Exercise, the Electrocardiogram, and Peripheral Circulation

Objective:

To explain, in words or with diagrams, the relationship between the contraction of the heart and the electrical activity in the heart muscle, measured as the electrocardiogram, (ECG), at the level of 85% proficiency for each student.

In order to achieve this objective, you will need to be able to:

1. Explain the organization of the cardiac conduction system of the heart.
2. Measure the electrocardiogram (ECG) quantitatively using limb leads.
3. Measure finger blood flow quantitatively using a pulse plethysmograph.
4. Relate waves of the ECG to cardiac pumping and blood flow.

Materials:

PC Computer
IWX/214 data acquisition unit
USB cable
IWX/214 power supply
ECG cable and electrode lead wires
PT-104 Pulse plethysmograph
Alcohol swabs
Disposable ECG electrodes

Methods:

Setup

1. Plug the power supply into the data recording unit and connect the USB cable between the unit and the computer. Make sure the computer is on.
2. Use the power switch on the back of the data recording unit to turn the unit on. Confirm that the **red power light is on.**
   THIS MUST BE DONE IN ORDER FOR THE PROGRAM TO START UP PROPERLY!!!!!

Starting the Software

1. Click on the LabScribe2 shortcut on the computer's desktop to open the program. The LabScribe **Main window** will appear as the program opens.
2. An information box will appear if the computer recognizes the data recording unit, "hardware found". Click OK.
3. Pull down the **Settings menu**, select **Human Heart** and then the **Exercise-ECG-Circulation-LS2** settings file. The iWorx instructions for the ECG lab will appear on the computer screen (Adobe Reader). Click the **X** on this window to close.
4. After a short time, LabScribe set up for the ECG lab will appear on the computer screen.

Connecting the ECG Cable and Pulse Transducer Setup

1. Plug the pulse plethysmograph into the CH3 input of the data recording unit, as shown above.
2. Insert the ECG cable into CH1 & CH2 and insert the connectors on the red, black, and green electrode lead wires into the matching sockets on the ECG cable.
3. ***The ECG cables and connectors must be kept as far as possible away from electrical outlets, power sources, and power supplies and cables, including cell phone chargers***
4. The subject should remove all jewelry from their wrists and ankles.
5. Use an alcohol swab to clean three regions with little or no hair, on the inside of the subject's right wrist, left wrist, and right ankle.
6. Let the areas dry before applying electrodes
7. Remove the plastic disk from a disposable electrode and apply it to one of the cleaned areas. Repeat for the other two areas.
8. Snap the lead wires onto the 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** or ground) lead is connected to the right ankle
9. Place the plethysmograph on the volar surface (where the fingerprints are located) of the distal segment of the subject's middle finger, and wrap the Velcro strap around the end of the finger to attach the unit firmly in place.

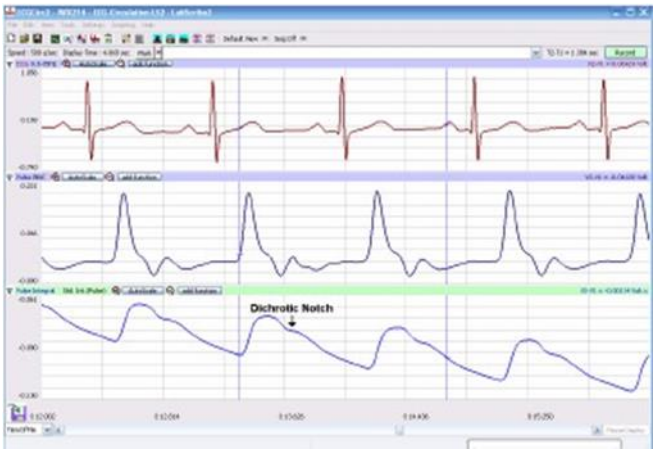
Procedures:

Exercise 1: The ECG and Finger Blood Flow During Rest

Objective: To identify ECG waves and to determine the relationship between the ECG activity and the finger blood flow, during rest.

1. The subject should 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, electrical activity from the muscles (EMG) will appear on the ECG recording as noise.
2. If the Record button is not displayed, click on the **Main window** icon in the toolbar.

3. Click on the **Record** button to begin recording. The signal should begin scrolling across the screen.
4. Click on the **AutoScale** button at the upper margin of the **ECG** and **Pulse (finger blood flow)** channel. The recording should be similar to that shown below. We will ignore the third channel (**Pulse Integral**) in this exercise.



- If the signal on either the **ECG** or the **Pulse (finger blood flow)** channel is upside down when compared to the traces in the figure above, click on the downward arrow to the left of the channel title and select the **Invert** function.
- If the **blood flow** signal is small or noisy, adjust the tension on the strap holding the pulse plethysmograph to the finger.

5. Record for a minute or two.
6. Click **Stop** to halt recording.

Exercise 2: The ECG and Finger Blood Flow After Exercise

Objective: To identify ECG waves and to determine the relationship between the ECG activity and the finger blood flow, after exercise.

1. While the subject is resting, disconnect the lead wires from skin electrodes.
2. Instruct the subject to exercise for three minutes by running in place or ouside. Immediately after the exercise period is over, have the subject sit down and relax next to the recording equipment.
3. Quickly reconnect the lead wires to the electrodes.
4. Click on the **Record button**. Click **AutoScale** on all three channels.
5. Continue recording for 2 minutes and then click **Stop** to halt recording.

Data Analysis

Use the following techniques to analyze the data from both Exercises 1 and 2. The information extracted from these exercises will demonstrate the effects of rest, exercise, and recovery on ECG activity.

1. Scroll through the recording and find a section of data when the subject was resting.
2. Use the **Display Time** icons, as necessary, to adjust the **Display Time** of the **Main window** to *show at least four* complete ECG/Pulse cycles on the **Main window**.
3. Click on the **Analysis window** icon in the toolbar to switch from 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 mathematical functions **V2-V1**, and **T2-T1** should appear in this table. The values for **V2-V1**, and **T2-T1** on each channel are seen in the table across the top margin of each channel. If any of these functions are missing, ask for assistance to add them
5. Use the mouse to click and drag the cursors into position for determining the following bulleted intervals and amplitudes for each of three cardiac cycle. *Record these values in Table 1 on the following page*.

    - The **beat period** (**R-R**) – 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 (R-R). Measure the beat period for two additional pairs of R waves.
    - The **P-Q interval** – time of conduction through the AV node. To measure this time interval, place one cursor at the beginning of the P wave and the second cursor at the beginning of the QRS complex. The value for **T2-T1** on the **ECG** channel is the P-R interval. Measure this time interval for two additional ECG cycles.
    - The **Q-T interval** – time for ventricular systole. To measure this time interval, place one cursor at the beginning of the QRS complex and the second cursor at end of the T wave. The value for **T2-T1** on the **ECG** channel is the Q-T interval. Measure this time interval for two additional ECG cycles.
    - The **T-Q interval** – time for ventricular diastole. To measure this time interval, place one cursor at the end of the T wave and the second cursor at the beginning of the QRS wave. The value for **T2-T1** on the **ECG** channel is the T-Q interval. Measure this time interval for two additional ECG cycles.
    - The **R-Peak Flow interval -** the time interval between the peak of the R wave and the peak of the finger blood flow wave that follows the R wave. To measure this interval, place one cursor on the peak of an R wave and the second cursor on the peak of the pulse wave to its right. The value for **T2-T1** on any channel is this interval. Measure this interval for two additional ECG/Pulse cycles.
    - The **Flow wave amplitude**. To measure the flow wave amplitude, place one cursor on the baseline that precedes the flow wave and the second cursor on the peak of flow wave. The value for **V2-V1** on the **Pulse** channel is this amplitude. Measure this amplitude for two additional pulse waves.

6. Calculate the values bulleted below and record in Table 1**.**
    - The average beat period (R-R) in seconds/beat.
    - The average P-Q interval.
    - The average Q-T interval.
    - The average T-Q interval.
    - The average R-Peak-Flow interval.
    - The average Flow wave amplitude.

- The heart rate (HR) is expressed in beats per minute and is calculated from the average beat period (R-R) by using the following equation:

$$HR\ (b/min) = \frac{60\ sec/min}{R\text{-}R}$$

7. Scroll through the recording and find the section of data immediately after exercise. Repeat Steps 2 through 6 for this section of data.
8. Move to the sections of data at 1 minute after exercise Repeat Steps 2 through 6 for this section of data.
9. Move to the section of data at 2 minutes after exercise. Repeat Steps 2 through 6 for this section of data.

Table 1. Exercise, the Electrocardiogram, and Finger Blood Flow

	Rest				Immediately after exercise				1 min after exercise				2 min after exercise			
	1	2	3	Avg	1	2	3	Avg	1	2	3	Avg	1	2	3	Avg
Beat period R-R Interval																
P-Q Interval																
Q-T Interval																
T-Q Interval																
R-Peak Flow Interval																
Flow wave amplitude																
Heart Rate (use avg beat period)																

Discussion

1. How does the heart rate from the subject at rest, immediately after exercise, and at 1 min, and 2 min after exercise compare? Explain the physiological reasons for any differences.
3. What is occurring during the P-Q interval? How do the average P-Q intervals from rest and each time interval compare? How does the average at rest value compare to the "normal" value?
4. What is occurring during the Q-T interval? How does the average Q-T interval from rest and each time interval compare? How does the average at rest value compare to the "normal" value?
5. What is occurring during the T-Q interval? How does the average T-Q interval from rest and each time interval compare? Explain any variations.
6. What does the R-Peak Flow interval represent? (What is occurring during this interval?) How does the average R-Peak Flow interval from rest and each time interval compare? Explain any variations.
7. How does the average pulse-wave amplitude from rest and each time interval compare? Explain any variations.
8. Explain the effect of exercise on the blood flow through the subject's finger.