

Experiment CP-3: The Effects of Exercise on the Electrocardiogram (ECG) and the Pulse

Background

The arterial system functions as a pressure reservoir. Blood enters via the heart and exits through the capillaries. Signals from the autonomic nervous system control the tone of smooth muscle sphincters around the arterioles. In this way, the autonomic nervous system can control the distribution of blood to the various organs in the body. The distribution of blood that flows to a particular organ is influenced by local conditions. If there are cells that require arterial blood, due to a decline in pH or oxygen levels or an increase in carbon dioxide levels, smooth muscle sphincters open to permit blood into particular capillary beds.

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) subject. These parameters will be recorded when the subject 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 or Macintosh computer

IX-ELVIS

USB cable

Power supply

Red, black, and green ECG leads

PTN-104 Pulse transducer

FT-220 Dynamometer

Stethoscope

Alcohol swabs

Disposable ECG electrodes

IX-ELVIS Setup

1. Place the IX-ELVIS unit on the bench, close to the computer.
2. Connect the IX-ELVIS to the computer with the supplied USB cable.
3. Insert the power plug into the rear of the IX-ELVIS and plug the transformer into the electrical outlet. Turn on the power switches on the rear and on the upper right side of the top of the unit and confirm that the LEDs are illuminated.

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.
2. On the Main window, pull down the Settings menu and select Load Group.
3. Locate the folder that contains the settings group, ELVISNI.iwxgrp. Select this group and click Open.
4. Pull down the Settings menu again. Select the ExerciseECGPulse-LS2 settings file.
5. After a short time, LabScribe will appear on the computer screen as configured by the ExerciseECGPulse-LS2 settings.
6. The settings used to configure the LabScribe software and the IX-ELVIS 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.

ECG Lead Wires and Pulse Transducer Setup

1. Locate the red, black, and green ECG electrode lead wires ([Figure CP-3-S1](#)), and the PTN-104 pulse plethysmograph ([Figure CP-3-S2](#)).

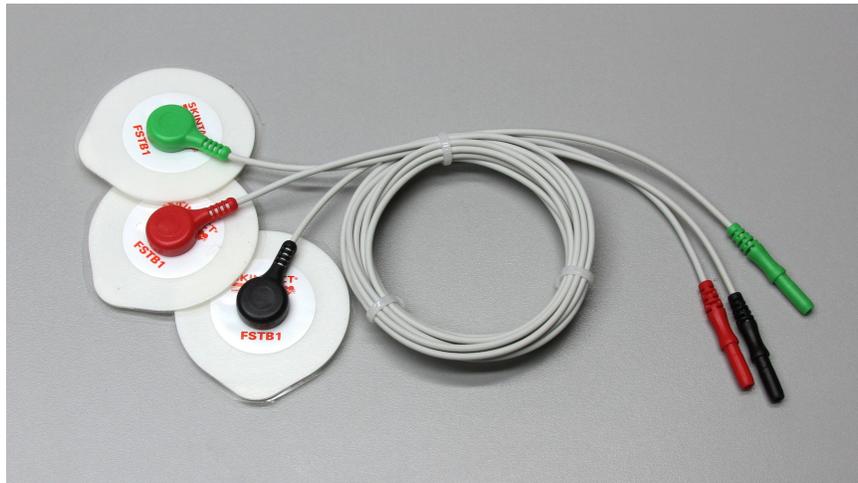


Figure CP-3-S1: The C-ISO-255 ECG cable with three lead wires attached.



Figure CP-3-S2: The PTN-104 pulse plethysmograph.

2. Plug the mini-DIN connector to the PTN-104 into the Channel 3 input of the IX-ELVIS ([Figure CP-3-S3](#)).
3. Insert the connectors on the red, black, and green electrode lead wires into the matching sockets of Channel 1 of the IX-ELVIS ([Figure CP-3-S3](#)).

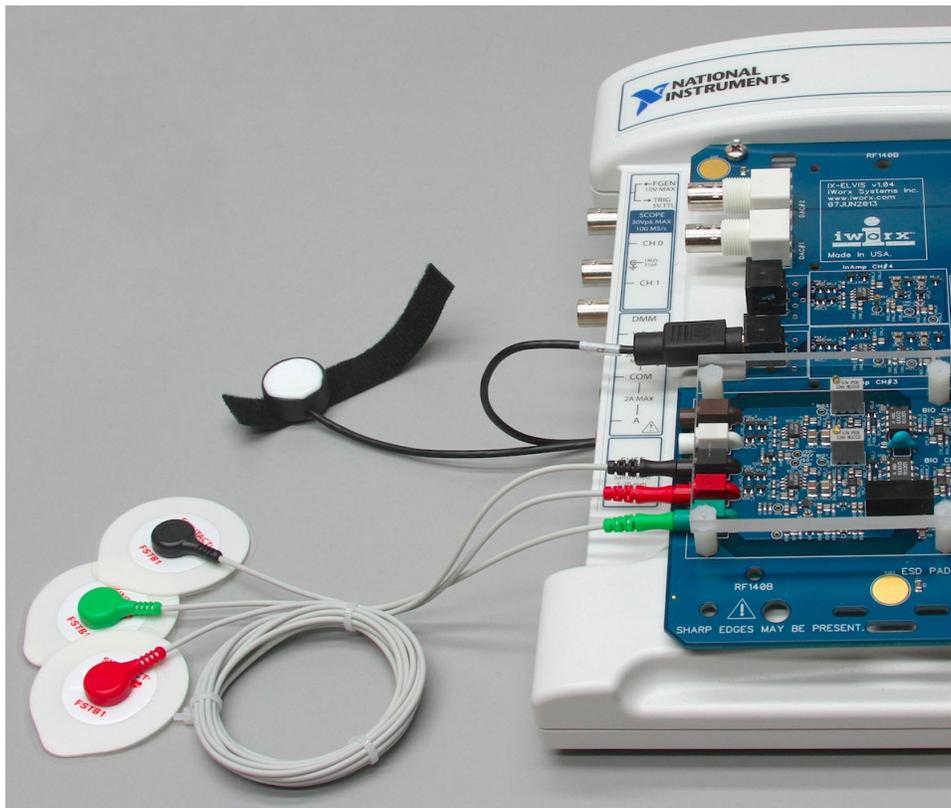


Figure CP-3-S3: The ECG lead wires and pulse transducer connected to the IX-ELVIS.

4. Instruct the subject to remove all jewelry from their wrists and ankles.
5. Use an alcohol swab to clean and scrub a region with little or no hair, on the inside of the subject's right wrist. Let the area dry.
6. Remove a disposable ECG electrode from its plastic shield, and apply the electrode to the scrubbed area on the wrist.
7. Repeat Steps 5 and 6 for the inside of the left wrist 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,
 - the black (-1) lead is connected to the right wrist,
 - the green (C or ground) lead is connected to the right leg.
10. 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.
11. 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.

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.

Procedure

1. Click on the Record button, located on the upper right side of the LabScribe Main window ([Figure CP-3-L1](#)). The signal should begin scrolling across the screen.

Note: If the user clicks the Record button and there is no communication between the IX-ELVIS and the computer, an error window will appear in the center of the Main window. Make sure the IX-ELVIS is turned on and 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, Pulse, and Pulse Integral channels. Your recording should look like [Figure CP-3-L1](#).
 - If the signal on either the ECG or the Pulse channel is upside down when compared to trace in [Figure CP-3-L1](#), 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 below each clavicle.
 - 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 "<Subject's Name> Resting ECG/Pulse" 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. Your data may look like [Figure CP-3-L1](#).
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. Designate the file type as *.iwxdata. Click on the Save button to save the data file.

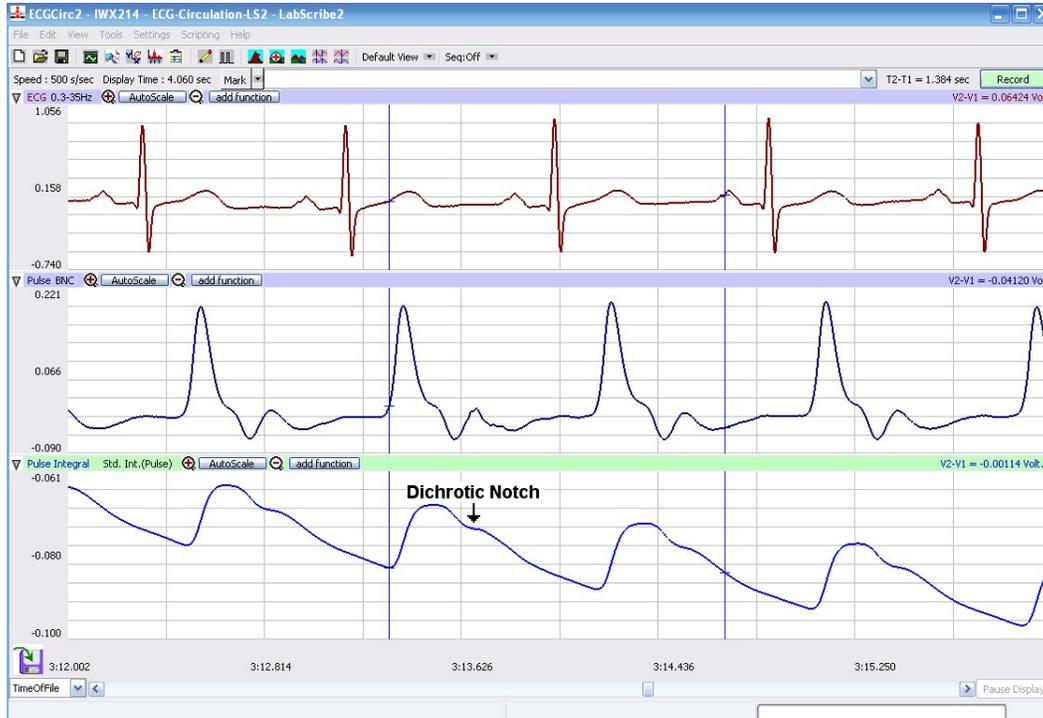


Figure CP-3-L1: ECG, pulse and pulse integral displayed on the Main window. The arrow is placed above a dichrotic notch.

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.

Procedure

1. While the subject is resting, disconnect the ECG lead wires and the pulse plethysmograph cable from the IX-ELVIS.
2. Coil up the ECG lead wires and the PTN-104 cable so the subject can hold the cables in his or her 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 three minutes. Immediately after the exercise period is over, have the subject sit down and relax next to the recording equipment.
4. Quickly reconnect the ECG lead wires and the PTN-104 cables to the IX-ELVIS.

5. Click on the Record button. Click AutoScale on all three channels. While recording, type “ECG/Pulse-Recovery from Exercise” 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.
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 or pressing the Enter key on the keyboard.
7. Click Stop to halt recording.
8. Select Save in the File menu on the LabScribe 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 four or five 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 at least four complete ECG/Pulse cycles on the Main window. Four adjacent ECG/Pulse cycles can also be selected by:
 - Placing the cursors on either side of a group of four complete ECG/Pulse cycles; and
 - Clicking the Zoom between Cursors button on the LabScribe toolbar to expand the segment with the four selected ECG/Pulse cycles to the width of the Main window.
3. Click on the Analysis window icon in the toolbar ([Figure CP-3-L2](#)) or select Analysis from the Windows menu to transfer the data displayed in the Main window to the Analysis window ([Figure CP-3-L3](#)).

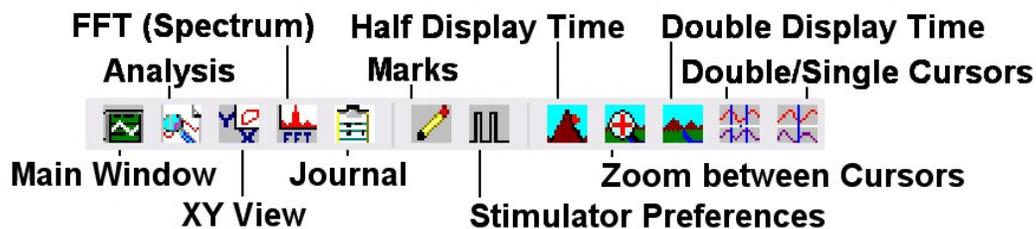


Figure CP-3-L2: The LabScribe toolbar.

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 for a channel are seen in the table across its top margin.
5. 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.

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 amplitudes and time intervals of the ECG/Pulse cycle.
 - Transfer the names of the mathematical functions used to determine the amplitudes and time interval to the Journal using the Add Title to Journal function in the ECG Channel pull-down menu.
 - Transfer the values for the amplitudes and beat period to the Journal using the Add Ch. Data to Journal function in the ECG Channel pull-down menu.
7. Use the mouse to click on and drag the cursors to specific points on the ECG/Pulse recording to measure the following:
 - 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. Measure the amplitudes of two additional R waves.
 - The beat period, which is the time interval between two adjacent R waves ([Figure CP-3-L3](#)): To measure the beat period, place one cursor on the peak of a 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 more pairs of R waves.

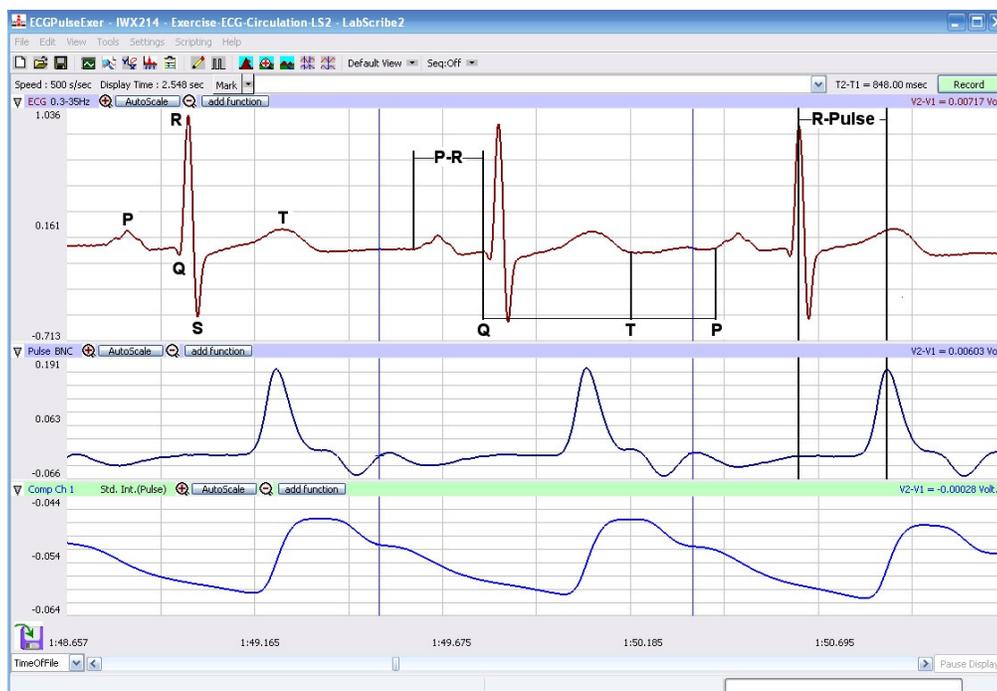


Figure CP-3-L3: An ECG trace recorded in the Main window with labels to indicate the four time values to be measured during data analysis.

- 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. Measure this time interval for two additional ECG cycles.
 - 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. Measure this time interval for two additional ECG cycles.
 - 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. Measure this time interval for two additional ECG cycles.
 - 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 ([Figure CP-3-L3](#)): To measure this interval, place one cursor on the peak of a 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 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 ([Figure CP-3-L4](#)). The value for V2-V1 on the Pulse channel is this amplitude. Measure this amplitude for two additional pulse waves.
8. 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:
Heart Rate (beats/minute) = 60 seconds/minute / # seconds/beat
 - 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.
9. 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.
10. Move to the sections of data marked at 30 second intervals throughout the recovery period began 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 affect on the blood flow through subject's finger as the subject is performing leg exercises?

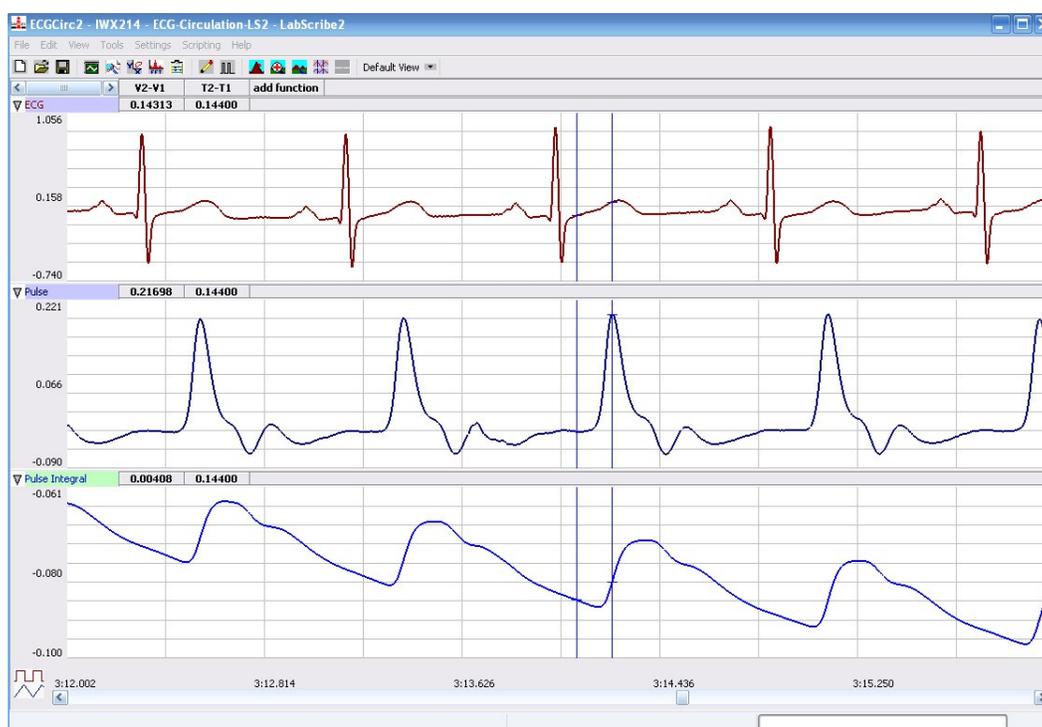


Figure CP-3-L4: ECG, pulse, and pulse integral displayed in the Analysis window with cursors placed to measure the pulse amplitude with the V2-V1 function.

Exercise 3: The ECG and Pulse After Hand Exercises

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

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-220 hand dynamometer is not plugged into the IX-ELVIS unit at this time. The 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.
5. Immediately after the subject stops squeezing the hand dynamometer, click on the Record button. Click AutoScale on all three channels. While recording, type "ECG/Pulse-Recovery from Hand Exercise" 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 three minutes or until the amplitude of the finger pulse signal (Channel 3) has attained a reasonably constant level for one minute.
6. Click Stop to halt recording.
7. 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?