

Experiment HH-5: The Diving Reflex

Equipment Required

PC or Mac Computer

IXTA, USB cable, IXTA power supply

PT-104 Pulse plethysmograph

Three pans, each with 3" of water at 5, 15, or 25°C

iWire-B3G (optional)

RM-204 Respiration monitor (optional)

Pulse Transducer Setup

1. Locate the PT-104 pulse plethysmograph in the iWorx kit.



Figure HH-5-S1: The PT-104 pulse plethysmograph.

2. Plug the DIN8 connector to the PT-104 (plethysmograph) into Channel A5 of the IXTA.
3. Place the plethysmograph on the volar surface (where the fingerprints are located) of the distal segment of the left middle finger or thumb, and wrap the Velcro strap around the end of the finger to attach the unit firmly in place.
4. Instruct the subject to sit quietly.



Figure HH-5-S2: The PT-104 connected to the IXTA.

Optional Experiment/Equipment

Use the Respiration Monitor as shown in the lab.

Use the iWire-B3G cable to record an ECG as well as the pulse and heart rate.

Experiment HH-5: The Diving Reflex

Exercise 1: Heart Rate at Rest

Aim: To measure the heart rate of a subject at rest.

Approximate Time: 15 minutes

Procedure

1. Click on the Record button, located on the upper right side of the LabScribe Main window. The signal should begin scrolling across the screen.
2. Click on the AutoScale All button. Your recording should look like the image below.
 - If the signal on 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** 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.



Figure HH-5-L1: The pulse and heart rate recording of a subject at rest displayed in the Main Window.

Data Analysis

1. Scroll through the recording and find a twenty second section of data with exemplary pulse waves. Since the subject is breathing normally, the trace on the Heart Rate channel should cycle, which demonstrates normal respiratory sinus arrhythmia.
2. Use the Display Time icons to adjust the Display Time of the Main window to show the complete heart rate cycles on the Main window.
3. Click on the Analysis window icon in the toolbar to transfer the data displayed in the Main window to the Analysis window.

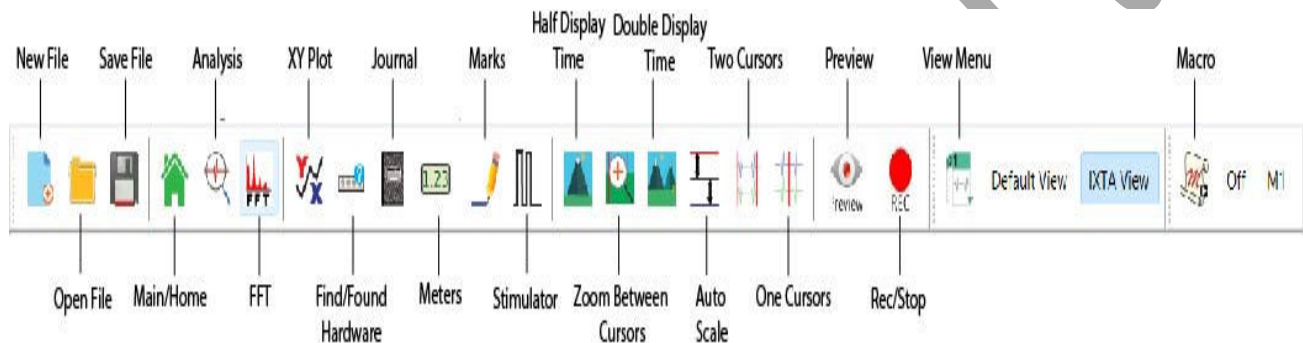


Figure HH-5-L2: The LabScribe Toolbar.

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, Max, Min, and Mean, appear in this table. The values for these three parameters on each channel are seen in the table across the top margin of each channel.

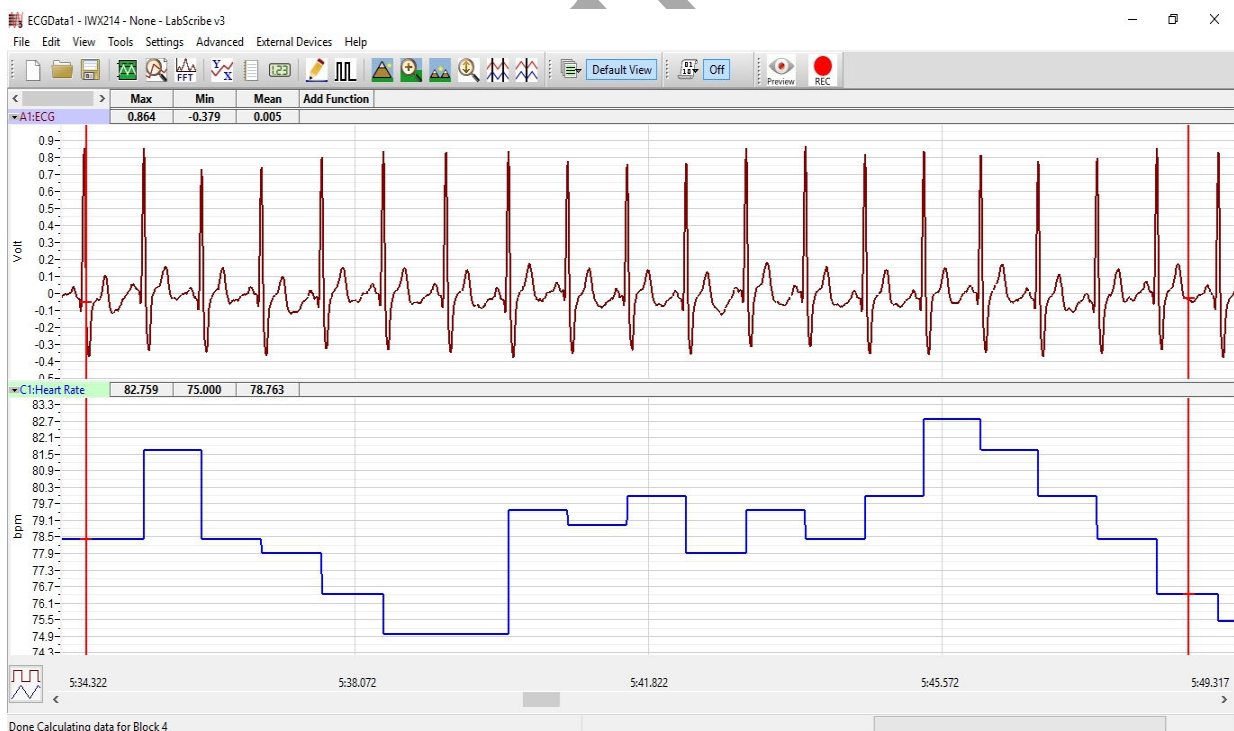


Figure HH-5-L3: The pulse and heart recording of a subject at rest displayed in the Analysis window.

5. Once the cursors are placed in the correct positions for determining the maximum, minimum, and mean heart rates in the section of data displayed in the Analysis window, the values of these parameters 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 a cursor on the left margin of the data displayed in the Analysis window, and the other cursor on the right margin of the displayed data.
 - Transfer the names of the mathematical functions used to determine the maximum, minimum, and mean heart rates to the Journal using the Add Title to Journal function in the Heart Rate Channel pull-down menu.
 - Transfer the values for the maximum, minimum, and mean heart rates to the Journal using the Add Ch. Data to Journal function in the Heart Rate Channel pull-down menu.
7. Enter the subject's resting heart rate into Table 1.

Exercise 2: Heart Rate and Apnea

Aim: To measure the heart rate of a subject while they are holding their breath.

Approximate Time: 15 minutes

Procedure

1. Click on the Record button. The signal should begin scrolling across the screen.
2. Remind the same subject to sit quietly with their hands in their lap. Instruct the subject to hold his or her breath as long as possible in this exercise.
3. Click on the AutoScale button at the upper margin of the Pulse and Heart Rate channels. Your recording should look like the image below. Use the same techniques used in Exercise 1 to display the signals properly.
4. When the pulse recording is a suitable trace, type **Holding Breath** in the Mark box to the right of the Mark button. Click the mark button as the subject begins to hold his or her breath (apnea).
5. Quickly type **Breathing Again** in the Mark box. Click the mark button to attach the comment to the data when the subject resumes breathing. Continue recording for at least thirty seconds after the subject begins breathing again.
6. Click Stop to halt recording.
7. Select Save in the File menu.

Data Analysis

1. Scroll through the recording and find the section of data that was collected while the subject was holding his or her breath.
2. Use the Display Time icons, or the cursors and the Zoom between Cursors button, to adjust the Display Time of the Main window to show the data from ten seconds before the subject held his or her breath to twenty seconds after breathing resumed.
3. Click on the Analysis window icon in the toolbar to transfer the data displayed in the Main window to the Analysis window.
4. Place one cursor at the point when the subject held his or her breath and the other cursor at the point breathing resumed.
5. Look at the Function Table in the Analysis window and make sure the mathematical functions used in the analysis, Max, Min, and Mean, appear.
6. Use one of the techniques explained in Exercise 1 to record the values for these parameters in the Journal, or on a separate data table.
7. Enter the subject's heart rate during apnea into Table 1.

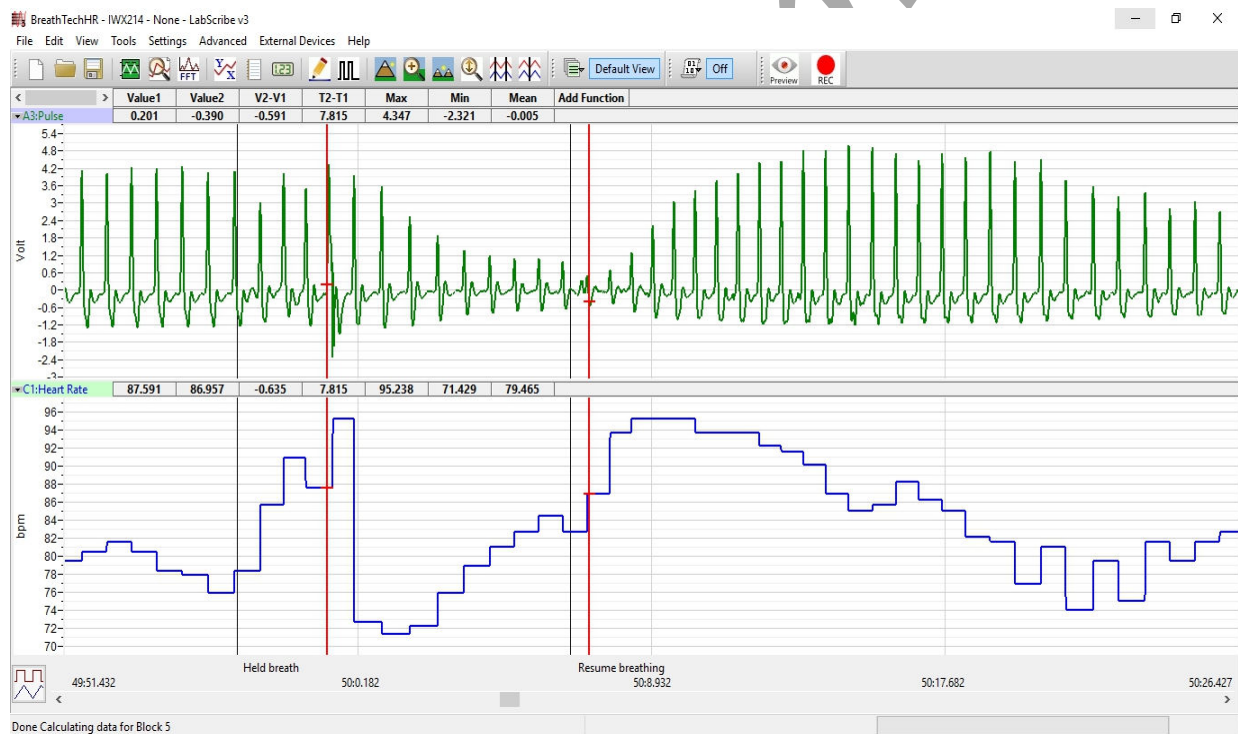


Figure HH-5-L4: Heart rate change during apnea.

Questions

1. How does the subject's average heart rate while resting compare to the heart rate while holding breath?
2. How do the subject's maximum and minimum heart rates while resting compare to the same heart rates while holding breath?

Exercise 3: Heart Rate While Testing the Diving Reflex

Aim: To measure the effects of “diving” into cold water on heart rate.

Approximate Time: 30-45 minutes

Procedure

1. Have the subject sit in front of a pan of room temperature water (25°C). If the subject wears glasses, the glasses should be removed. If the subject has long hair, the hair should be pulled back away from the face.
2. Click on the Record button. The signal should begin scrolling across the screen.
3. Click on the AutoScale All button. Use the same techniques used in Exercise 1 to display the signals properly.
4. When the pulse recording is a suitable trace, type **25°C Water** in the Mark box.
5. Instruct the subject to hold his or her breath and submerge his or her face (up to the hairline and in front of the ears) in water for 20 seconds. Click the mark button as the subject's face enters the water.
6. Quickly type **Face Out of Water** in the Mark box. As the subject pulls his or her face out of the water, click the mark button.
7. Click Stop to halt recording after this trial.
8. Select Save in the File menu.
9. Repeat the diving exercise into the pan of 25°C water two additional times. Allow enough time between trials for the subject's heart rate to return to normal.

***Note:** If a preliminary examination of the data indicates the subject's heart rate did not change, the subject may not have a good diving reflex. Select another subject to perform this exercise.*

10. Repeat this exercise with the same subject submerging his or her face in pans of water at 15°C and 5°C.

Data Analysis

1. Scroll through the recording and find the first trial when the subject submerged his or her face in 25°C water.
2. Use the Display Time icons, or the cursors and the Zoom between Cursors button, to adjust the Display Time of the Main window to show the data from ten seconds before the subject submerged his or her face to twenty seconds after removing his or her face from the water.
3. Click on the Analysis window icon in the toolbar to transfer the data displayed in the Main window to the Analysis window.

4. Place one cursor at the point when the subject submerged his or her face in the water and the other cursor at a point five seconds later.
5. Look at the Function Table in the Analysis window and make sure the mathematical functions used in the analysis, Max, Min, and Mean, appear.
6. Use one of the techniques explained in Exercise 1 to record the values for these parameters in the Journal, or on a separate data table.
7. Move one cursor to the point that is five seconds before the subject removed his or her face from the water and the second cursor to the point when the subject's face was removed from the water. Record the maximum, minimum, and mean heart rates for this time period as performed in Step 6.
8. Repeat these measurements for each of the three trials at 25°C, 15°C, and 5°C.
9. Determine the averages of the maximum, minimum, and mean heart rates in the first five seconds and the last five seconds of submersion at each temperature. Enter these values in Table 1.

Table HH-5-L1: Heart Rate at Rest, during Apnea and Facial Exposure to Different Temperatures.

Treatment		Average Heart Rate (BPM)		
		Max	Min	Mean
Resting				
Holding Breath				
Face in 25°C Water	First 5 sec			
	Last 5 sec			
Face in 15°C Water	First 5 sec			
	Last 5 sec			
Face in 5°C Water	First 5 sec			
	Last 5 sec			

Questions

1. What happens to the subject's heart rate as their face is submerged in water at 25°C?
2. What happens to the subject's heart rate as their face is submerged in water at 15°C? In water at 5°C?
3. What causes the subject's heart rate to change when their face is submerged in cold water?
4. How does the mammalian diving reflex help a person who falls into cold water? Think in terms of the organs that need oxygen.

Optional: Measuring Respiration Rate and Depth

Attaching a RM-204 respiration monitor to the subject permits relative changes in the subject's rate and depth of respiration to be measured during normal breathing, apnea, and testing the diving reflex. The use of a respiration monitor is optional and it is not required to complete the exercises in this experiment.

1. Locate the RM-204 respiration monitor.
2. Plug the DIN8 connector of the RM-204 into Channel A6 of the IXTA.
3. Wrap the elastic belt of the respiration monitor around the subject's chest at a level that is below the sternum. Place the sensor inside the belt so that the sensor is in the center of chest at a level that is even with the subject's elbows.
4. If the subjects are sitting during these exercises, they should sit erect so that the muscles involved in pulmonary ventilation are able to move with few restrictions.



Figure HH-5-L5: The RM-204 respiration monitor.



Figure HH-5-L6: The RM-204 connected to the IXTA.

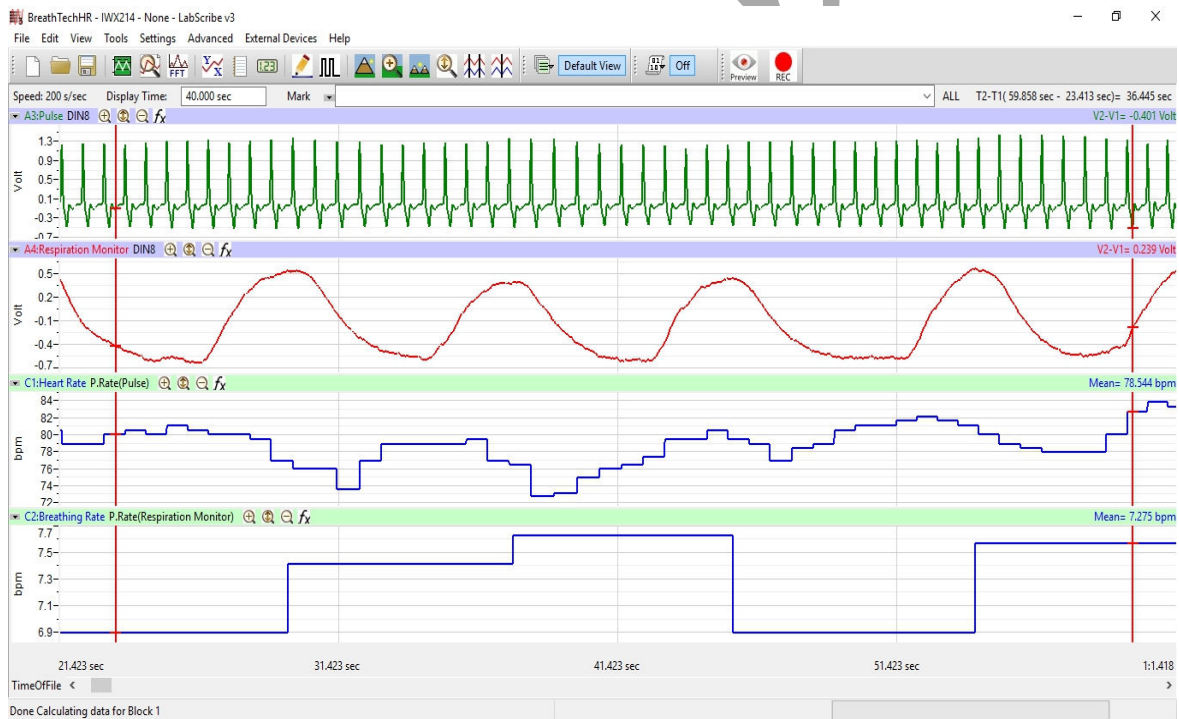


Figure HH-5-L7: The pulse wave, respiration, heart rate, and breathing rate recorded with a pulse plethysmograph and a RM-204 respiration monitor.

Note: An interesting addition to the analysis of this lab is to look at the change in amplitude of the pulse, often seen even if little rate change is seen. The very reliable reduction in amplitude is a good measure of reduction of blood flow to the fingers, as seen in peripheral vasoconstriction.