves the sequential contractions of the atria and the ventricles which are triggered by action potentials in the myocardial cells. The combined electrical activity of the myocardial cells produces electrical currents that spread through the body fluids. These currents are large and detectable by recording through electrodes placed on the skin. The regular pattern of signals produced by the heart is called the electrocardiogram or ECG (Figure HH-1-B1).
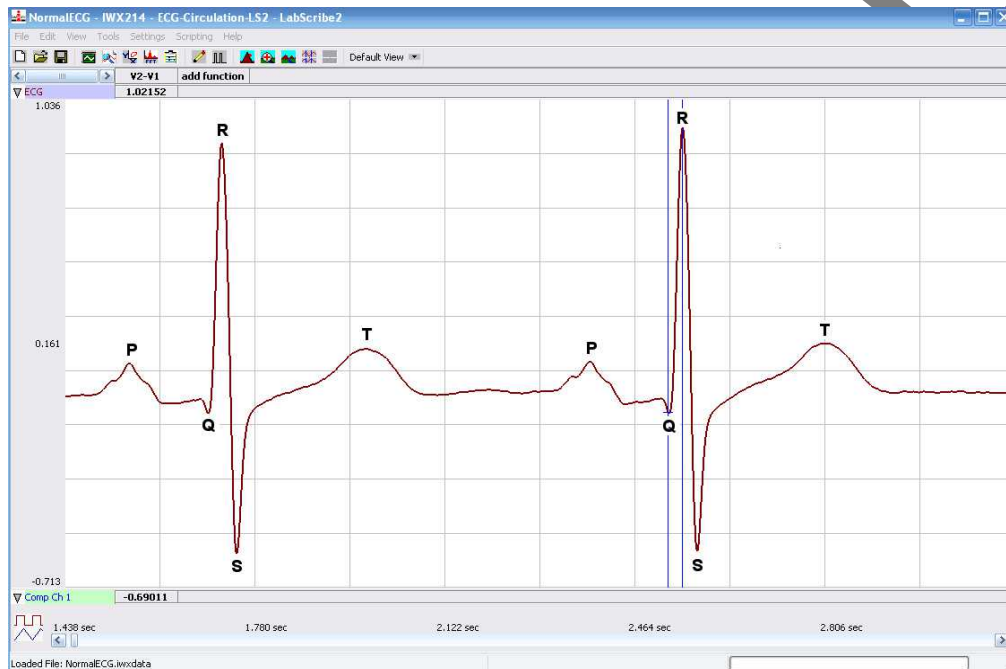

Figure HH-1-B1: ECG recording displayed in the Main window with labels showing the P, QRS, and T waves.

The components of the ECG are correlated to electrical activity in the atria and ventricles such that:

- Atrial depolarization produces the P wave.
- Atrial repolarization and ventricular depolarization produce the QRS complex.
- Ventricular repolarization produces the T wave.

The depolarization of the myocardial cells in the ventricle causes the ventricles to contract and force blood into the major arteries of the circulatory system in a pulsatile manner.

In this experiment, you will record a single lead ECG. You will also examine the effects of temperature changes in the periphery on heart rate.

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Equipment Required

PC or Mac Computer

USB cable

IX-B3G data recorder

Three snap electrode lead wires

Stethoscope

Alcohol swabs

Disposable ECG electrodes

Ice, cold and hot water, plastic bags

IX-B3G Setup

Use the USB cable to connect the computer to the USB port on the IX-B3G data recorder.

Start the Software

1. Click on the LabScribe shortcut on the computer's desktop to open the program. If a shortcut is not available, click on the Windows Start menu, move the cursor to All Programs and then to the listing for iWorx. Select LabScribe from the iWorx submenu. The LabScribe Main window will appear as the program opens. There will be a message indicating that LabScribe has recognized the IX-B3G.

2. On the Main window, pull down the Settings menu and select Load Group.

3. Locate the folder that contains the settings group, IXB3G.iwxgrp. Select this group and click Open.

4. Pull down the Settings menu again. Select the ECG-Circulation settings file from Human Heart.

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

6. For your information, the settings used to configure the LabScribe software and the IX-B3G unit for this experiment are programmed on the Preferences Dialog window which can be viewed by selecting Preferences from the Edit menu on the LabScribe Main window.

7. Once the settings file has been loaded, click the **Experiment** button on the toolbar to open the associated pdf files.

ECG Cable Setup

1. Locate the IX-B3G and three electrode lead wires (Figure HH-1-S1) in the iWorx kit.

2. Insert the connectors on the red, black, and green electrode lead wires into the matching sockets on the IX-B3G.

3. Instruct the subject to remove all jewelry from their wrists and ankles. Another option is to use the area just under each clavicle which will give a better recording.

4. Use an alcohol swab to clean and scrub a region with little or no hair, on the inside of the subject's right wrist/clavicle. Let the area dry.

5. Remove a disposable ECG electrode from its plastic shield, and apply the electrode to the scrubbed area on the wrist or under the clavicle.

6. Repeat Steps 6 and 7 for the inside of the left wrist/clavicle and the inside of the right ankle or lower right abdomen.
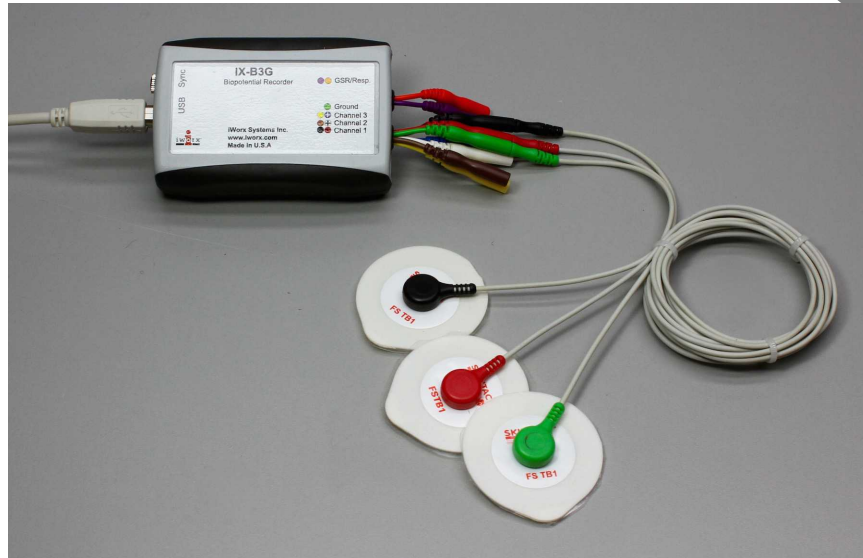

Figure HH-1-S1: The IX-B3G ECG cable with three lead wires and electrodes connected.

7. Snap the lead wires onto the electrodes, so that:

   • the red (+1) lead is attached to the left wrist or just under the left clavicle,

   • the black (-1) lead is connected to the right wrist or just udner the right clavicle,

   • the green (C or ground) lead is connected to the right leg or on the abdomen.

8. Instruct the subject to sit quietly with their hands in their lap. If the subject moves, the ECG trace will move off the top or bottom of the screen. If the subject moves any muscles in the arms or upper body, electromyograms (EMGs) from the muscles will appear on the ECG recording as noise.

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Exercise 1: The ECG in a Resting Subject

Aim: To measure the ECG in a resting individual.

Procedure

1. Click on the Record button, located on the upper right side of the LabScribe Main window (Figure HH-1-L1). The signal should begin scrolling across the screen.

Note: If the user clicks the Record button and there is no communication between the iWorx unit and computer, an error window will appear in the center of the Main window. Make sure the iWorx unit is connected to the USB port of the computer. Click OK and select the Find Hardware function from the LabScribe Tools menu.

2. Click on the AutoScale button at the upper margin of the ECG channel. Your recording should look like Figure HH-1-L2.

   • If the signal is upside down when compared to the trace in the figure, click on the downward arrow to the left of the channel title and select the Invert function. The trace should now look similar to the one in the figure.

   • If a larger ECG signal is required, the electrodes should be moved from the wrists to the skin immediately below each clavicle.

3. When you have a suitable trace, type <Subject's Name> Resting ECG in the Mark box to the right of the Mark button. Press the Enter key on the keyboard to attach the comment to the data. Record for a minute or two.

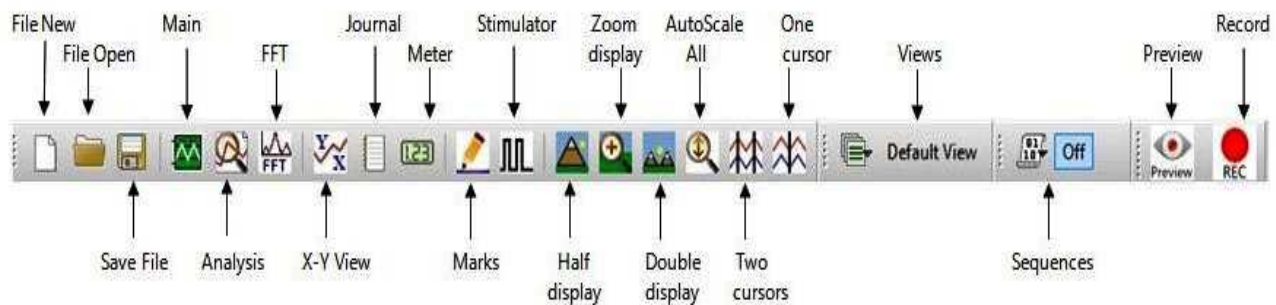4. Click Stop to halt recording.

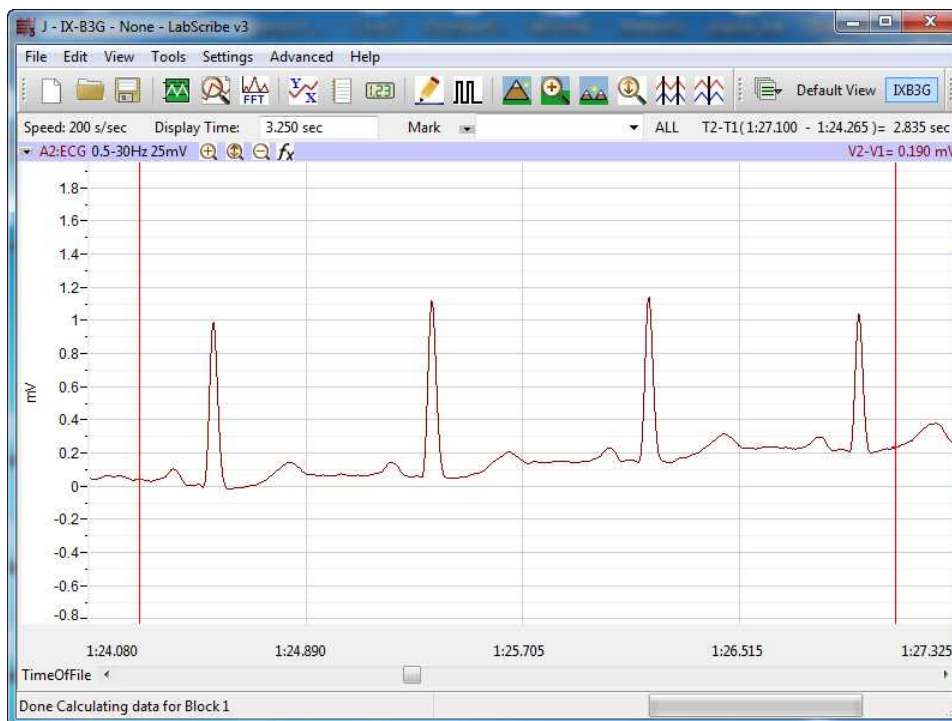*Figure HH-1-L1: The LabScribe toolbar.*

Figure HH-1-L2: ECG displayed on the Main window.

5. 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, (like your lab group folder). Designate the file type as *.iwxdata. Click on the Save button to save the data file.

Data Analysis

1. Scroll through the recording and find a section of data with five or six exemplary ECG cycles in succession.

2. Use the Display Time icons to adjust the Display Time of the Main window to show at least four complete ECG cycles on the Main window. Four adjacent ECG cycles can also be selected by:

   • Placing the cursors on either side of a group of four complete ECG cycles.

   • Clicking the Zoom between Cursors button on the LabScribe toolbar to expand the segment with the four selected ECG cycles to the width of the Main window.

3. Click on the Analysis window icon in the toolbar or select Analysis from the Windows menu to transfer the data displayed in the Main window to the Analysis window.

4. Look at the Function Table that is above the uppermost channel displayed in the Analysis window. The names of the mathematical functions used in the analysis, V2-V1 and T2-T1, appear in this table. The values for V2-V1 and T2-T1 from each channel are seen in the table across the top margin of each channel. In this exercise will only need to record the values for T2-T1.

5. Once the cursors are placed in the correct positions for determining the time intervals on each ECG cycle, the values of the time intervals can be recorded in the on-line notebook of LabScribe by typing their names and values directly into the Journal, or on a separate data table.

6. The functions in the channel pull-down menus of the Analysis window can also be used to enter the names and values of the parameters from the recording to the Journal. To use these functions:

   • Place the cursors at the locations used to measure the period of the ECG cycle.

   • Transfer the names of the mathematical function used to determine the time interval to the Journal using the Add Title to Journal function in the ECG Channel pull-down menu.

   • Transfer the values for the beat period to the Journal using the Add Ch. Data to Journal function in the ECG Channel pull-down menu.
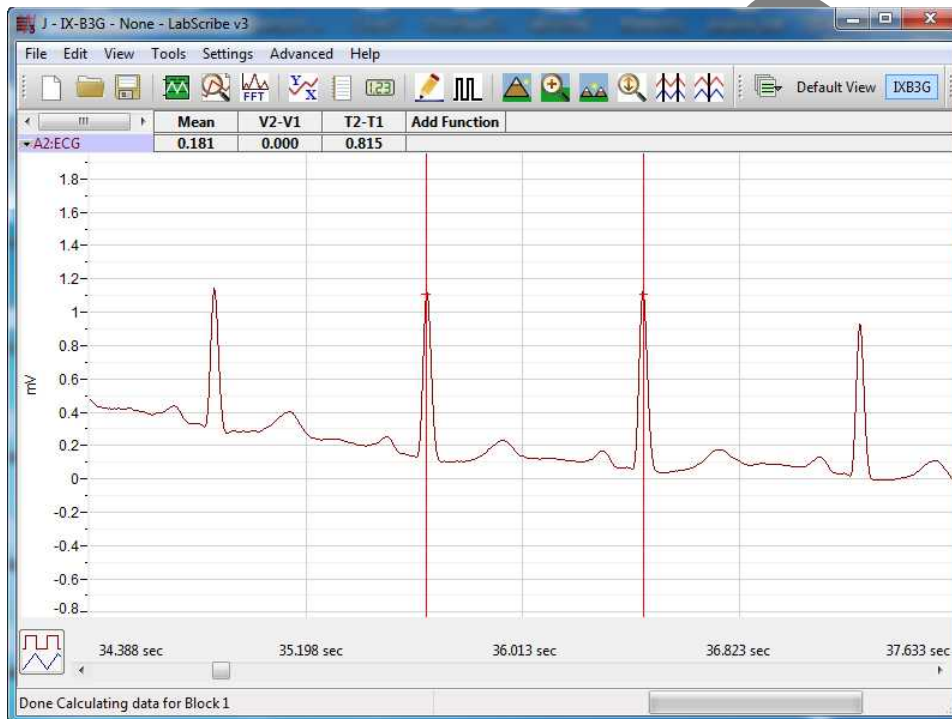

Figure HH-1-L3: ECG displayed on the Analysis window with cursors in place to measure the beat period with the T2-T1 function.

7. Use the mouse to click on and drag the cursors to specific points on the ECG recording to measure the following:

   • The beat period, which is the time interval between two adjacent R waves. To measure the beat period, place one cursor on the peak of an R wave and the second cursor on the peak of the adjacent R wave. The value for T2-T1 on the ECG channel is the beat period. Measure the beat period for two additional pairs of R waves.

8. Calculate the following values and record your results into the Journal or on a separate data table:

- The average beat period, in seconds/beat.

- The heart rate, which is expressed in beats per minute and calculated from the average beat period by using the following equation:

- Heart Rate (beats/minute) = 60 seconds/minute
   # seconds/beat

Questions

1. What electrical and mechanical events take place during the R wave?

Exercise 2: The ECG in Other Subjects

Aim: To measure the ECG in other subjects.

Procedure

Repeat Exercise 1 on other subjects.

Data Analysis

Analyze the data for each subject using the same techniques used in Exercise 1.

Exercise 3: The Effect of Cold on the Heart Rate

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

Procedure

1. Click on the Record button. The signal should begin scrolling across the screen.

2. Click on the AutoScale button at the upper margin of the ECG channel. Use the same techniques used in Exercise 1 to display the signal properly.

3. When you have a suitable trace, type <Subject's Name> RoomTempECG in the Mark box to the right of the Mark button. Press the Enter key on the keyboard to attach the comment to the data. Record for a minute or two.

4. Type Cold ECG in the Mark box to the right of the Mark button. 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 to attach the comment to the data. Record for two minutes while the cold pack is on the subject's forearm.

5. Type Remove in the Mark box. Simultaneously remove the ice bag and press the Enter key on the keyboard.

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

7. Select Save in the File menu on the LabScribe window.

Data Analysis

1. Scroll through the recording and find a section of data with four or five exemplary ECG cycles, in succession, that were recorded at room temperature.

2. Use the Display Time icons, or the cursors and the Zoom between Cursors button, to adjust the Display Time of the Main window to show at least four complete ECG cycles on the Main window.

3. Click on the Analysis window icon in the toolbar to transfer the data displayed in the Main window to the Analysis window.

4. Look at the Function Table in the Analysis window and make sure the mathematical functions used in the analysis, T2-T1, appears.

5. Once the cursors are placed in the correct positions for determining the time intervals, transfer the names and values of the parameters measured in the Analysis window to the Journal using one of the two techniques described in Exercises 1, or transfer the values to a separate data table.

6. Use the mouse to click on and drag the cursors to specific points on the ECG recording to measure the following:

   - The beat period. Measure the time between two adjacent R waves using the same technique employed in Exercises 1 and 2. Determine the beat period for three ECG cycles.

7. Repeat Steps 5 and 6 for the data at 1 and 2 minutes into the cooling period, and at 1 and 2 minutes into the rewarming period

8. Calculate the following values and type your results into the Journal or on a separate data table:

   - The heart rate while the forearm was at room temperature, cooled for 1 and 2 minutes, or rewarmed for 1 and 2 minutes.

Questions

1. Does cooling of the forearm affect the heart rate?

2. Through what mechanism does cooling affect the peripheral circulation?

3. What other factors may affect peripheral circulation?

Exercise 4: The Effect of Heat on the Pulse

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

Procedure

1. Follow the directions used in Exercise 3 to do an experiment on the right forearm of the subject

with a bag of warm water. Mark the recording to indicate when the bag of warm water was applied and removed from the forearm.

Questions

1. Does warming of the forearm affect the heart rate?

2. Through what mechanism does warming affect the peripheral circulation?