Experiment HH-6: Heart Rate Variability (HRV)

Equipment Required

PC or Mac Computer

IXTA, USB cable, IXTA power supply

iWire-B3G ECG cable and electrode lead wires

Alcohol swabs

Disposable ECG electrodes

Mechanical or electronic metronome

Step or platform, 30cm high

ECG Cable Setup

1. Locate the iWire-B3G ECG cable and electrode lead wires.

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

2. Insert the connector on the end of the iWire-B3G ECG cable into the iWire 1 input on the front of the IXTA.
3. Insert the connectors on the red, black, and green electrode lead wires into the matching sockets on the ECG cable.
4. 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.
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/clavicle. 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/clavicle.
7. Repeat Steps 5 and 6 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.
9. Instruct the subject to sit quietly with their hands in their lap. If the subject moves, the ECG trace may move off the top or bottom of the screen. If any muscles in the arms or upper body are moved, electromyograms (EMGs) from the muscles will appear on the ECG recording as noise.

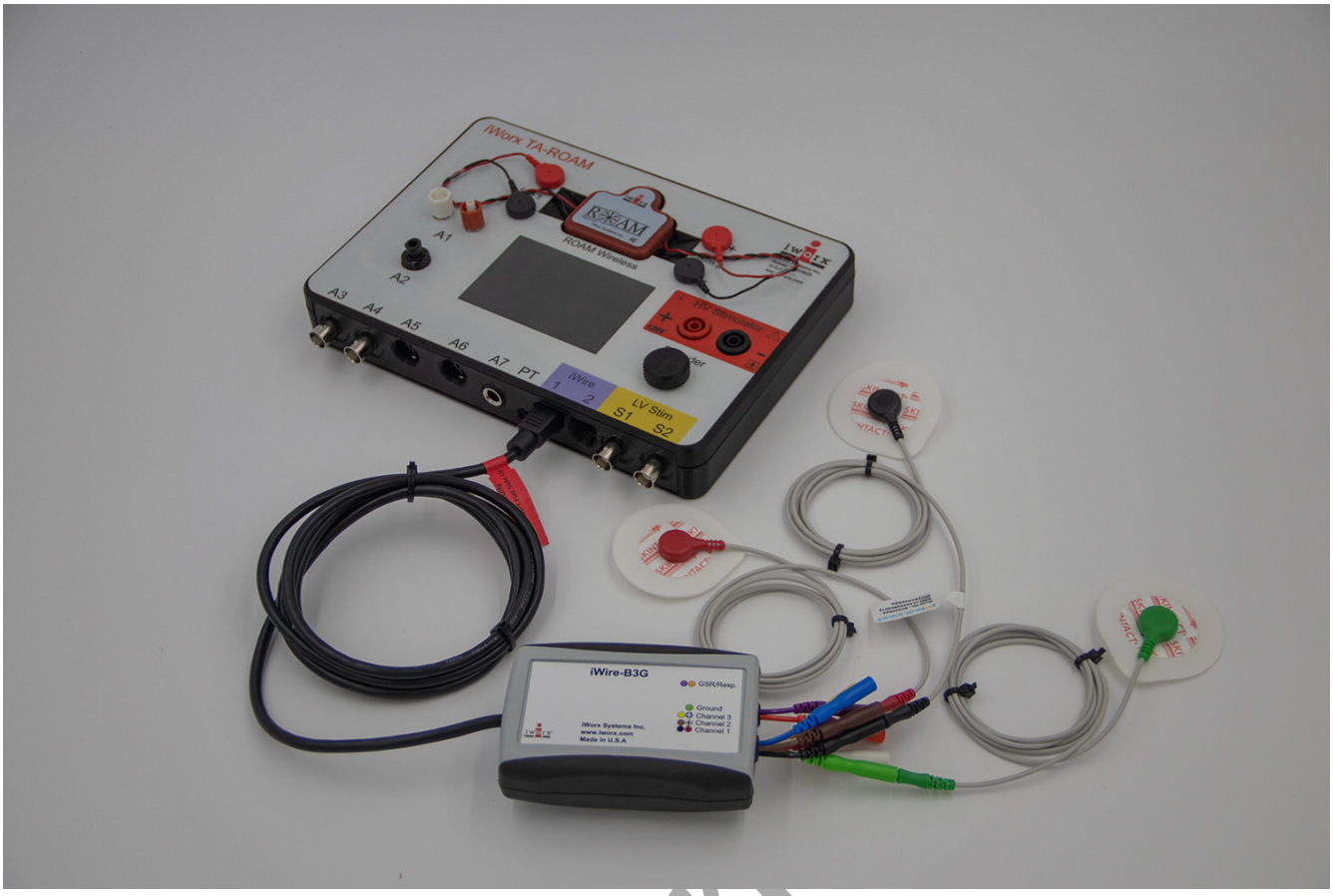

Figure HH-6-S1: The ECG cable connected to an IXTA.

Experiment HH-6: Heart Rate Variability (HRV)

Exercise 1: HRV in Resting Subject

Aim: To determine heart rate variability in a resting individual.

Approximate Time: 20 minutes

Procedure

1. Based on gender, weight, physical fitness level, smoking preference, health. or any other characteristics, separate the subjects into groups. Make sure each group is represented by an equal number of subjects; this number will depend on the time available, the number of groups created, and the number of subjects available.
2. Connect the recording equipment to a subject and instruct the subject to sit and relax for ten minutes. To analyze five minutes of ECG using an HRV analysis function, a total of ten minutes of data is required to properly perform the HRV analysis.
3. At the beginning of the ten-minute relaxation period, click on the Record button.
4. Click on the AutoScale All button. Your recording should look like the figure below.
    - If the signal on the ECG 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.
5. Type **Resting ECG** in the Mark box. Click the mark button to attach the comment to the data. Record the subject's resting ECG for at least ten minutes. Mark the recording at one minute intervals using the Mark button.
6. Click Stop to halt recording.

Note: *If there are no signals showing up in the HRV channels, adjust the threshold and tolerance levels by going to the HRV-Lo Setup window and moving the blue horizontal cursors, repeat with the HRV-Hi channel. Click the* ***black*** *text to the right of the title of the channel and click SetUp Function.*

7. Select Save As in the File menu, type a name for the file. Click on the Save button to save the data file.

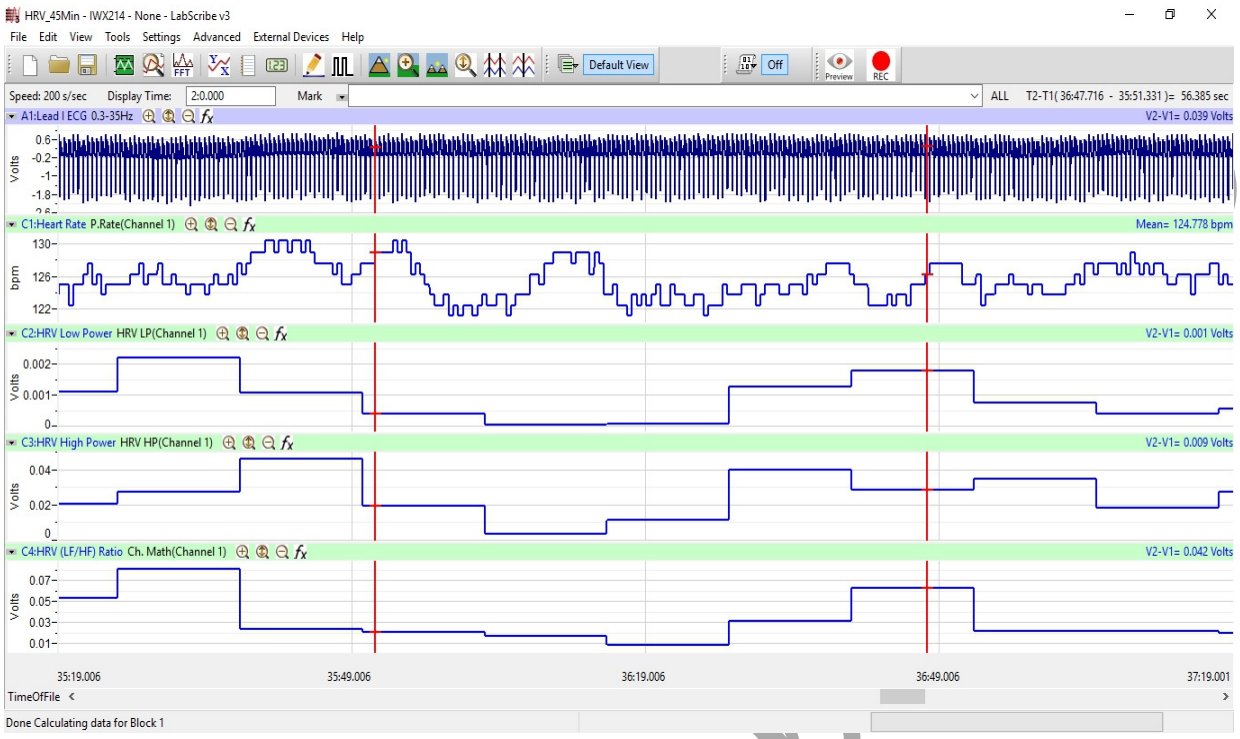

Figure HH-6-L1: The ECG, heart rate, LP, HP, HRV ratio (from top to bottom) of a resting subject displayed in the Main window.

Data Analysis

1. Scroll to the first minute of the ten minute recording from the resting subject.
2. Use the Display Time icons to adjust the Display Time of the Main window to include the first minute of data.

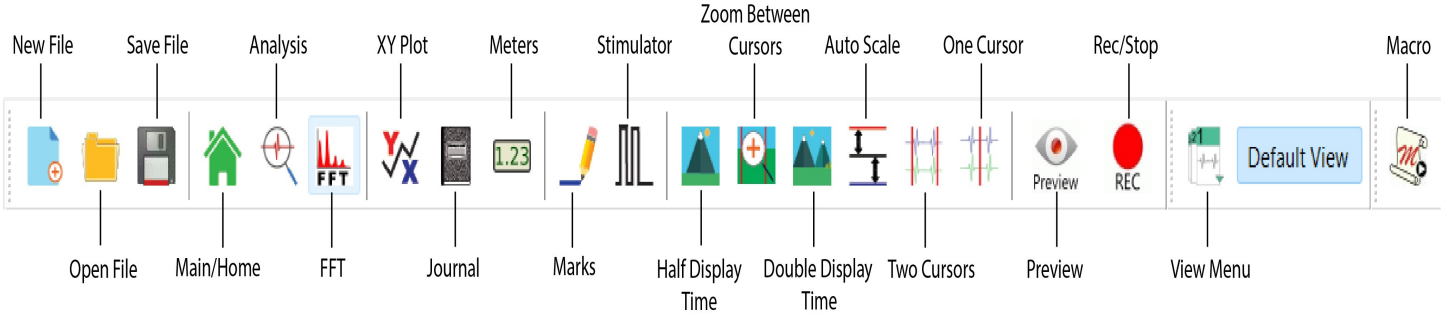

Figure HH-6-L2: The LabScribe toolbar.

3. Click on the Analysis window icon in the toolbar.

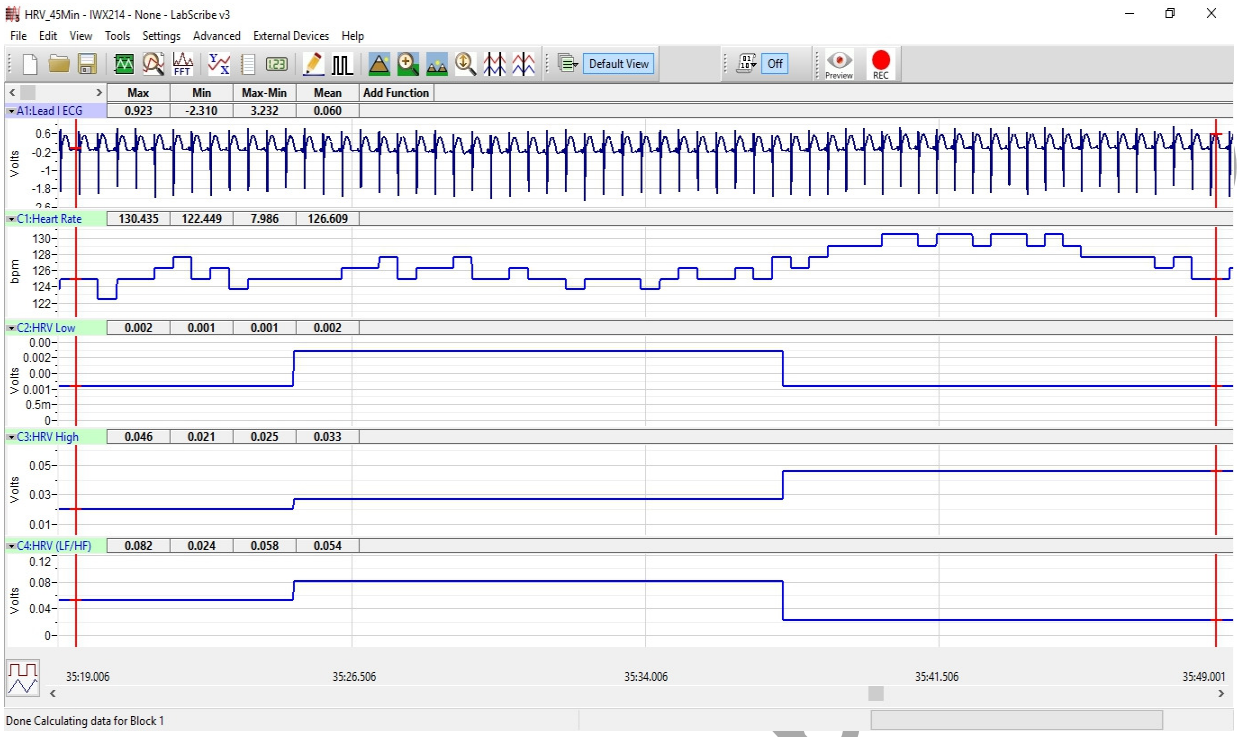

Figure HH-6-L3: The ECG, heart rate, LP, HP, HRV ratio (from top to bottom) of a resting subject displayed in the Analysis window.

4. Look at the Function Table that is above the uppermost channel displayed in the Analysis window. The name of the mathematical function used in the analysis, Mean, appears in this table. The values for the Mean from each channel are seen in the table across the top margin of each channel.
5. Place the cursors on either side of the 1 minute section of data recorded. The section of data selected should be clear of artifacts on the ECG channel.
6. The values for the mean heart rate, mean LP coefficient, mean HP coefficient, and mean HRV ratio within the first minute of rest 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.
7. 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 needed to select a fifteen to twenty second segment of data that is clear of artifacts.
    - Transfer the names of the mathematical functions used to determine the amplitudes and time intervals 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.

8. Use the same analysis to measure the mean values of heart rate, LP, HP, and HRV ratio from the other one-minute segments of the recording. You should see the heart rate of a resting subject fluctuate in a cyclical manner, known as respiratory sinus arrhythmia (RSA), which is caused by breathing. The subject's heart rate is displayed to demonstrate any variations in heart rate that occur during the recording period, but the heart rate function is not a required part of the heart rate variability analysis.
9. Record the values for the parameters from all five time segments in Table 1.

Questions

1. Did the LP values of the subject at rest go up or down as his or her HP values went up?
2. How do the HRV ratios from the first through the fifth minute of the rest period compare? Is your subject more or less "stressed" as the rest period passes?
3. How do the resting HRV ratios of the subjects in your study group compare? To make a comparison use the HRV ratio from each subject's fifth minute in the rest period.
4. How does the mean resting HRV ratio of the study group compare to the mean resting HRV ratios from other study groups? Again, use the ratio from the fifth minute in each rest period.
5. Which study group had the lowest resting HRV ratio?
6. Which study group had the highest resting HRV ratio?
7. What can the study group with the highest resting HRV ratio do to reduce their HRV ratio?

Exercise 2: HRV After Exercise

Aim: To determine heart rate variability in an individual during recovery from exercise.

Approximate Time: 45 minutes

Procedure

1. The subject will elevate his or her heart rate by performing a three minute step test. Place the step against the side of a lab bench or up against a wall to prevent it from slipping from under the feet of the subject.
2. The step test is three minutes long at the rate of 24 complete steps per minute. Each step is composed of four movements, each movement takes place on the beat of a metronome that is set to 96 beats per minute. The four movements in each step are:
    - 1st beat: Lift right foot up on step.
    - 2nd beat: Push the body up using the right leg, lift the left foot on the step.
    - 3rd beat: Lower the right foot to the ground.
    - 4th beat: Lower the left foot to the ground.
3. Disconnect the three ECG lead wires from the ECG electrodes on the subject.
4. Instruct the subject to begin the three-minute step test.

5. As soon as the three-minute step test ends, the subject should sit in a chair.
6. Quickly connect the ECG leads to the subject's electrodes.
7. Click on the Record button and begin recording the subject's ECG for at least ten minutes. The same computed functions recorded during Exercise 1 will be recorded in this exercise.
8. Click Stop to halt recording.
9. Select Save in the File menu.

Data Analysis

1. Use the same techniques used in Exercise 1 to measure the mean heart rate, LP, HP, and HRV ratios from the first through fifth minute of recovery from exercise.
2. Record the values for each parameter for all five time segments in the Journal using the techniques used in Exercise 1, or on a separate data table.
3. Record the values for the parameters in Table 1.

Questions

1. How do the HRV ratios in the first through fifth minutes of recovery from exercise compare? Is your subject less "stressed" at the end of the recovery period?
2. How does the HRV ratio from the fifth minute of the resting period compare to the HRV ratios from the first through the fifth minute of the recovery from exercise period?
3. How do the recovery HRV ratios of the subjects in your study group compare? To make a comparison use the HRV ratio from each subject's fifth minute in the recovery period.
4. How does the mean recovery HRV ratio of the study group compare to the mean recovery HRV ratios from other study groups? Again, use the ratio from the fifth minute in each recovery period.
5. Which study group had the lowest recovery HRV ratio?
6. Which study group had the highest recovery HRV ratio?
7. What can the study group with the highest recovery HRV ratio do to reduce their HRV ratio?

Exercise 3: HRV During a Test

Aim: To determine heart rate variability in an individual who is taking a psychological test.

Approximate Time: 30 minutes depending on the type of test

Procedure

1. Select a psychological test that the subject can perform while his or her ECG is recorded:
    - A personality test.
    - A "lie detector" test.
    - An analogy test.
    - A practice MCAT or GRE test.
    - A Stroop "color" test.
2. Allow the subject to rest for a total of fifteen minutes to fully recover from Exercise 2.
3. At the end of the fifteen-minute rest period, click the Record button and record the subject's ECG, heart rate, LP, HP, and HRV Ratio values for a five-minute baseline period.
4. Continue to record from the subject as they take a timed psychological test. Type **Test Begins** in the Mark box to the right of the Mark button. Click the mark button to attach the comment to the data at the point the subject begins the test.
5. Type **Test Ends** in the Mark box. Click the mark button when the subject finishes the psychological test or when five minutes of testing have elapsed, whichever is earlier.
6. Continue to record the subject's ECG, heart rate, LP, HP, and HRV ratio during a ten-minute post-test period.
7. Click Stop to halt recording.
8. Select Save in the File menu.

Data Analysis

1. Use the same techniques used in Exercises 1 and 2 to measure the mean heart rate, LP, HP, and HRV ratios from the first through fifth minute of the pre-test, test, and post-test segments.
2. Record the values for each parameter for all fifteen time segments in the Journal using the techniques used in Exercises 1 and 2, or on a separate data table.
3. Record the values for the parameters in Table 1.

Questions

1. How do the HRV ratios in the first through fifth minutes of the testing period compare? Is your subject more or less stressed at the end of the testing period?
2. How does the HRV ratio from the fifth minute of the resting period compare to the HRV ratios from the first through the fifth minute of the testing period?
3. How do the testing HRV ratios of the subjects in your study group compare? To make a comparison use the HRV ratio from each subject's fifth minute in the testing period.
4. How does the mean testing HRV ratio of the study group compare to the mean testing HRV ratios from other study groups? Again, use the ratio from the fifth minute in each testing period.
5. Which study group had the lowest testing HRV ratio?

6. Which study group had the highest testing HRV ratio?
7. What can the study group with the highest testing HRV ratio do to reduce their HRV ratio?
8. How do the HRV ratios in the first through fifth minutes of the post-test period compare? Is your subject more or less stressed at the end of the post-test period?
9. How does the HRV ratio from the fifth minute of the resting period compare to the HRV ratios from the first through the fifth minute of the post-test period?
10. How do the post-test HRV ratios of the subjects in your study group compare? To make a comparison use the HRV ratio from each subject's fifth minute in the post-test period.
11. How does the mean post-test HRV ratio of the study group compare to the mean post-test HRV ratios from other study groups? Again, use the ratio from the fifth minute in each post-test period.
12. Which study group had the lowest post-test HRV ratio?
13. Which study group had the highest post-test HRV ratio?
14. What can the study group with the highest post-test HRV ratio do to reduce their HRV ratio?
15. Which study group showed the healthiest recovery from the "stress" of the test? You decide which values to compare to best make this determination.

Table HH-6-L1:Heart Rate and HRV Values for Each Five Minute Task.

	Heart Rate (BPM)					HRV LP				
Min	Rest	PostExer	PreTest	Test	Post Test	Rest	PostExer	PreTest	Test	Post Test
1st										
2nd										
3rd										
4th										
5th										

Table HH-6-L1:Heart Rate and HRV Values for Each Five Minute Task (continued).

	HRV HP					HRV Ratio				
Min	Rest	PostExer	PreTest	Test	Post Test	Rest	PostExer	PreTest	Test	Post Test
1st										
2nd										
3rd										
4th										
5th										