

Electrocardiography

Recording the electrical activity of the heart

An electrocardiogram (ECG or EKG) is a graphical recording of the electrical events occurring within the heart. A typical ECG tracing consists of five identifiable deflections (Fig. 1). Each deflection is noted by one of the letters P, Q, R, S, or T. The P wave is the first waveform in a tracing and represents the depolarization of the heart's atria. The next waveform is a complex and consists of the Q, R, and S deflections. The QRS complex represents the depolarization of the heart's ventricles. The deflection that represents the repolarization of the atria is usually undetectable because of the intensity of the QRS waveform. The final waveform is the T wave and it represents the repolarization of the ventricles.

Because an ECG is a recording of the heart's electrical events, it is valuable in diagnosing diseases or ailments that damage the conductive abilities of the heart muscle. When cardiac muscle cells are damaged or destroyed, they are no longer able to properly conduct electrical impulses. This causes the electrical signal to terminate at the damaged tissue or be directed away from the normal signal path. The termination or redirection of the electrical signal will alter the manner in which the heart contracts. A cardiologist can look at a patient's electrocardiogram and determine the presence of damaged cardiac muscle based on the waveform, as well as the time interval between electrical events.

We will be using the Vernier LabPro data collection system to record our ECG's. This system consists of an electrode box, a LabPro interface, and a computer (Fig. 2). One end of the electrode box has three electrodes that you will attach to your lab partner

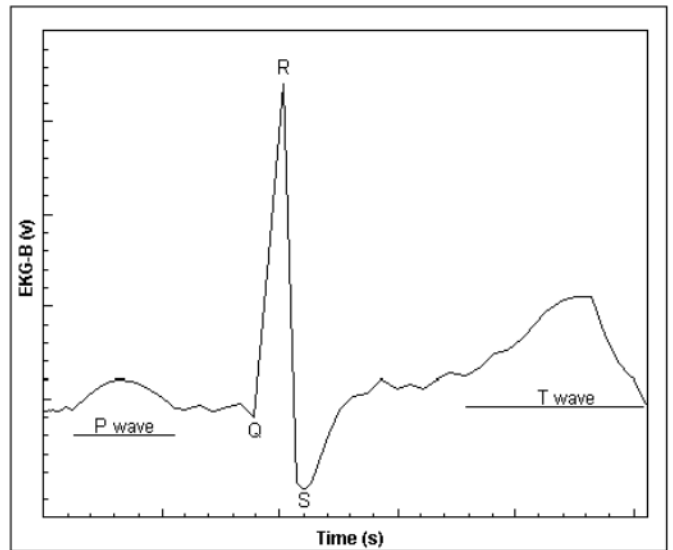


Fig. 1: A typical ECG tracing

using special ECG pads. The other end of the electrode box has a cable that plugs into the LabPro interface. The electrode box detects and amplifies the electrical activity of the heart. The LabPro interface box converts this analog voltage to a digital format, and sends it to the computer via a serial cable. The LoggerPro software running on the computer will allow you to analyze, save, and print your ECG.

Preparing the subject

Standard ECG's are normally recorded using a combination of connections between the arms and legs. These connections are called the "standard limb leads" and are outlined in your lab manual on page 335 (Fig. 31.4). We will use a slightly modified hookup that uses the arms only. This will reduce the risk of pulling the computer interface off the lab bench.

1. Have your lab partner remove any jewelry such as watches and bracelets.
2. Prepare each of the electrode attachment sites by scrubbing them very lightly with a green ScotchBrite pad and then wiping the area with an alcohol pad. Choose areas with as little hair as possible.
3. After each attachment site has dried, remove a fresh electrode pad from the backing sheet, and place it on each prepared site.
4. Attach the snap clip on each electrode lead to the snap connector on top of the electrode pads. Match the color lead to those shown in Fig. 2.

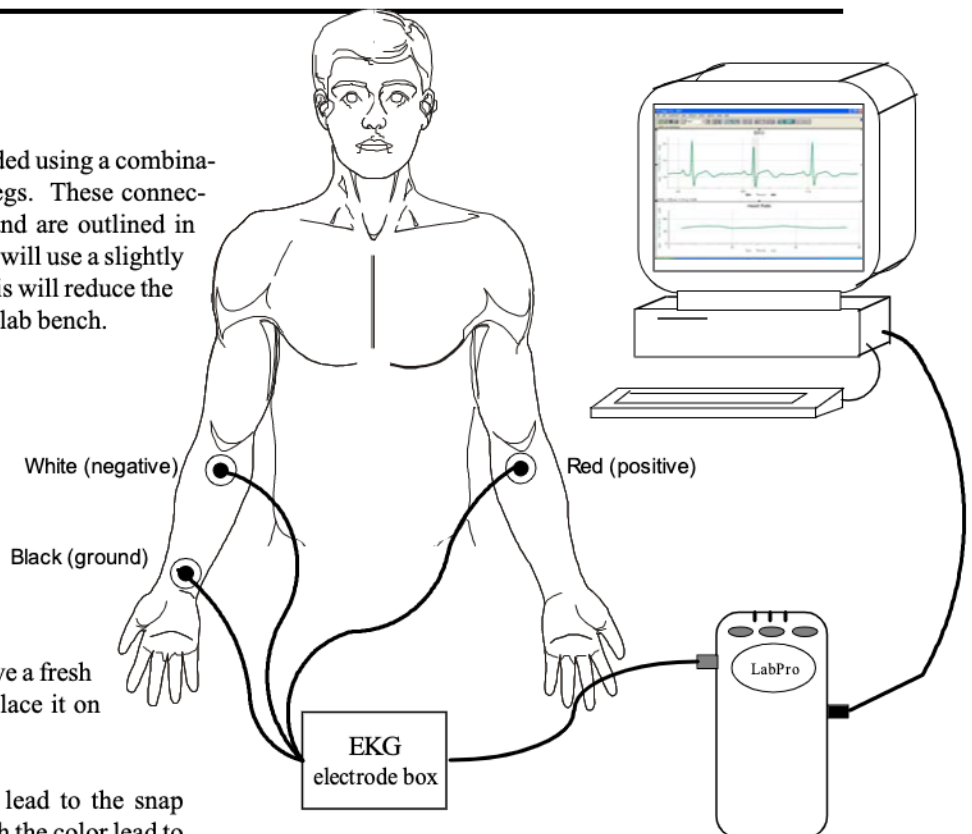


Fig. 2: Proper equipment setup for recording an ECG

Recording the electrocardiogram

You will record an ECG on your lab partner under baseline (resting) conditions first, then immediately after strenuous exercise. Finally, you will perform a final recording while the subject

holds his or her breath. You will then compare the activity and breathholding ECG's to the baseline measurements. You will be asked to determine the reasons for the observed differences in the recordings.

Baseline recording and analysis

Recording

1. Position your lab partner comfortably in a supine position, if possible, or sitting relaxed in a laboratory chair.

2. Attach the electrodes to the subject if you have not already done so.


3. Confirm that the electrode box is connected to Channel 1 of the LabPro interface. Also confirm that the LabPro power supply is plugged in and the interface is connected to the computer. If everything is connected properly, the green LED on the LabPro interface near the serial connector should be continuously lit.

4. From the computer's Desktop, double-click the 1612 folder, then double-click your group's folder (Ex. 1612-Thursday 2pm-5pm; Fig. 3). Finally, double-click the ECG template file. This will start the LoggerPro software and load the template file.

5. When the ECG Template file loads you should have a screen that looks like Fig. 4. The top window will display the ECG tracing and the lower screen will display the heart rate data. The green LED on the LabPro should be blinking now.

6. Confirm that the ranges on your graphs are correct. You will be collecting 30 seconds of data, so the X-axes on both graphs should go from 0 to 30 seconds. The Y-axis on the top (ECG) graph should go from 0mV to 3.0mV. The Y-axis on the lower (Heart Rate) graph should go from ~40 beats per minute (bpm) to ~120bpm. If the ranges are incorrect, click on the incorrect number and type in the correct number.

7. Before you record any data, you must save a copy of the template file under your name. Select File->Save As... from the menu bar. **Confirm that you are saving to your group's folder.** This is important if you want to retrieve your data later. If you save to the desktop, your files will be deleted when the computer is shut down. If you save to another group's folder, you may not be able to find your data later. Once you are sure you are saving in your group's folder, type in your name (ex. John Doe-baseline), and click Save.

8. Once you have saved a copy of the ECG file, you are ready to collect data. Have the subject relax and click 

9. You should see the ECG tracing appear in the upper window and the heart rate data will appear in the lower window. The heart rate data may not appear until the end of the 30 second collection interval.

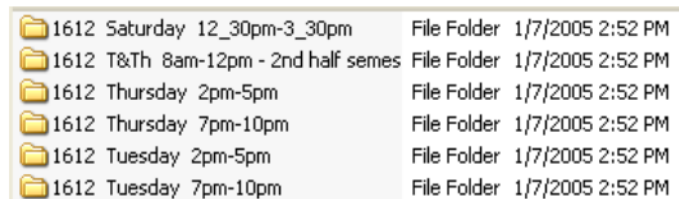


Fig. 3: Group folders. Be sure to save your data to your group's folder so that you may retrieve it later.

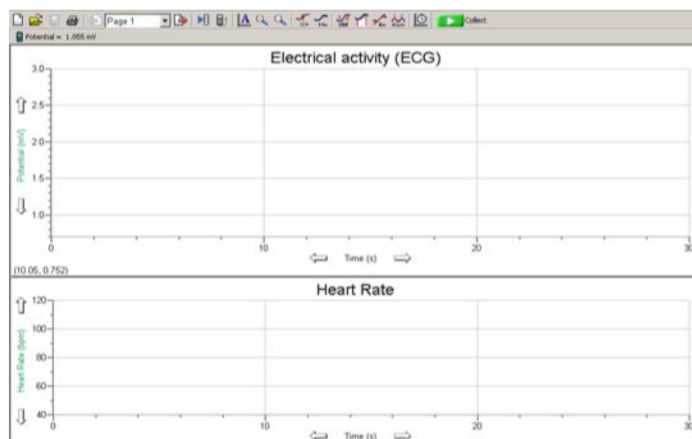


Fig. 4: LoggerPro ECG data screen

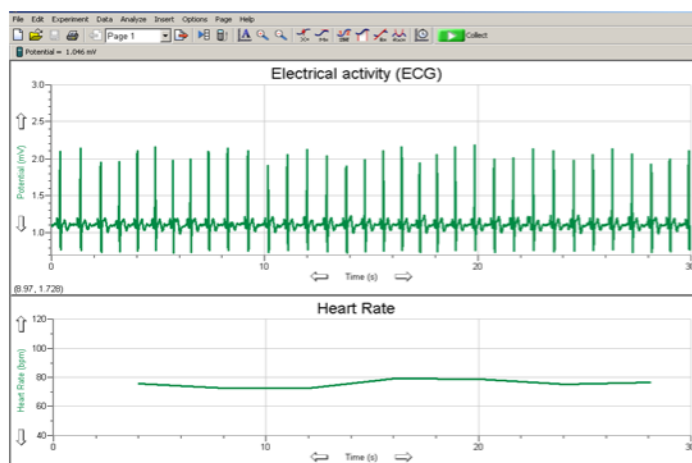


Fig. 5: LoggerPro screen immediately after data capture.





10. Data collection will stop automatically after 30 seconds and the screen should look like Fig. 5.

11. Select File->Save to save your data before you begin the data analysis section of the exercise.

Analysis of ECG data

1. To analyze several individual beats, you will need to magnify a region of the data encompassing 3-4 beats.

2. Click above and to the left of the beats that you wish to magnify. Hold the mouse button down and draw a box around several beats by dragging the box down and to the right (Fig. 6).

3. Once you have selected a region, click on the “Zoom in” button  to magnify the selected beats (Fig. 7). The arrows under the X-axis ( ) allow you to scroll forward and backward through the data. Use the “Autoscale” button  to return to the unmagnified view.

4. Once you have found a good representative tracing, you should measure the time intervals of the different waves. Consult your lab book for where to start and end a measurement and to obtain the normal values for each of the intervals.

5. Position the cursor on the ECG tracing at the beginning of the wave you are measuring. Hold the mouse button down and drag it to the end of the wave. The elapsed time (in seconds) of the waveform within the box will be displayed in the lower left hand region of the ECG window as “dx:”.

6. Repeat for each of the waves and record the data below.

Duration of one beat - from one QRS to the next QRS:

-measured = _____

-normal = ~ _____

QRS interval:

-measured = _____

-normal = ~ _____

Q-T interval:

-measured = _____

-normal = ~ _____

P-Q interval:

-measured = _____

-normal = ~ _____

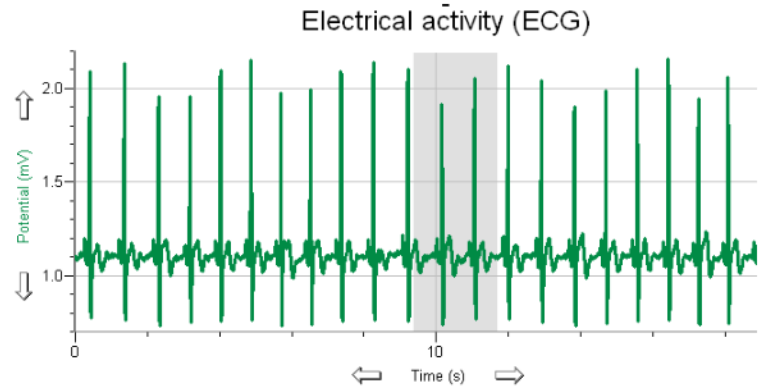


Fig. 6: Highlighting data for magnification.

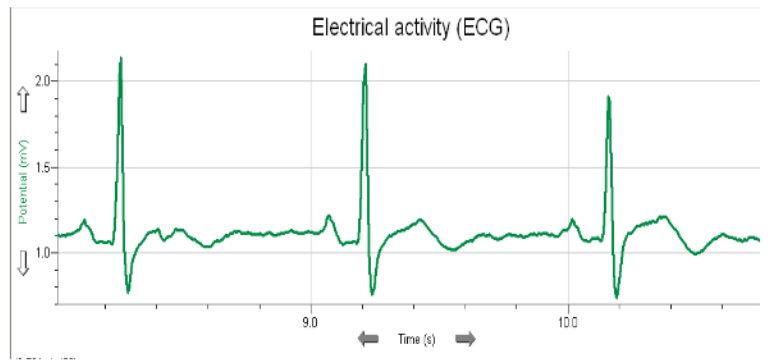


Fig. 7: Magnified ECG showing 3 individual beats.

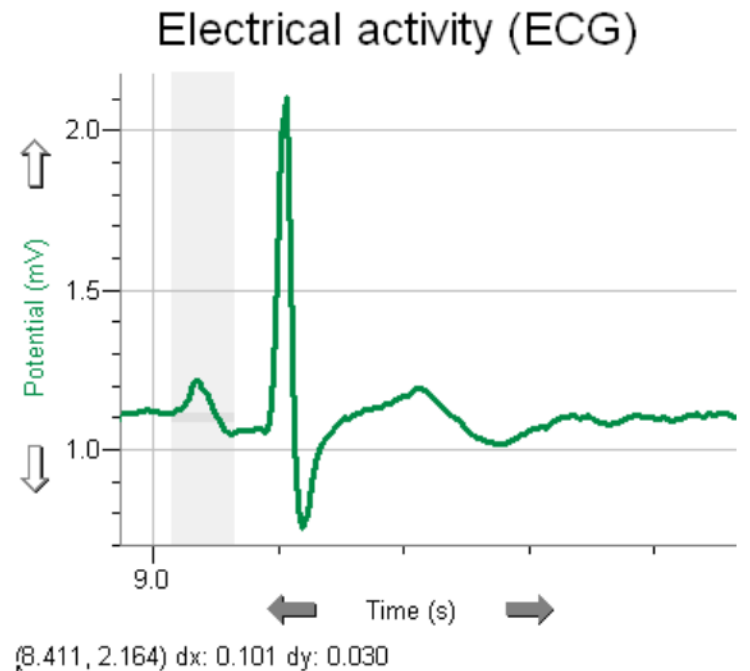



Fig. 8: Measuring the interval of the “P” wave. The elapsed time of the interval is displayed as “dx: 0.101 seconds”.

Analysis of heart rate data

1. Direct your attention to the lower window with the graph of the heart rate data. LoggerPro calculates the heart rate based on the number of “peaks” in the ECG tracing during successive 4 second intervals.
2. By selecting an area of the graph, you can determine the maximum, minimum, mean, and standard deviation of the heart rate within that interval.
3. Draw a box around the heart rate data as you did for the ECG

data. After you have selected the range to analyze, click the “Statistics” button  to display the maximum, minimum, mean, and standard deviation for the heart rate data (Fig. 9).

4. The standard deviation is a measure of the variability of the data. The standard deviation of the data set in Fig. 9 is approximately 2.5. This means that most of the heart rate calculation were within 2.5 of the mean.

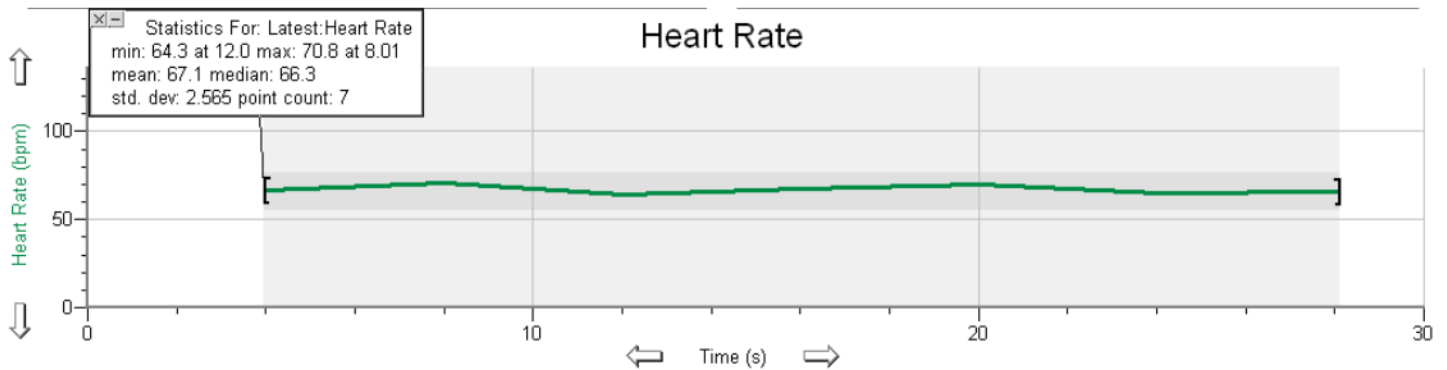


Fig. 9: Heart rate data with statistical analysis.

Printing your data

1. You may print your data by selecting File->Print Graph from the main menu bar.

Clean up

1. Save your data and close the LoggerPro software.
2. Disconnect the electrode snap leads from electrode pads. Peel the electrode pads off of the subject’s arms and dispose of them in the trash.
3. Leave the LabPro interface connected for the next group.