Experiment RP-3: The Effect of Breathing on Heart Rate

Background

Breathing is a function that can be performed both voluntarily and involuntarily. When exercising and recovering from exercise, the depth and rate of breathing are adjusted by the autonomic nervous system. The portions of the autonomic nervous system that control heart rate, circulation, muscle tension, and many other bodily functions are influenced by conscious breathing.

While breathing normally, heart rates usually increase during inhalation and decrease during exhalation. This cyclic change in heart rate, that is driven by breathing, is known as Respiratory Sinus Arrhythmia (RSA).

The diaphragm, the large muscle between the thoracic and abdominal cavities, is the primary motive force for pulmonary ventilation. During inhalation, the diaphragm contracts and moves downward creating negative pressure in the thoracic cavity. This negative pressure pulls more blood into the major veins in the chest, which improves venous return to the heart and increases the amount of blood entering the right side of the heart. If more blood is entering the heart, more blood needs to be pumped out of the heart. The solution for moving more blood is an increase in the heart rate. The increase in heart rate is controlled through the integration of information from the organ systems involved in the cardiovascular system. Conversely, as the diaphragm relaxes during exhalation, the pressure in the thoracic cavity becomes less negative, venous return decreases, less blood enters the heart, and the heart rate can decrease.

Studies have shown that respiratory sinus arrhythmia (RSA) is more prominent in younger than older adults. RSA prominence, measured by the difference between the minimum and maximum heart rates in a breathing cycle, decreases by 10% per decade between ages 20 and 70. RSA prominence is also related to aerobic conditioning. It has been observed that well-trained athletes have higher RSA prominence than is normally expected for their age group. It has been suggested that RSA prominence would be a good measure of aerobic fitness

In this experiment, you will determine the heart rate and RSA prominence of a subject breathing at rest. You will also determine the effect of apnea, different inhalation volumes, and the movement of the muscles involved in breathing on heart rate. To make valid comparisons from exercise to exercise, the exercises in this lab need to be performed by the same subject.

Equipment Required

PC or Mac Computer

IX-ELVIS

USB cable

Power supply

PTN-104 Pulse transducer

SPN-304 Spirometer and tubing

SP1 Flowhead

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 Breathing-HeartRate-LS2 settings file.
5. After a short time, LabScribe will appear on the computer screen as configured by the Breathing-HeartRate-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.

Spirometer and Pulse Plethysmograph Setup

1. Locate the SPN-304 spirometer, a plastic single-use SP1 flowhead, and the airflow tubing (Figure RP-3-S1).
2. Firmly push the two air flow tubes onto the two outlets on the flowhead (ribbed tubing to red outlet).
3. Firmly push the other ends of the two air flow tubes onto the two outlets on the SPN-304 spirometer unit (ribbed tubing to red outlet).
4. The Heart Sounds-Spirometer switch on the SPN-304 should be set to the Spirometer position, to the left, when the labeled surface of the SPN-304 is facing you.
5. Locate the PTN-104 pulse plethysmograph (Figure RP-3-S2).

Figure RP-3-S1: The SPN-304 spirometer, SP1 flowhead, and the airflow tubing.

2. Plug the mini-DIN connector of the SPN-304 spirometer into the Channel 4 input of the IX-ELVIS, and the mini-DIN connector of the PTN-104 pulse plethysmograph into the Channel 3 input of the same unit (Figure RP-3-S3).
3. 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.

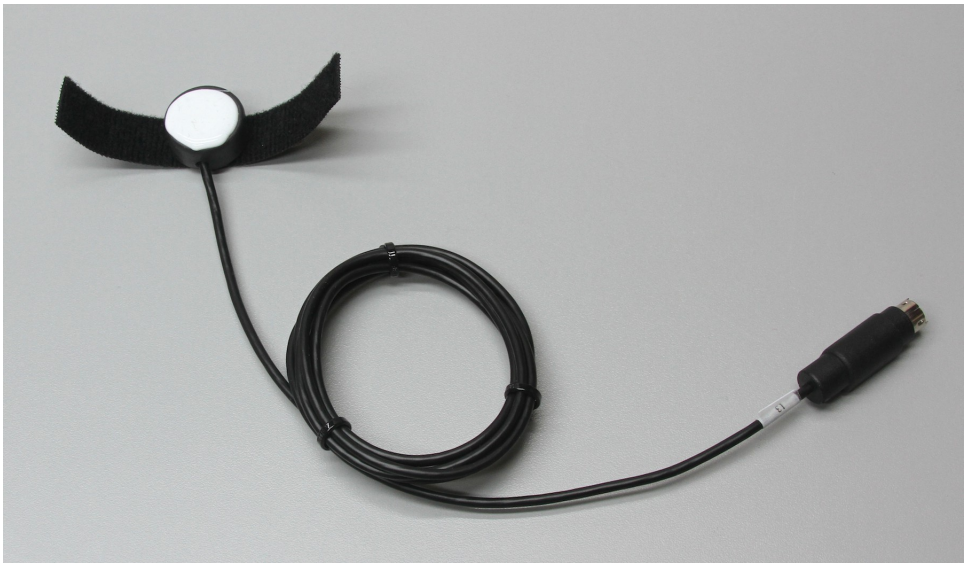

Figure RP-3-S2: The PTN-104 pulse plethysmograph.

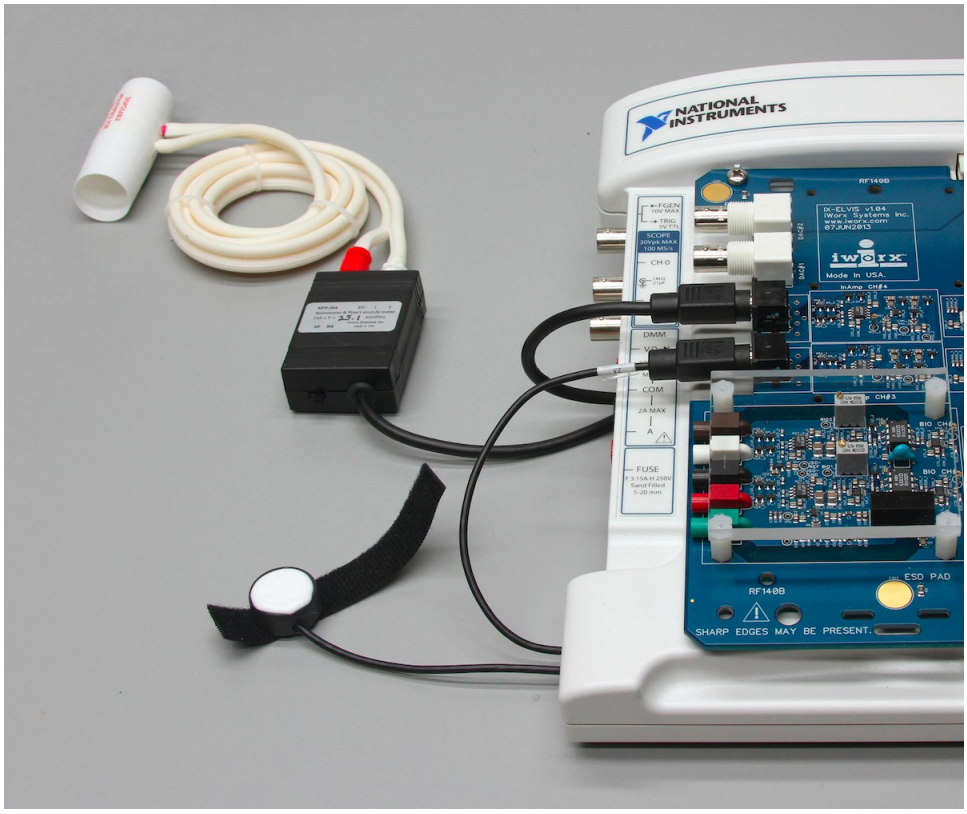

Figure RP-3-S3: A PTN-104 pulse plethysmograph and a SPN-304 spirometer and flowhead connected to an IX-ELVIS.

Before Starting

1. Please read the procedures for each exercise completely before beginning the experiment. You should have a good understanding of how to perform these exercises before making recordings.
2. The spirometer will monitor breathing from a subject. It is important that the subject is healthy and has no history of respiratory or cardiovascular problems.
3. On the flowhead, the outlets connected to the airflow tubing should always be pointed up to avoid problems with condensation developing within the tubing.
4. Use a clip to prevent air from entering or leaving the nose as the subject is breathing. Air that passes through the nose is not included in the volume measurements and causes errors in these values.
5. The settings file, Breathing-HeartRate, programs LabScribe to record the breathing of the subject on the Air Flow channel. The computed function used on the Volume channel converts the data recorded on the Air Flow channel to lung volume measurements.
6. To be sure that the spirometer calibration parameters are properly configured to accurately measure Lung Volume:

- Click on the words STPD Vol Human (Air Flow), that are next to the title of the Lung Volume channel, to open the computed function pull-down menu.
- Select Setup from this pull-down menu to open the Spirometer Calibration Dialog window.
- The SPN-304 spirometer and the SP1 flowhead should be chosen.
- Make sure the reset time is set to 'No Reset' and the first ten seconds of the recording are used to zero the baseline of the Volume channel.
- The calibrated volume difference between cursors should be set to one liter. Click OK.

8. Allow the SPN-304 to warm up for 10 minutes before recording for the first time.

Note: Do not hold the spirometer amplifier in your hand; the heat of your hand will alter the volumes recorded.

9. When spirometry data is recorded in the conventional manner, inhalation is always displayed as an upward deflection. To determine if the subject is breathing through the correct end of the flowhead.
   - Click on the Save to Disk button in the lower left corner of the Main window to switch the LabScribe software into Preview mode. When LabScribe is in Preview mode, there is a red X across the Save to Disk button. In Preview mode, the IX-ELVIS works without recording data on the hard drive or any other storage media which allows a subject to become comfortable with breathing through a spirometer.
   - Click on the Preview button. Have the subject inhale through the flowhead. Click on the AutoScale button at the upper margin of the Air Flow and Volume channels. If the flowhead is oriented properly, the traces on the Air Flow and Volume channels will go up during inhalation. If the traces on these channels go down during inhalation, reverse the positions of the airflow tubes at the outlets of the flowhead.

   Note: *If the user clicks the Preview button and an error window appears the Main window indicating the IX-ELVIS cannot be found, make sure the IX-ELVIS is turned on and connected to the USB port of the computer. Then, click on the OK button in the error window. Pull down the LabScribe Tools menu, select the Find Hardware function, and follow the directions on the Find Hardware dialogue window*

10. Click on the Stop button.
11. Before proceeding to the actual exercises, make sure the LabScribe software in set to Record mode. Click on the Save to Disk button, in the lower left corner of the Main window, to change LabScribe from Preview mode to Record mode. When LabScribe is in Record mode, there is a green arrow on the Save to Disk button.

Exercise 1: Heart Rate While Breathing at Rest

Aim: To determine the effect of breathing while at rest on the subject's heart rate and the change in heart rate during respiratory sinus arrhythmia (RSA).

Procedure

1. Instruct the subject to:
   - Sit quietly and become accustomed to breathing through the spirometer flowhead
   - Breathe normally before any recordings are made.
   - Hold the flowhead so that its outlets are pointed up.
   - Remove the flowhead from his or her mouth and hold it at the mouth level in a position that prevents a breath from moving through the flowhead

   Note: *The LabScribe software will zero the Volume channel during the first ten seconds of recording. No air should be moving through the flowhead during this time.*

2. Type "<Subject's Name> Resting" in the Mark box that is to the right of the Mark button.
3. Click on the Record button. After waiting ten seconds for the Volume channel to zero, have the subject place the flowhead in his or her mouth and begin breathing. Press the Enter key on the keyboard to mark the recording.
4. Click the AutoScale buttons of the Air Flow and Volume channels. Notice the slowly moving wave on the Volume channel. Record ten breaths, which normally takes about 90 seconds to record.
5. Click Stop to halt recording. Your data may look like Figure RP-3-L1.
6. 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 RP-3-L1: Pulse, air flow, lung volumes, and heart rate during breathing at rest, displayed on the Main window. An upward deflection on the Volume channel indicates inhalation.

Data Analysis

1. Scroll to the recording of the subject's breathing and heart rate while at rest. Display four adjacent breathing cycles that are free of artifacts in the Main window.
2. Use the Display Time icons to adjust the Display Time of the Main window to show the four complete breathing cycles on the Main window. The four adjacent breathing cycles can also be selected by:
   - Placing the cursors on either side of a group of four complete breathing cycles; and
   - Clicking the Zoom between Cursors button on the LabScribe toolbar (Figure RP-3-L2) to expand the four selected breathing cycles to the width of the Main window.

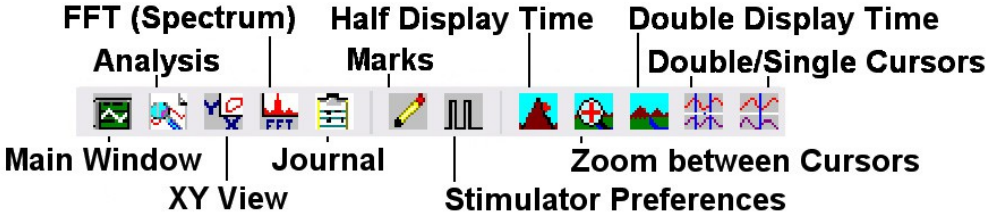

Figure RP-3-L2: The LabScribe toolbar.

3. Click on the Analysis window icon in the toolbar (Figure RP-3-L2) or select Analysis from the Windows menu to transfer the data displayed in the Main window to the Analysis window (Figure RP-3-L6).
4. Look at the Function Table that is above the uppermost channel displayed in the Analysis window. The mathematical functions, Max-Min, Max, Min, and Mean, should appear in this table. Values for these four parameters on each channel are seen in the table across the top margin of each channel.
5. Sections of the data displayed on the Heart Rate channel may be calculated incorrectly if pulses on the raw data (Pulse) channel have low amplitudes. These pulses with low amplitudes might not be identified by the rate function on the Heart Rate channel and used in the calculation of the subject's heart rate. Pulses used in the rate calculation can be properly identified by either adjusting the position of the trace on the Pulse channel or adjusting the position of the threshold, a parameter in the rate function dialogue window which identifies the pulses to be counted in the rate calculation.
    - To raise the level of the trace on the Pulse channel, use the mouse to click on and drag the trace higher on the screen. If the pulse trace is moved up by the proper amount, the peaks of the missed pulse will intersect the invisible threshold level set by the rate function dialogue window. The pulses or waves that used to be missed in the rate calculation will now be included in the calculation. On the Heart Rate channel, the revised plot of the rate calculation will be displayed automatically. If the rate is still not displayed properly, the pulse trace can be moved up again.

      Note: Setting the proper threshold level also prevents small artifacts in the data from being counted as pulse waves.
    - To adjust the level of the threshold parameter for the Heart Rate channel, click on the Channel Function/Mode area to the right of the Channel Title on the Heart Rate channel. Select Setup from the menu to open the rate function dialogue window. Change the level of the threshold: by typing a new value in the box; or, by clicking on the up or down arrows on the right side of the box; or, by clicking on and sliding the threshold line, that is displayed on the graph of the pulse data at the bottom of the dialogue window, up or down.
6. There may be section of data on the Volume channel where the baseline is sloped. The sloping occurs when the temperature inside the spirometer increases while the subject breathes through the unit. Ultimately, the change in temperature inside the spirometer affects the computed function on the Volume channel that initially sets the baseline of that channel to zero.
    - The easiest way to flatten the slope of the baseline on the Volume channel is to increase the length of time used to set that baseline. When more data points are used to establish the baseline, the slope of the baseline will get closer to zero and become easier to use as a point of reference for measuring lung volumes.
    - To increase the length of the recording used in set the baseline on the Volume channel, click on the Channel Function/Mode area to the right of the Channel Title on the Volume channel. Select Setup from the menu to open the Spirometer Calibration dialogue window. Change the amount of time used to set the slope of the baseline on the Volume channel from 10 seconds to the length of the largest block of recorded data. For example, if a subject's

respiration was recorded in data blocks that are between 30 and 300 seconds long, set the length of time used in setting the baseline slope to 300 seconds.

7. Once the cursors are placed in the correct positions for determining the tidal volume and heart rate during inhalation and exhalation, the values for these parameters can be recorded in the on-line notebook of LabScribe by typing their names and values directly into the Journal.
8. The functions in the channel pull-down menus of the Analysis window can also be used to enter the names and values of these parameters from the recording to the Journal. To use these functions:
   - Place the cursors at the locations used to measure the tidal volume and heart rates during the breath cycle.
   - Transfer the names of the mathematical functions used to determine the volumes and rates to the Journal using the Add Title to Journal function in the Volume Channel pull-down menu.
   - Transfer the values for the volumes and rates to the Journal using the Add All Data to Journal function in the Volume Channel pull-down menu.
9. Use the mouse to click on and drag one cursor to the trough before the first breath cycle displayed on the Volume channel, and the other cursor to the trough before the second breath cycle (Figure RP-3-L3).
10. The values for the following parameters on a breath cycle are determined when the cursors are placed at the two positions described in Step 9:
    - Tidal Volume (TV), which is the value for Max-Min on the Volume Channel.
    - Minimum Heart Rate, which is the value for Min on the Heart Rate channel.
    - Maximum Heart Rate, which is the value for Max on the Heart Rate channel.
    - Respiratory Sinus Arrhythmia (RSA) Prominence or the difference between the minimum and maximum heart rates during a breath cycle, which is the value for Max-Min on the Heart Rate channel.
    - Mean Heart Rate, which is the value for Mean on the Heart Rate channel.
11. Record the values in the Journal using one of the techniques described in Steps 7 or 8.
12. Repeat the measurements of tidal volume, maximum and minimum and mean heart rate, and RSA prominence on two additional normal breath cycles.
13. Average the three values obtained for each rate and the tidal volume. Enter the means in a table in the Journal. You can open and close the Journal by clicking on its icon on the LabScribe toolbar (Figure RP-3-L2).

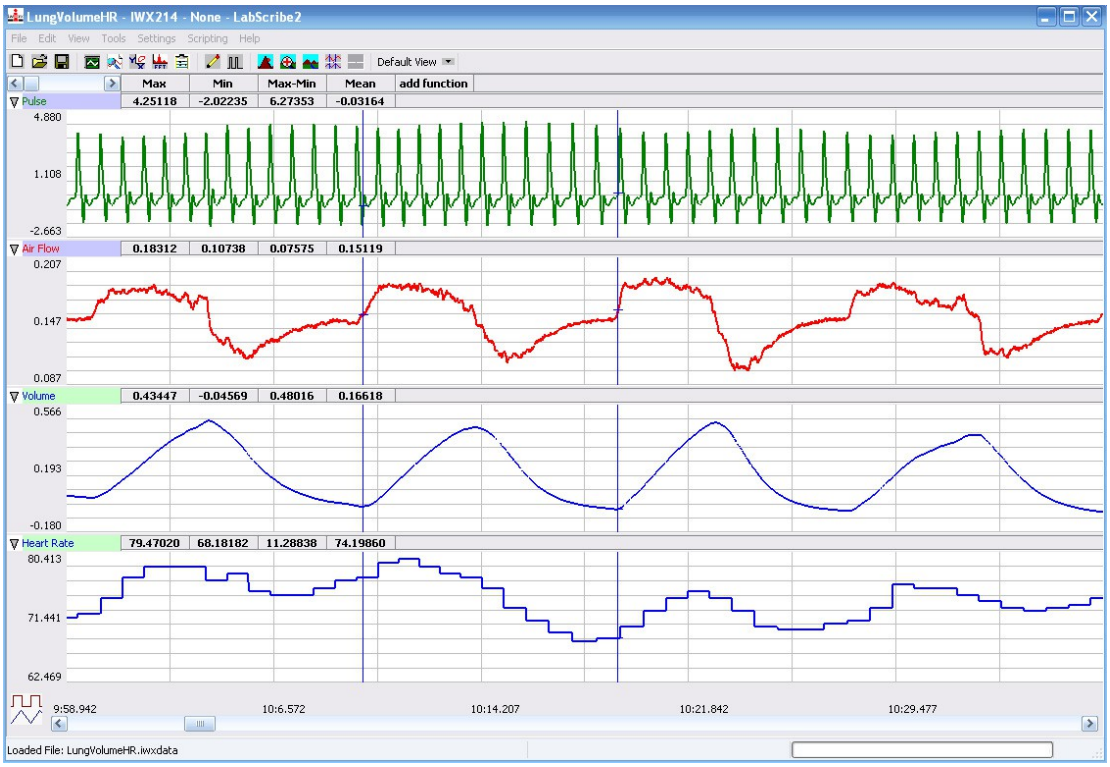

Figure RP-3-L3: The heart rate and breathing rates of a subject performing abdominal breathing while resting, displayed in the Analysis window.

14. Record the means for the tidal volume and heart rates in Table RP-3-L1.

Questions

1. The difference between the heart rates before and after inhalation is known as RSA prominence. What is the average RSA prominence of the subject (Table RP-3-L1)?
2. What percentage of the pre-inhalation heart rate is the RSA prominence?
3. How does the RSA prominence of this subject compare to subjects from other groups in class?

Table RP-3-L1: Heart Rate Variation during Breathing at Rest.

Subject	Heart Rate (BPM)				Tidal Volume (mls)
_____	Min	Max	D Heart Rate	Mean	
Breath 1					
Breath 2					
Breath 3					
Mean					

Exercise 2: Heart Rate during Apnea

Aim: To measure the effect of apnea, after a maximum inhalation, on the subject's heart rate.

1. The subject should sit quietly and breath normally before this exercise begins. the subject should already be accustomed to breathing through a flowhead
2. Remind the subject of the following:
   - Hold the flowhead with its outlets pointed up.
   - Before the recording begins, the subject should remove the flowhead from his or her mouth, and hold it at mouth level in a position that prevents a breath from moving through the flowhead.
   - After the recording begins, wait at least 10 seconds before putting the flowhead in his or her mouth.

   Note: *The LabScribe software will zero the Volume channel during the first ten seconds of recording. No air should be moving through the flowhead during this time.*

3. Before the recording begins, instruct the subject about the breathing pattern for this exercise:
   - After the 10 second calibration period, the subject should take 2 or 3 normal breaths through the flowhead.
   - Then, the subject will take a deep inhalation and hold his or her breath as long as possible.
   - When the subject resumes breathing, he or she should continue to breath through the flowhead until the breathing pattern is back to normal.
4. Type "<Subject's Name> Breathing at Rest" in the Mark box that is to the right of the Mark

button.

5. Click on the Record button. After waiting ten seconds for the Volume channel to zero, have the subject place the flowhead in his or her mouth and begin breathing normally. Press the Enter key on the keyboard.
6. Click the AutoScale buttons of the Air Flow and Volume channels. Notice the slowly moving wave on the Volume channel. Record three breaths, which normally takes about twenty seconds to record. Type “Apnea” in the Mark box.
7. Press the Enter key on the keyboard as the subject inhales as deeply as possible. After reaching his or her maximum inhalation volume, the subject should hold his or her breath a long as possible.
8. While the subject is holding his or her breath, type “Resume Breathing” in the Mark box. Press the Enter key on the keyboard to mark the recording when the subject resumes breathing.
9. The subject should continue to breath through the spirometer until his or her breathing returns to normal.
10. Click Stop to halt recording. Your data should look like Figure RP-3-L4.
11. Select Save in the File menu.

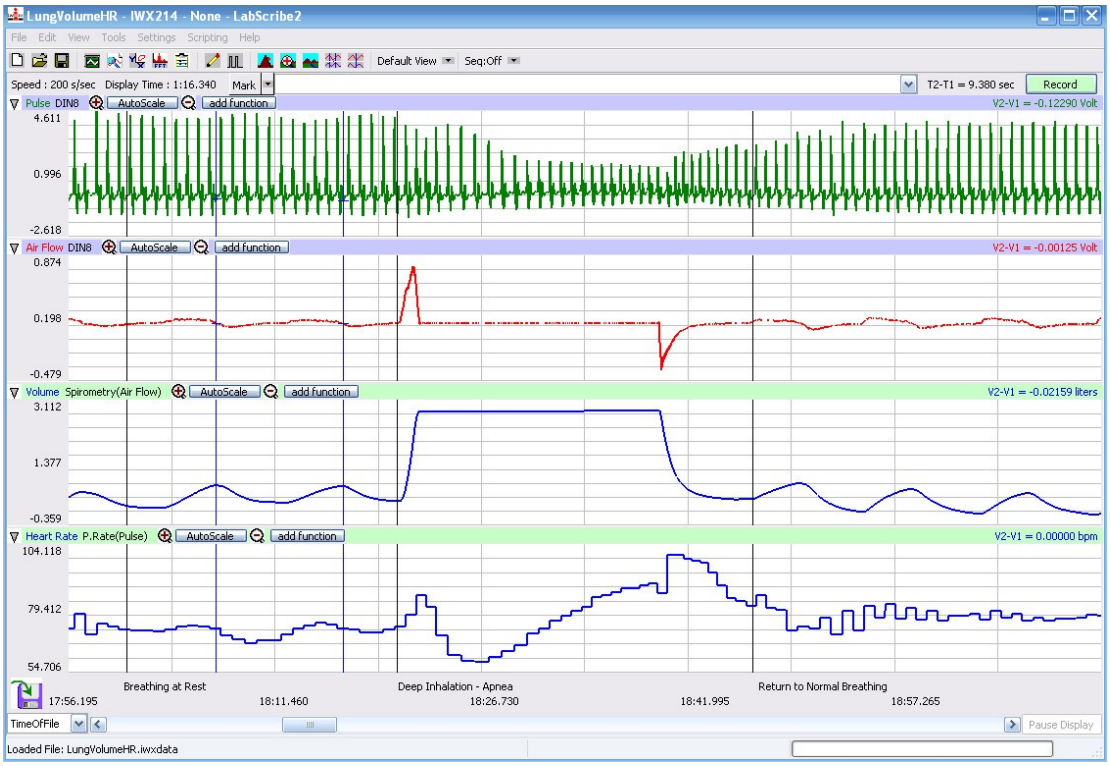

Figure RP-3-L4: Pulse, air flow, lung volumes, and heart rate before, during and after apnea, displayed in the Main window.

Data Analysis

1. Scroll to the recording of the subject's breathing before, during and after holding his or her breath that is displayed in the Main window.
2. Use the Display Time icons to adjust the Display Time of the Main window to show the breathing from before to after apnea on the Main window. This segment of the data can also be selected by:
    - Placing the cursors on either side of the selected data; and
    - Clicking the Zoom between Cursors button on the LabScribe toolbar to expand the selected to the width of the Main window.
3. Click on the Analysis window icon in the toolbar (Figure RP-3-L2) or select Analysis from the Windows menu to transfer the data displayed in the Main window to the Analysis window (Figure RP-3-L5).
4. The functions used to analysis this data are the same as the ones used in Exercise 1 and programmed by the settings file.
5. Minimize the heights of the Pulse and Air Flow channels and maximize the heights of the traces on the Volume and Heart Rate channels as it was done in Exercise 1.
6. Use one of the techniques described in Exercise 1 to record the volume and heart rates in the Journal.
7. Use the mouse to click on and drag a cursor to the trough, on the Volume channel, that precedes the three normal breaths taken by the subject before the deep inhalation. The second cursor goes on the trough after the third normal breath.
8. The values for the following parameters during breathing at rest are determined when the cursors are placed at the two positions described in Step 7:
    - Maximum Heart Rate - Breathing at Rest, which is the value for Max on the Heart Rate channel.
    - Minimum Heart Rate - Breathing at Rest, which is the value for Min on the Heart Rate channel.
    - Difference (Max-Min) Heart Rate-Breathing at Rest, which is the value for Max-Min on the Heart Rate channel.
    - Mean Heart Rate - Breathing at Rest, which is the value for Mean on the Heart Rate channel.

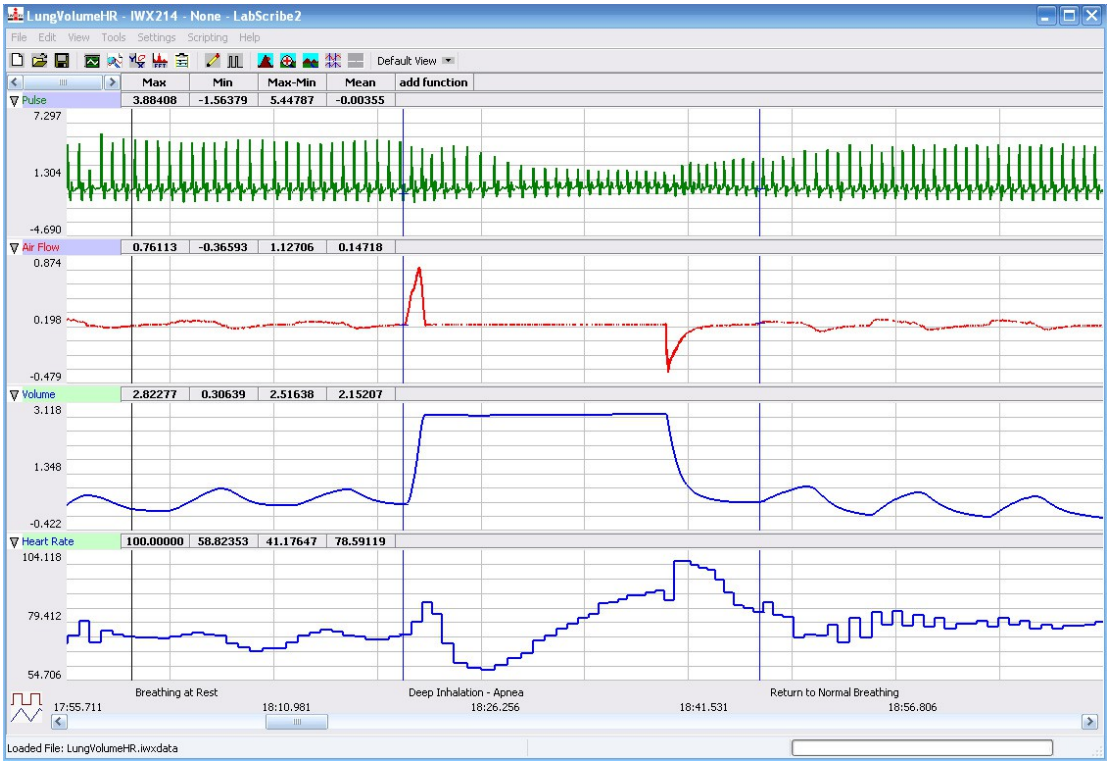

Figure RP-3-L5: Pulse, air flow, lung volume, and heart rate before, during and after apnea, displayed in the Analysis window. The cursors are positioned to measure the volume and rates during apnea.

9. Record the values in the Journal using one of the techniques described in Exercise 1. Record the volume and heart rates in Table RP-3-L2.
10. Use the mouse to click on and drag a cursor to the trough, on the Volume channel, that precedes the subject's deep inhalation. The second cursor goes at the end of the subject's exhalation after apnea (Figure RP-3-L5).
11. The values for the following rates during apnea are determined when the cursors are placed at the two positions described in Step 10:
    - Inspiratory Capacity (IC), which is the sum of the Tidal Volume (TV) and Inspiratory Reserve Volume (IRV) and which is the value for Max-Min on the Volume Channel.
    - Maximum Heart Rate - Apnea, which is the value for Max on the Heart Rate channel.
    - Minimum Heart Rate - Apnea, which is the value for Min on the Heart Rate channel.
    - Difference (Max-Min) Heart Rate-Apnea, which is the value for Max-Min on the Heart Rate channel.
    - Mean Heart Rate - Apnea, which is the value for Mean on the Heart Rate channel.
12. Record the values in the Journal using one of the techniques described in Exercise 1. Record the heart rates in Table RP-3-L2.
13. Use the mouse to click on and drag a cursor to the trough, on the Volume channel, that precedes

the first breath taken by the subject after apnea. The second cursor goes on the trough after the first normal breath following apnea.

14. The values for the following parameters during the recovery to normal breathing are determined when the cursors are placed at the two positions described in Step 13:
    - Maximum Heart Rate - Recovery to Normal, which is the value for Max on the Heart Rate channel.
    - Minimum Heart Rate - Recovery to Normal, which is the value for Min on the Heart Rate channel.
    - Difference (Max-Min) Heart Rate-Recovery to Normal, which is the value for Max-Min on the Heart Rate channel.
    - Mean Heart Rate - Recovery to Normal, which is the value for Mean on the Heart Rate channel.
15. Record the values in the Journal using one of the techniques described in Exercise 1. Record the heart rates in Table RP-3-L2.

Table RP-3-L2: Heart Rate Variation before, during, and after Apnea.

Subject	Heart Rate (BPM)			
Deep Inhalation Volume: ____ Liters	Min	Max	D Heart Rate	Mean
Deep Inhalation				
Apnea				
Return to Normal				

Questions

1. How does the change in heart rate during deep inhalation compare to the change in heart rate during normal inhalation?
2. How does the change in heart rate during deep inhalation compare to the change in heart rate during apnea?
3. How does the change in heart rate during normal breathing compare to the change in heart rate during the recovery from apnea?
4. Which type of breathing reached a higher maximum heart rate: normal breathing, deep inhalation, apnea, or recovery from apnea?

Exercise 3: Sub-Maximal Inhalation Volumes and Heart Rate

Aim: To measure the effect of inhalation volumes that are higher than the Tidal Volume (TV), but less than the Inspiratory Capacity (IC), on the subject's heart rate.

1. Repeat Exercise 1 on the same subject using an inhalation volume that is between the Tidal Volume (TV) and the Inspiratory Capacity (IC).

Note: *Remember that the Inspiratory Capacity (IC) is equal to the sum of the Tidal Volume (TV) and the Inspiratory Reserve Volume (IRV).*

2. To aid the subject in determining an inhalation level that is between the tidal volume (TV) and the inspiratory capacity (IC), allow the subject to observe his or her recording on the computer screen. While watching the computer monitor, the subject can control his or her depth of breathing.
3. Record at least three breath cycles at each of two different inhalation levels that are fractions of the Inspiratory Capacity (IC). You data should look like Figure RP-3-L6.

Figure RP-3-L6: Pulse, air flow, lung volumes, and heart rate during breaths of various depths displayed in the Main window.

Data Analysis

1. Use the same techniques used in Exercise 1 to measure the inhalation volumes and heart rates from three breath cycles recorded at each of two different levels of submaximal inhalation (Figure RP-3-L7).
2. Use the same techniques to record the values for the parameters in the Journal and the means for each level of inhalation on Table RP-3-L3.

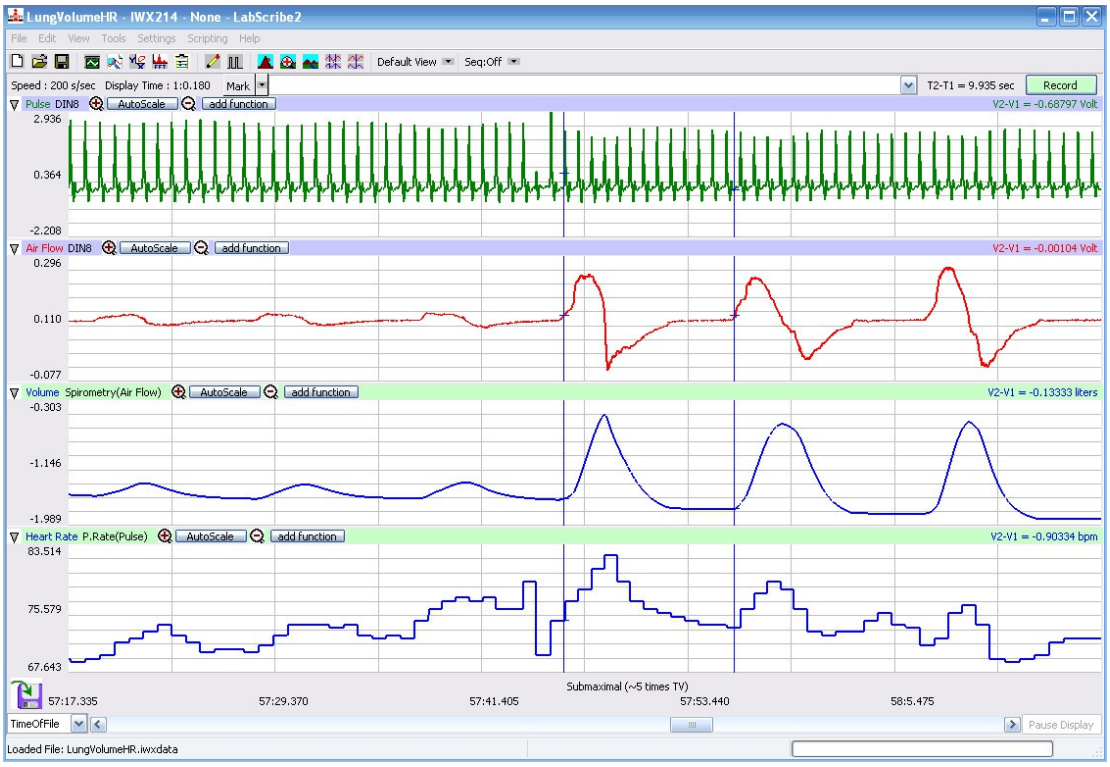

Figure RP-3-L7: Pulse, air flow, lung volumes, and heart rate during submaximal breaths, displayed in the Analysis window.

Table RP-3-L3: Heart Rate Variation with a Sub-Maximal Inhalation Volumes.

	Heart Rate (BPM)				Mean Inhalation Volume (mls)
	Min	Max	D Heart Rate	Mean	
Level 1 Mean					
Level 2 Mean					
Level 3 Mean					

Questions

1. How does the change in heart rate during a submaximal inhalation compare to the change in heart rate during normal inhalation?
2. How does the change in heart rate during a submaximal inhalation compare to the change in heart rate during deep inhalation (IC)?
3. Is there a linear relationship between inhalation volume heart rate. Use a sheet of graph paper or a graphing program to plot the heart rate as a function of inhalation volume?

Exercise 4: "Inhalation" without Air Exchange

Aim: To measure the effect of chest expansion caused by the muscles involved in inhalation without allowing air to enter the lungs.

Warning: No one with any cardiovascular diseases should be a subject in this exercise!

Procedure

1. Repeat Exercise 2 with the same subject, but without using a spirometer.
2. The subject should breath normally without breathing through a spirometer.
3. After the subject exhales normally, he or she closes his or her mouth and pinches off his or her nose.
4. With the flow of air into the lungs blocked, the subject lowers his or her diaphragm and expands his or her ribcage as if he or she were taking a deep breath. The subject should perform this procedure for as long as possible before returning to breathing normally
5. Even though no air is exchanged, the subject's heart rate should change.

Data Analysis

1. Use the same techniques used in Exercise 2 to determine the subject's heart rates before, during, and after the blocked inhalation (Figure RP-3-L8).
2. Use the same techniques to record the values for the parameters in the Journal and on Table RP-3-L4.

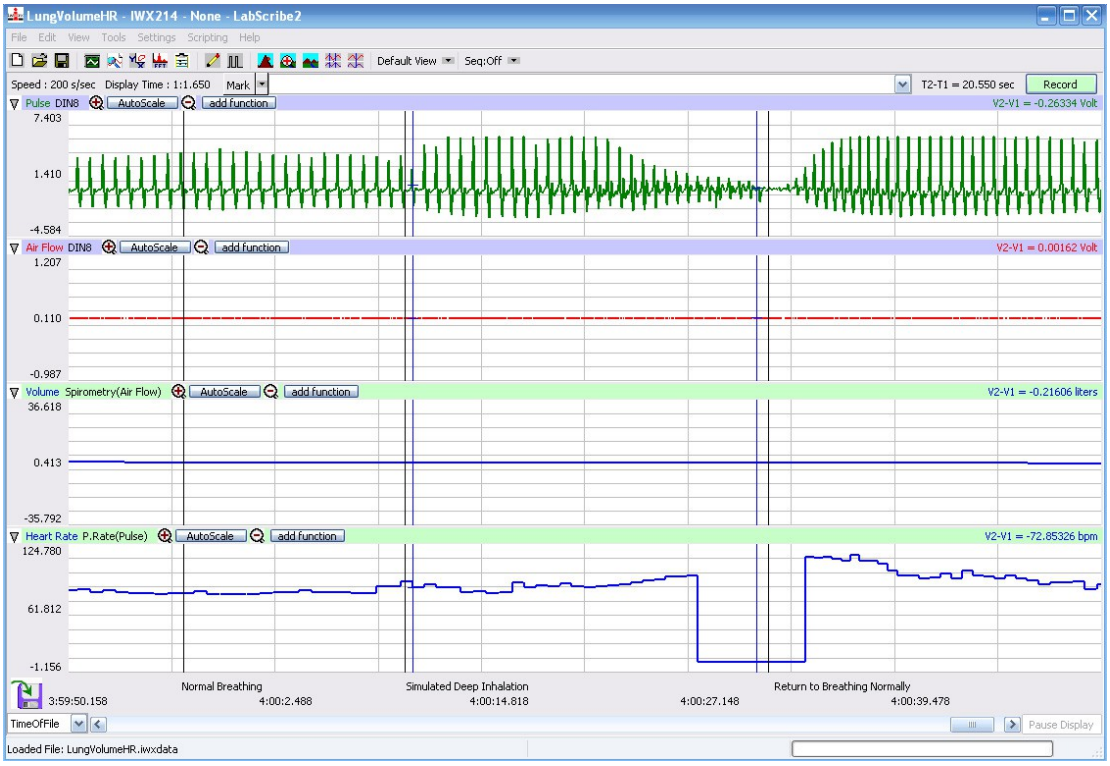

Figure RP-3-L8: Pulse and heart rate before, during and after inhalation was blocked, displayed on the Analysis window.

Table RP-3-L4: Heart Rate Variation with Inhalation Blocked.

	Heart Rate (BPM)			
	Min	Max	D Heart Rate	Mean
Normal Breathing				
Simulated Deep Breathing				
Return to Normal				

Questions

1. How does the change in heart rate during deep inhalation/apnea compare to the change in heart rate during the blocked inhalation?
2. Is the blocked inhalation able to create the same level of negative pressure in the thoracic cavity as deep inhalation?

Exercise 5: "Exhalation" without Air Exchange - Valsalva Maneuver

Aim: To measure the effect of chest compression caused by the muscles involved in exhalation without allowing air to exit the lungs.

Warning: No one with any cardiovascular diseases should be a subject in this exercise!

Procedure

1. Repeat Exercise 4 without using a spirometer.
2. The subject should breath normally without breathing through a spirometer.
3. After the subject inhales deeply, he or she closes his or her mouth and pinches off his or her nose.
4. With the flow of air out of the lungs blocked, the subject raises his or her diaphragm and compresses his or her rib cage as if he or she were blowing up a balloon. The subject should perform this procedure for as long as possible before returning to breathing normally
5. Even though no air is exchanged, the subject's heart rate should change.

Data Analysis

1. Use the same techniques used in Exercise 2 to determine the subject's heart rates before, during, and after the blocked exhalation.
2. Use the same techniques to record the values for the parameters in the Journal and on Table RP-3-L5.

Table RP-3-L6: Heart Rate Variation with Exhalation Blocked.

	Heart Rate (BPM)			
	Min	Max	D Heart Rate	Mean
Normal Breathing				
Simulated Exhalation				
Return to Normal				

Questions

1. How does the change in heart rate during deep inhalation/apnea compare to the change in heart rate during the blocked exhalation?
2. How does the change in heart rate during blocked inhalation compare to the change in heart rate during the blocked exhalation?