Experiment HH-3: Exercise, the Electrocardiogram, and Peripheral Circulation

Equipment Required

PC or Mac Computer

IXTA, USB cable, IXTA power supply

iWire-B3G ECG cable and electrode lead wires

PPG-320 Pulse plethysmograph

FT-220 Hand dynamometer

Disposable ECG electrodes

Note – You must connect the iWire-B3G to the IXTA prior to turning it on.

ECG Cable and Pulse Transducer Setup

1. Locate the iWire-B3G ECG cable and electrode lead wires and PPG-320 pulse plethysmograph.
2. Plug the connector to the PPG-320 into the PT port on the front of the TA.
3. Insert the connector on the end of the iWire-B3G ECG cable into the iWire 1 input on the front of the IXTA.
4. Insert the connectors on the red, black, and green electrode lead wires into the matching sockets on the ECG cable.
5. Instruct the subject to remove all jewelry from their neck, wrists and ankles. Another option is to use the area just under each clavicle which will give a better recording.
6. 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.
7. Repeat for the inside of the left wrist/clavicle and the inside of the right ankle.
8. Snap the lead wires onto the electrodes, so that:
    - the red (+1) lead is attached to the left wrist or under the left clavicle,
    - the black (-1) lead is connected to the right wrist or under the right clavicle,
    - the green (C or ground) lead is connected to the right leg or on the abdomen.

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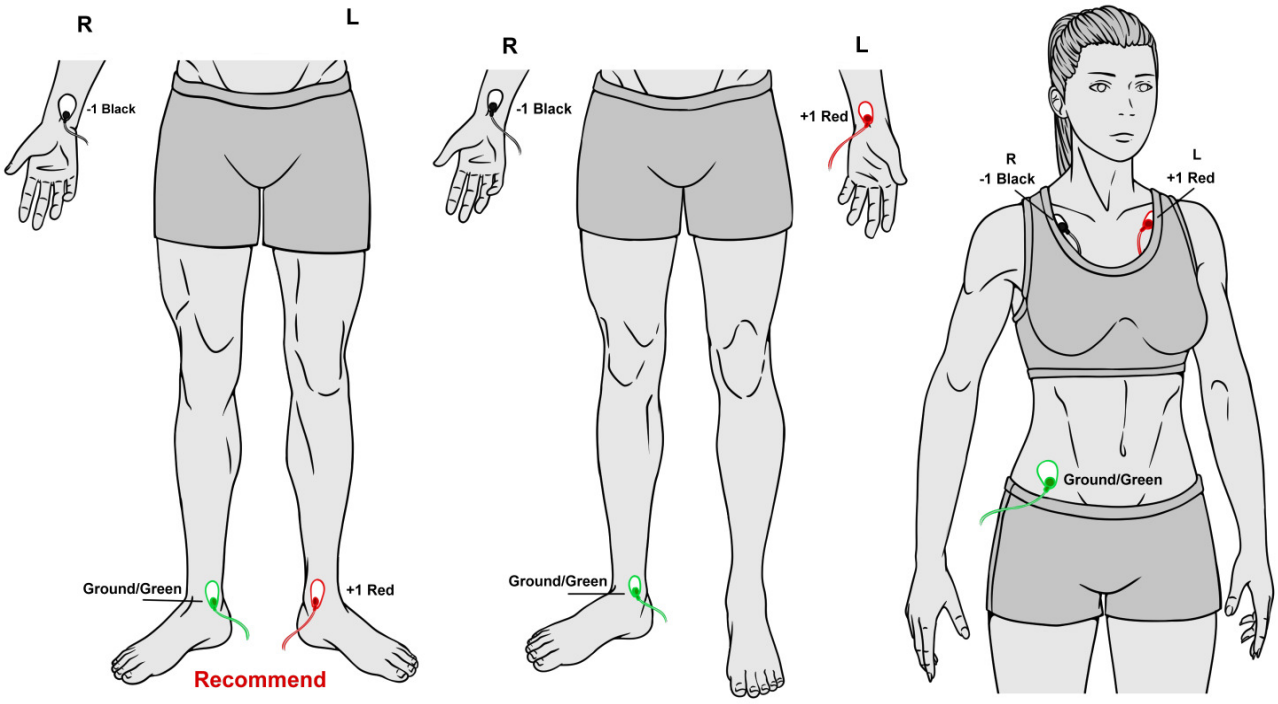
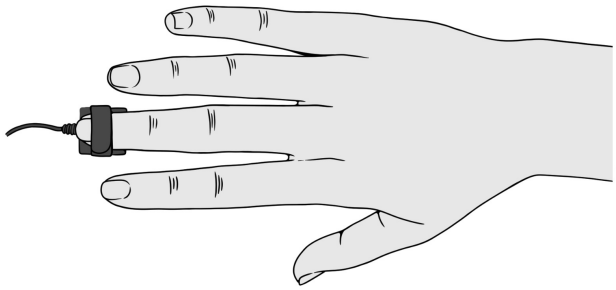


9. Place the plethysmograph on the volar surface (where the fingerprints are located) of the distal segment of the subject's middle finger or thumb, and wrap the Velcro strap around the end of the finger to attach the unit firmly in place.



10. 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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Figure HH-3-S1: The ECG cable and pulse transducer connected to an IXTA.

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Experiment HH-3: Exercise, the Electrocardiogram, and Peripheral Circulation

Exercise 1: The ECG and the Pulse in a Resting Subject

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

Approximate Time: 15 minutes

Procedure

1. Click on the Record button. The signal should begin scrolling across the screen.
2. Click on the AutoScale All button. Your recording should look like the figure below.
    - If the signal on either the ECG or the Pulse channel is upside down 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 the pulse signal is small or noisy, adjust the tension on the strap holding the pulse plethysmograph to the finger.
3. When you have a suitable trace, type **Resting ECG/Pulse** in the Mark box. Click the mark button to attach the comment to the data. Record for at least 5 minutes.
4. Click Stop to halt recording.
5. Select Save As in the File menu, type a name for the file. Click on the Save button to save the data file.

Exercise 2: The ECG and Pulse After Leg Exercises

Aim: To measure and correlate the ECG and the pulse immediately after exercise using the leg muscles.

Approximate Time: 30 minutes

Procedure

1. While the subject is resting, disconnect the snap leads and the pulse plethysmograph from the subject. If you choose you can also disconnect the leads from the ECG cable.
2. If you choose to disconnect the leads, coil up the lead cables so the subject can hold them in their hand while exercising with the leg muscles, like walking stairs or gently jogging in place. Remember that the lead wires are still attached to the electrodes, so the free portion of the cables need to be long enough to allow the subject to move easily, yet short enough that the subject does not trip.
3. Instruct the subject to exercise for at least three minutes to elevate their heart rate. Immediately after the exercise period is over, have the subject sit down and relax next to the recording equipment.
4. Quickly reconnect the pulse plethysmograph.

If using the iWire-B3G, reconnect the leads as well.

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5. Click on the Record button. Click AutoScale All. While recording, type **ECG/Pulse-Recovery from Exercise** in the Mark box and then click the mark button.
6. Continue recording until the subject's heart and breathing rates have returned to normal. This may take less than 2 minutes, or longer than 10 minutes, depending on the fitness of the subject.
    - **Enter marks and comments on the recording at 30 second intervals by typing comments on the Mark line and clicking on the Mark button.**
    - When HR returns to normal click Stop to halt recording.
7. Select Save in the File menu on the LabScribe window.

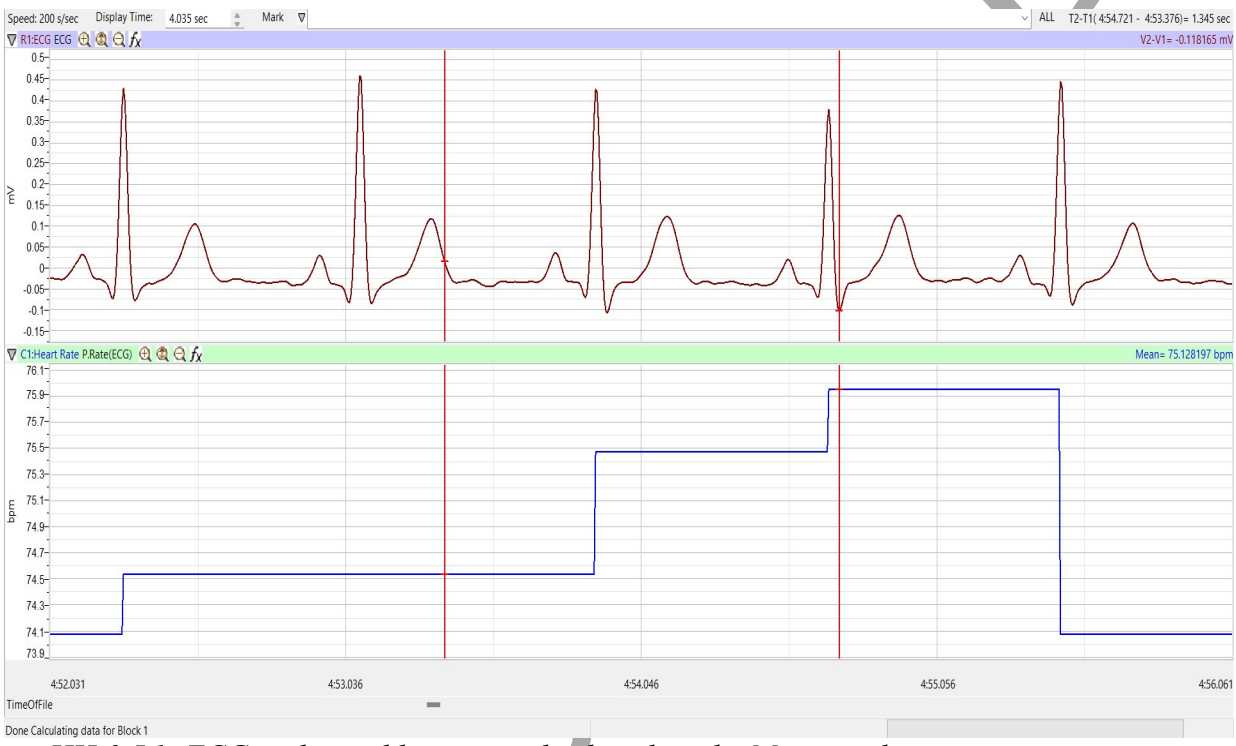

Figure HH-3-L1: ECG, pulse and heart rate displayed on the Main window.

Data Analysis

Use the following techniques to analyze the data from Exercises 1 and 2. The information extracted from these exercises will demonstrate the effects of exercise and recovery on heart or pulse rate.

1. Scroll through the recording and find a section of data with ten exemplary ECG/Pulse cycles recorded in succession while the subject was resting.
2. Use the Display Time icons to adjust the Display Time of the Main window to show the complete ECG/Pulse cycles on the Main window.
3. Data can be collected from the Main window or the Analysis window. If you choose to use the Analysis window, click on the Analysis window icon in the toolbar.
4. The mathematical functions, V2-V1, T2-T1 and Mean should appear on screen. Values for V2-

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V1, T2-T1 and Mean on each channel are seen in the table across the top margin of each channel, or to the right of each graph.

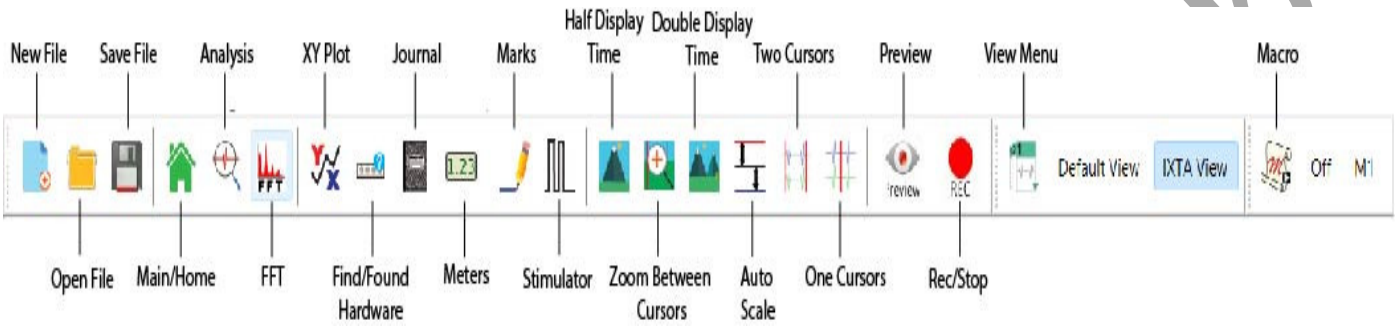

Figure HH-3-L2: The LabScribe toolbar.

4. Once the cursors are placed in the correct positions for determining the amplitudes and the time intervals on each ECG/Pulse cycle, the values of these amplitudes and 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.
5. Use the mouse to click on and drag the cursors to specific points on the ECG/Pulse recording to measure the following (measure at least 5 ECG cycles):

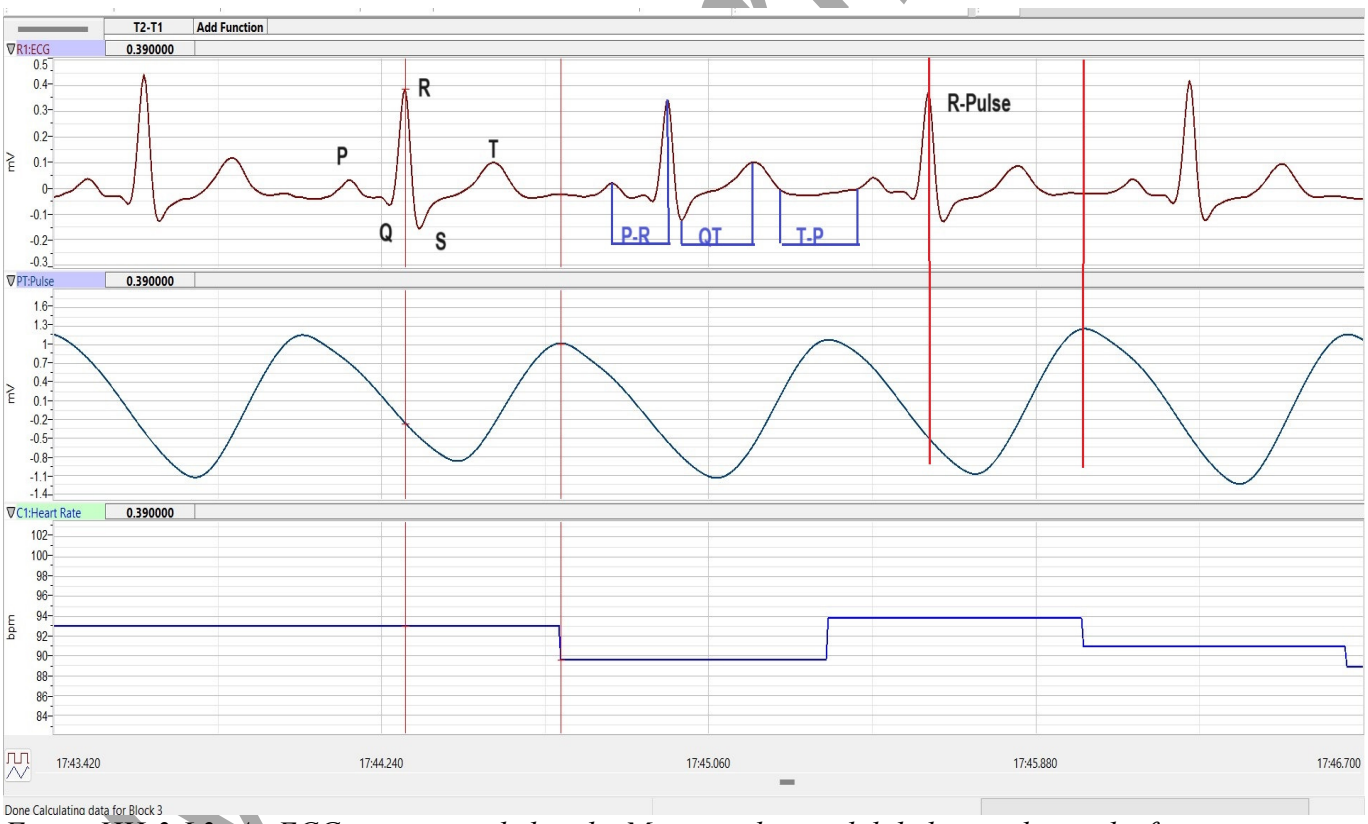

Figure HH-3-L3: An ECG trace recorded in the Main window with labels to indicate the four time values to be measured during data analysis.

Sample

- The R-wave amplitude. To measure the R wave amplitude, place one cursor on the Q wave that precedes the R wave and the second cursor on the peak of the R wave. The value for V2-V1 on the ECG channel is this amplitude.
- 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.
- The P-R interval. 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.
- The Q-T interval. 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.
- The T-P interval. To measure this time interval, place one cursor at the end of the T wave and the second cursor at the beginning of the P wave. The value for T2-T1 on the ECG channel is the T-P interval.
- The R-Pulse interval, which is the time interval between the peak of the R wave and the peak of the pulse 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 four additional ECG/Pulse cycles.
- The Pulse wave amplitude. To measure the pulse wave amplitude, place one cursor on the baseline that precedes the pulse wave and the second cursor on the peak of the pulse wave. The value for V2-V1 on the Pulse channel is this amplitude. Measure this amplitude for four additional pulse waves.

6. Calculate the following values and type your results into the Journal or on a separate data table:
   - The average R-wave amplitude.
   - 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:

$$\textbf{Heart Rate (beats/minute)} = \frac{\textbf{60 seconds/minute}}{\textbf{\# seconds/beat}}$$

Note: *Heart Rate can also be determined by looking at the Mean function on the Heart Rate Channel. The more data on screen - the more accurate the Mean heart rate.*

   - The average P-R interval.
   - The average Q-T interval.
   - The average T-P interval.
   - The average R-Pulse interval.
   - The average pulse wave amplitude.

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7. Scroll through the recording and find a section of data with four or five exemplary ECG/Pulse cycles recorded in succession when the subject just stopped exercising (Recovery time = 0 seconds). Repeat Steps 2 through 7 for this section of data.
8. Move to the sections of data marked at 30 second intervals throughout the recovery period and repeat the measurements performed in Steps 2 through 7.

Questions

1. How does the heart rate from the subject at rest and at 0, 30, 60, 90, and 120 seconds after exercise (recovery) compare? If there is any variation between the rates for each time period? Is there a trend and what is it?
2. How does the average P-R interval from rest and each time period in recovery compare? Do you see any variation or trend?
3. How does the average Q-T interval from rest and each time period in recovery compare? Do you see any variation or trend?
4. How does the average T-P interval from rest and each time period in recovery compare? Do you see any variation or trend?
5. How does the average R-Pulse interval from rest and each time period in recovery compare? Do you see any variation or trend?
6. How does the average R-wave ECG amplitude from rest and each time period in recovery compare? Do you see any variation or trend?
7. How does the average pulse wave amplitude from rest and each time period in recovery compare? Do you see any variation or trend?
8. Is there any effect on the blood flow through subject's finger as the subject is performing leg exercises?

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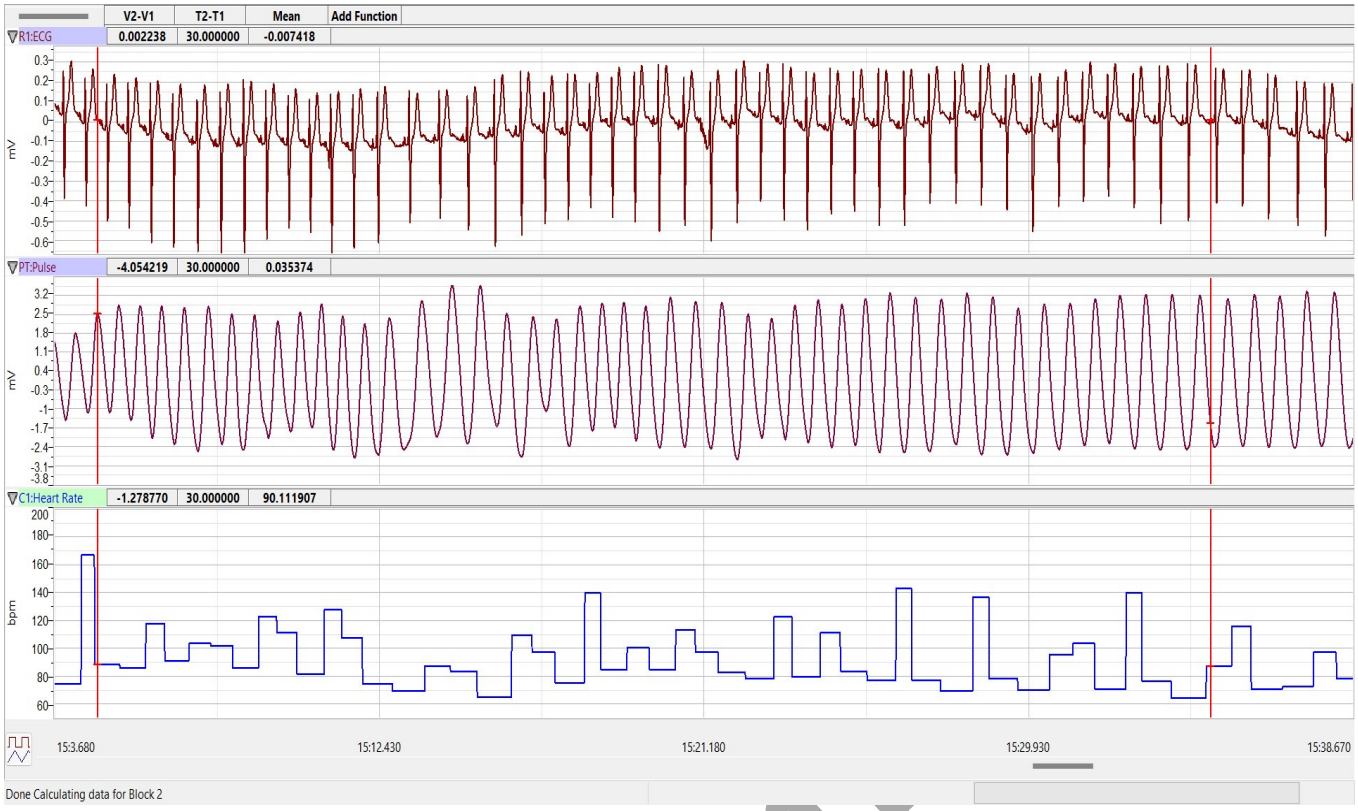

Figure HH-3-L4; ECG, pulse, and heart rate displayed in the Analysis window with cursors placed to measure the pulse amplitude with the V2-V1 function. Display has been doubled so that a Mean heart rate can be calculated over a 30 second time frame.

Exercise 3: The ECG and Pulse After Hand Exercises

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

Approximate Time: 15 minutes

Procedure

1. Instruct the subject to sit quietly with their hands in their lap.
2. Make sure the ECG lead wires are connected to the electrodes, and the pulse plethysmograph is attached to subject's finger properly.
3. Grasp the dynamometer in the palm of the hand with the plethysmograph attached.

Note: *The FT-325 / FT-220 hand dynamometer is not plugged into the iWorx unit at this time. The FT-325 / FT-220 is being used as the resistance against which the hand muscles do some work.*

4. Rhythmically squeeze the dynamometer bulb for three minutes or until the forearm muscles fatigue.

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5. Immediately after the subject stops squeezing the hand dynamometer, click on the Record button. Click AutoScale All. While recording, type **ECG/Pulse-Recovery from Hand Exercise** in the Mark box and click the mark button.
6. Record for three minutes or until the amplitude of the finger pulse signal has attained a reasonably constant level for one minute.
7. Click Stop to halt recording.
8. Select Save in the File menu.

Data Analysis

Use the techniques used in Exercises 1 and 2 to determine:

- The heart rate from the subject at rest and at 0, 30, 60, 90, and 120 seconds into the recovery period from hand exercise
- The average R-Pulse interval for rest and each time period of recovery.
- The average R-wave amplitude for rest and each time period of recovery.
- The average pulse wave amplitude for rest and each time period of recovery.

Questions

1. How do the amplitudes of the pulse waves from the rest and each time period of recovery from hand exercise compare?
2. How do the heart rates for rest and each time period of recovery from hand exercise compare?
3. How do the amplitudes of the pulse waves from the leg and hand exercises compare? Does one type of exercise cause more blood flow in the hand than the other?
4. How do the heart rates from the leg and the hand exercise compare? Does one type of exercise cause a higher heart rate than the other?
5. Do the R-pulse intervals and the R-wave amplitudes from the hand exercise differ from the same values from the leg exercise?

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