Experiment ADS-BIA-1: Breathing Techniques and Heart Rate

Background

The effect of breathing on heart activity has been known for thousands of years and studied extensively for hundreds of years. 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. We can also use conscious breathing to influence the portions of the autonomic nervous system that control heart rate, circulation, muscle tension, and many other bodily functions not easily assessed. In this experiment, you will perform some voluntary breathing functions and measure the effect they have on your heart rate.

Normal 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.

Abdominal Breathing

Diaphragmatic breathing, as described in the previous section, is also known as **abdominal breathing**. This breathing technique moves air deeper into the lungs, improves the flow of blood through its capillaries, and reduces the occurrence of infections in the lungs and other organs. The flow of lymph that carry immune cells is also improved with increased venous return.

Thoracic Breathing

Parameters like heart rate, muscle tension, skin conductance, and breathing rate increase when the sympathetic nervous system is stimulated during physiological stress. During chronic stress, the extended stimulation of the sympathetic nervous system creates an imbalance between sympathetic and parasympathetic nervous systems and leads to an increased risk of deleterious cardiovascular events.

Chronic stress also causes restrictions in the movement of the muscles and connective tissue in the chest that results in a decrease in the range of movement of the chest wall. Since breaths become rapid and shallow in this situation, most of the air exchange taking place during pulmonary ventilation occurs in the top portions of the lungs. This type of breathing is often referred to as **thoracic** or **chest breathing**.

Thoracic breathing is inefficient because the greatest blood flow in the lungs occurs in the capillaries of the lower lobes. If air does not reach these capillaries because chest expansion is low, oxygen transfer is low and tissues do not receive as much as oxygen as they need.

You can determine if you are an abdominal breather or a thoracic breather by observing the motion of your chest and your abdomen as you breath normally. Stand or sit erectly. Place your right hand on your chest and your left hand on your abdomen. As you breathe, observe which hand rises more. If you are a thoracic breather your right hand rises more; if you are an abdominal breather, your left hand will rise more.

With practice, you can train your body to improve its breathing technique. Slower and deeper breaths can lead to stimulation of the parasympathetic nervous system, a reversal of the changes seen with the stimulation of the sympathetic nervous system, and relaxation.

In this experiment, you will determine the heart and breath rates of a subject breathing normally and with different breathing techniques, which include shallow abdominal breathing, rapid bellows breathing, and deep abdominal breathing.

Experiment ADS-BIA-1: Breathing Techniques and Heart Rate

Equipment Required

PC or Mac Computer

ADS or ADS MAX Board, USB cable, Power Supply Cable

RMN-204 Respiration Monitor

PTN-104 Pulse sensor

Note: To ease setup, connect the sensor(s) to the A-ADS-IA adapter *before* plugging the adapter into the board. To disconnect, unplug the adapter from the board *first*, then remove the sensor(s).

Setup (ADS)

Note - Stop the experiment if the subject feels dizzy or nauseated.

1. Locate the PTN-104 pulse sensor and the RMN-204 respiration monitor.

2. Plug the connector of the PTN-104 into the Channel 1 input of the A-ADS-IA.
3. Plug the connector to the RMN-204 into the Channel 2 input of the A-ADS-IA.

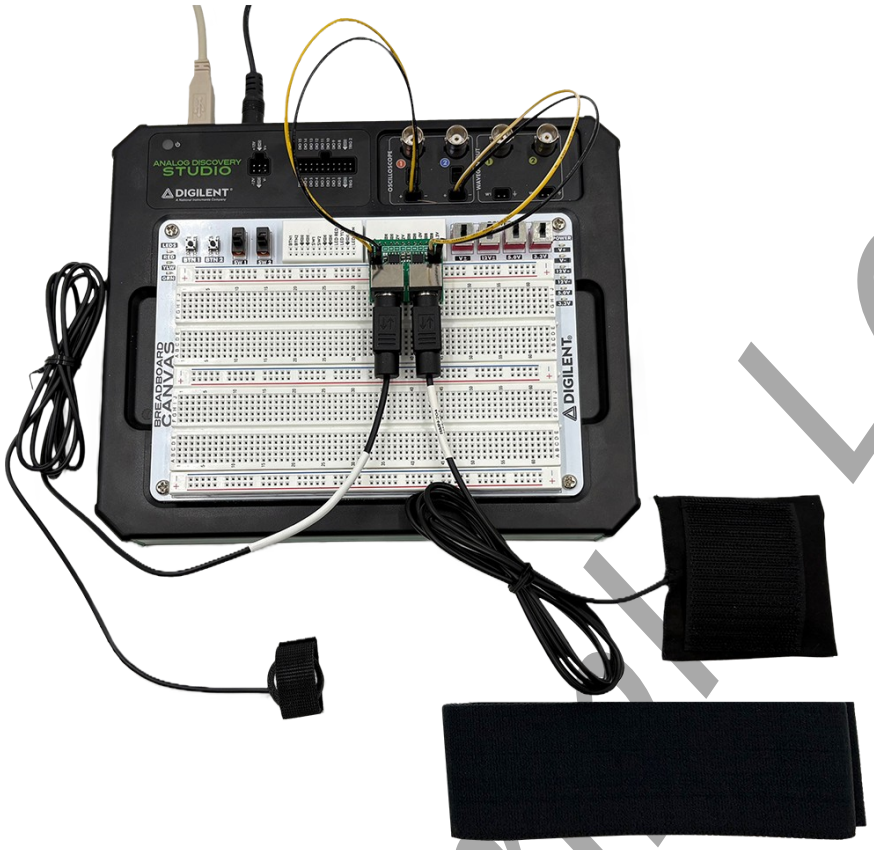

Figure ADS-BIA-1-S1: The PTN-104 pulse sensor and the RMN-204 respiration monitor connected to the ADS.

4. Select a subject and determine if they are a thoracic breather or an abdominal breather. Anyone who is prone to dizziness should not be a subject.
5. Place the PTN-104 on the volar surface (where the fingerprints are located) of the distal segment of the subject's middle finger. Wrap the Velcro strap around the end of the finger to attach the unit firmly in place.
6. 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 the chest at a level that is even with the subject's elbows.

Setup (ADS MAX)

If using the ADS MAX, setup instructions will be the same. Channel connections are labeled on the A-ADS-IA board, as shown below.

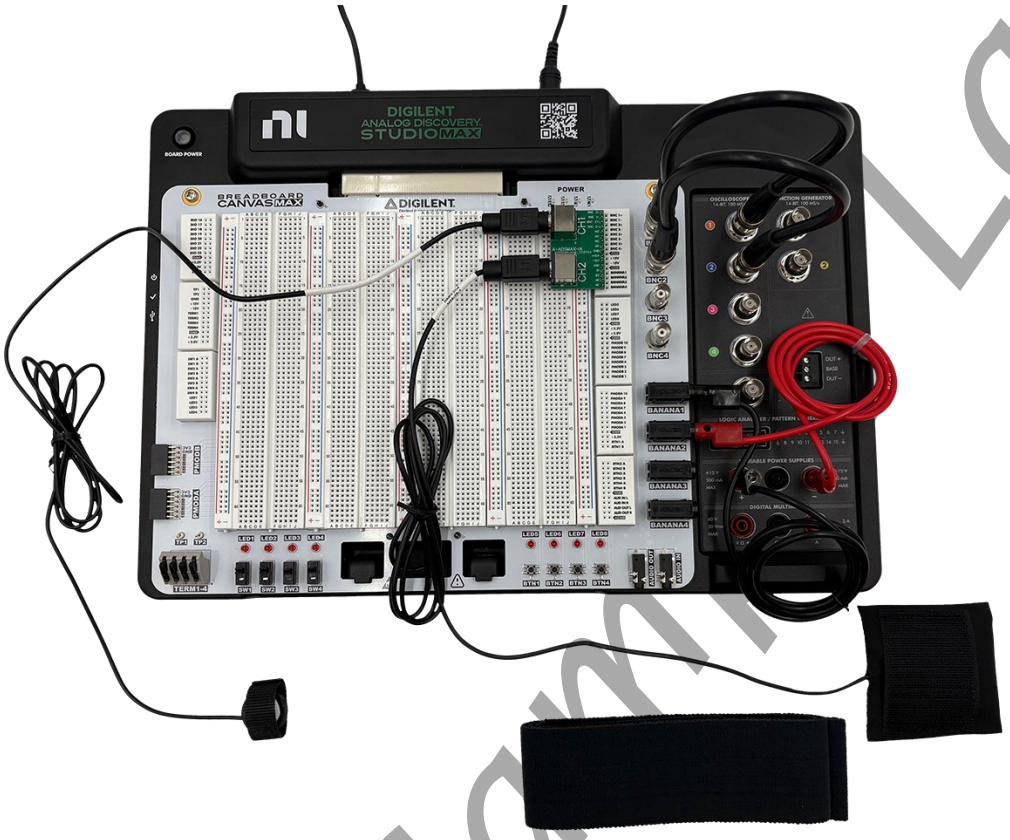

Figure ADS-BIA-1-S2: The PTN-104 pulse sensor and the RMN-204 respiration monitor connected to the ADS MAX.

Experiment ADS-BIA-1: Breathing Techniques and Heart Rate

Exercise 1: Breathing at Rest and Heart Rate

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

Approximate Time:30 minutes

Procedure

1. The subject should sit quietly and breathe normally before and during the recordings to prevent the creation of motion artifacts. Remind the subject to sit erect during the recording.
2. Type **Resting** in the Mark box.
3. Click on the Record button. Click the mark button to mark the recording.
4. Click the AutoScale All button. Record for at least one minute.
5. Click Stop to halt recording. Your data may look like the image below.
6. Select Save As in the File menu, type a name for the file. Click on the Save button to save the data file.

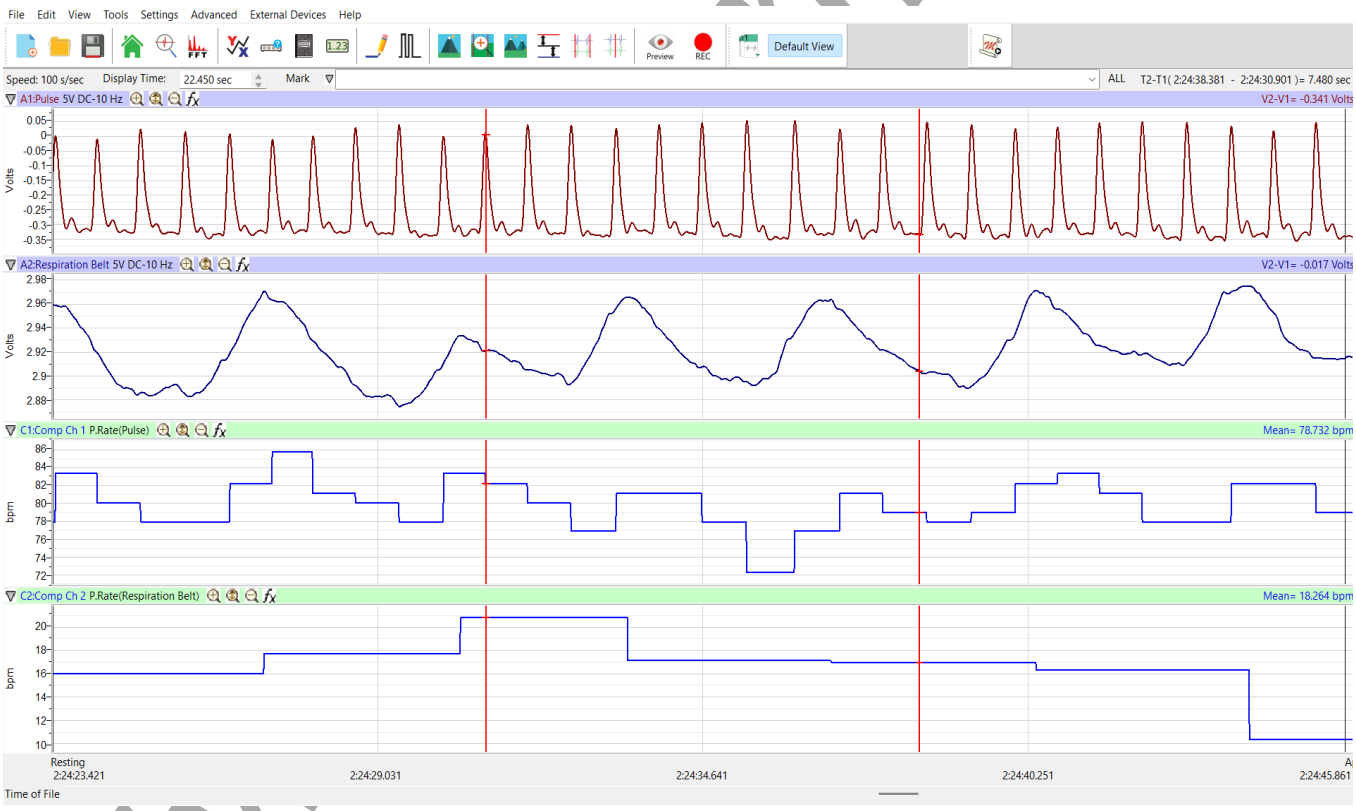

Figure ADS-BIA-1-L1: The pulse, respiration, heart rate, and breathing rate of a subject using abdominal breathing while at rest, displayed in the Main window.

Data Analysis

1. Scroll to the recording of the subject's breathing and heart rate while at rest. Display at least four adjacent breathing cycles that are free of artifacts in the Main window. Use the Display Time icons to adjust the Display Time of the Main window to show the complete breathing cycles.

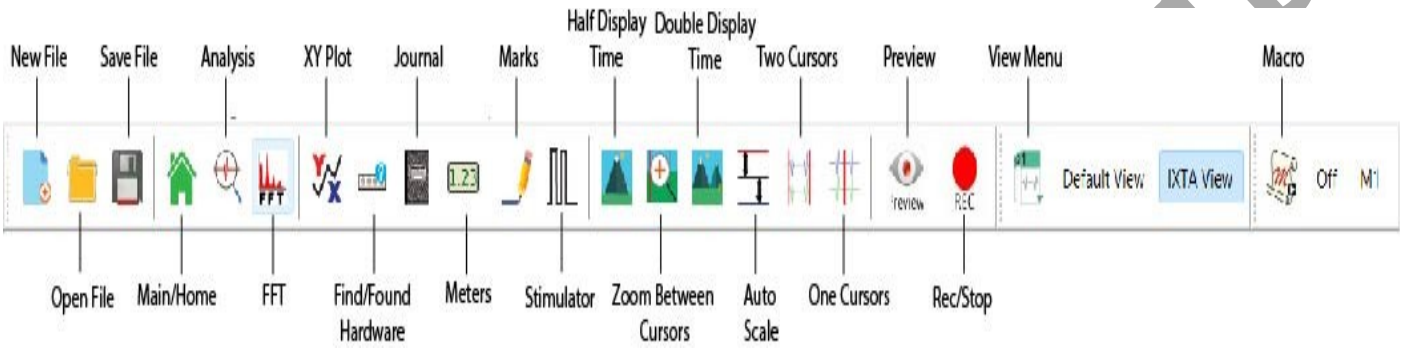

Figure ADS-BIA-1-L2: The LabScribe toolbar.

3. Click AutoScale All.
4. Click on the Analysis window icon in the toolbar to transfer the data to the Analysis window.
5. 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.
6. Use the mouse to click on and drag one cursor to the trough before the inhalation of the first breath cycle displayed on the Volume channel, and the other cursor to the trough before the inhalation of the second breath cycle.
7. The values for the following parameters on a breath cycle are determined when the cursors are placed at the two positions described in Step 6:
    - **Maximum Heart Rate**, which is the value for Max on the Heart Rate channel.
    - **Minimum Heart Rate**, which is the value for Min 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.
    - **Mean Breath Rate**, which is the value for Mean on the Breath Rate channel.

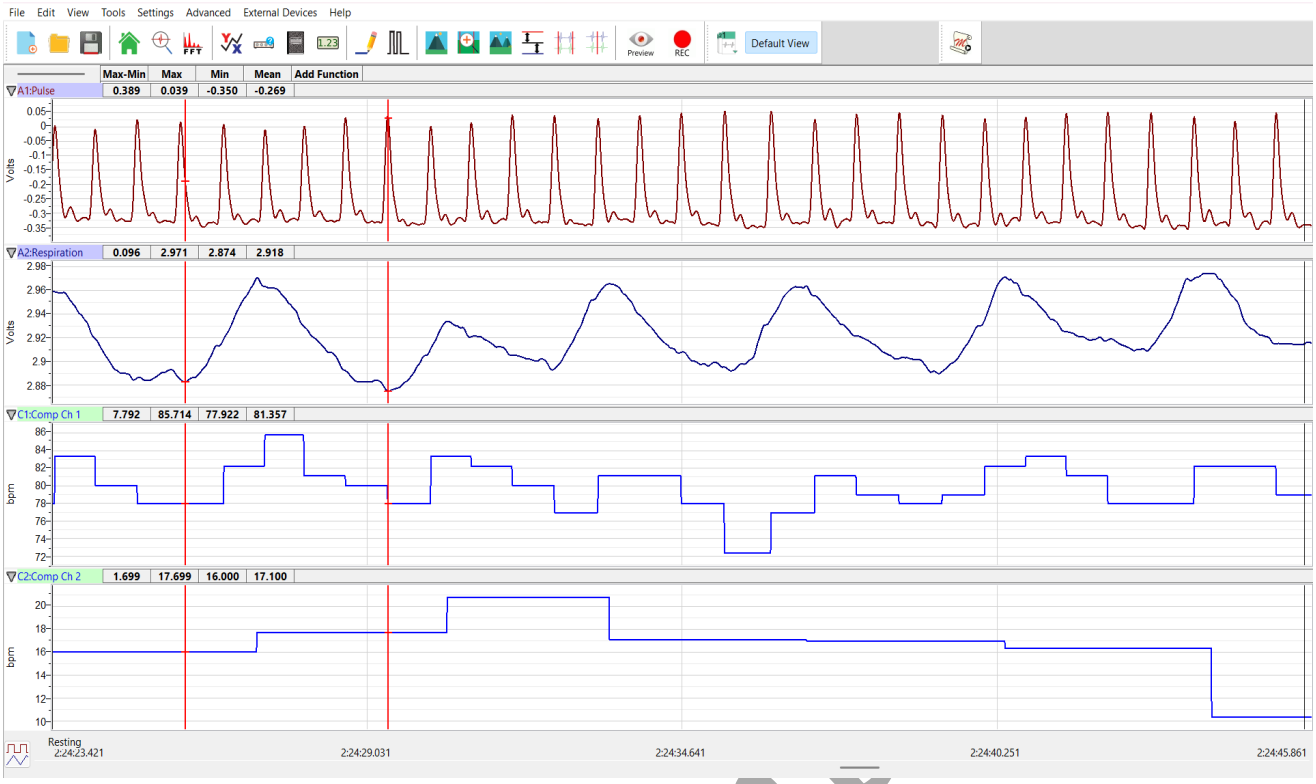

Figure ADS-BIA-1-L3: The pulse, respiration, heart rate, and breathing rate of a subject using abdominal breathing while at rest, displayed on the Analysis window. The cursors are in positions to mark the beginning and end of a breath cycle.

8. Once the cursors are placed in the correct positions for determining the breathing and heart rates, 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.
9. The functions in the right-click menu 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 breathing 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 menu.
    - Transfer the values for the volumes and rates to the Journal using the Add All Data to Journal function in the Volume menu.
10. Record the values in the Journal using one of the techniques described in Step 9, and in Table 1.

Table ADS-BIA-1-L1: Heart Rate Variation during Breathing at Rest.

	Heart Rate (bpm)				Mean Breath Rate (bpm)
	Max	Min	RSA (Max-Min	Mean	
Breath 1					
Breath 2					
Breath 3					
Mean					
Normal Breathing Technique					
Aerobic Fitness					

11. Use the mouse to click on and drag the left cursor to the trough before the inhalation of the third breath cycle displayed on the Volume channel. Repeat Step 8 for this breath cycle.
12. Use the mouse to click on and drag the left cursor to the trough before the inhalation of the fourth breath cycle displayed on the Volume channel. Repeat Step 8 for this breath cycle.
13. Ask the subject to rate their aerobic fitness as high, moderate, or low. Note this rating in Table 1, along with the subject's normal breathing technique (refer to the Background for more info).
14. Enter the mean values for the subject's parameters while breathing at rest in Table 2.

Questions

1. The difference between the heart rates during a breath cycle is known as RSA prominence. What is the average RSA prominence of the subject?
2. What percentage of the pre-inhalation heart rate is the RSA prominence?
3. How does the RSA prominence of this subject compare to those of other subjects? Does the aerobic fitness of the subject correlate with their RSA prominence?

Table ADS-BIA-1-L2: Heart Rates during Different Breathing Techniques.

Breathing Technique	Heart Rate (bpm)				Mean Breath Rate (bpm)
	Max	Min	RSA (Max-Min)	Mean	
Rest _____					
Shallow Abdom.					
Bellows					
Deep Abdom.					

Exercise 2: Apnea and Heart Rate

Aim: To determine the effect of apnea on the subject's heart rate by having the subject hold their breath.

Approximate Time: 15 minutes

Procedure

1. The subject should sit quietly and breath normally before the recording begins. Also, remind the subject to sit erect and quietly during the recordings, and to breath normally at the beginning of the exercise.
2. In this exercise, the subject breathes normally until a regular breathing pattern is established. Then, the subject takes a deep inhalation through their mouth and holds that breath for at least 15-20 seconds. Finally, the subject exhales slowly, through the mouth, over 10-15 seconds.
3. Type **Normal** in the Mark box.
4. Click Record. Click the mark button. Click AutoScale All and record until the subject's breathing is regular and predictable. Do not move on to Apnea until breathing is established and regular.
5. Type **Apnea** in the Mark box. Click the mark button as you instruct the subject to take the deep breath and hold it.
6. Type **Recovery** in the Mark box and click the mark button as the subject exhales and returns to breathing normally. Continue to record until the subject's breathing has returned to a normal pattern. Click Stop to halt the recording.
7. Click on Save in the File menu.

Data Analysis

1. Scroll to the recording of the subject's breathing before, during, and after holding their 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.
3. Click on the Analysis window icon in the toolbar to transfer the data to the Analysis window.
4. The functions used to analysis this are the same as the ones used in Exercise 1 and programmed by the settings file.

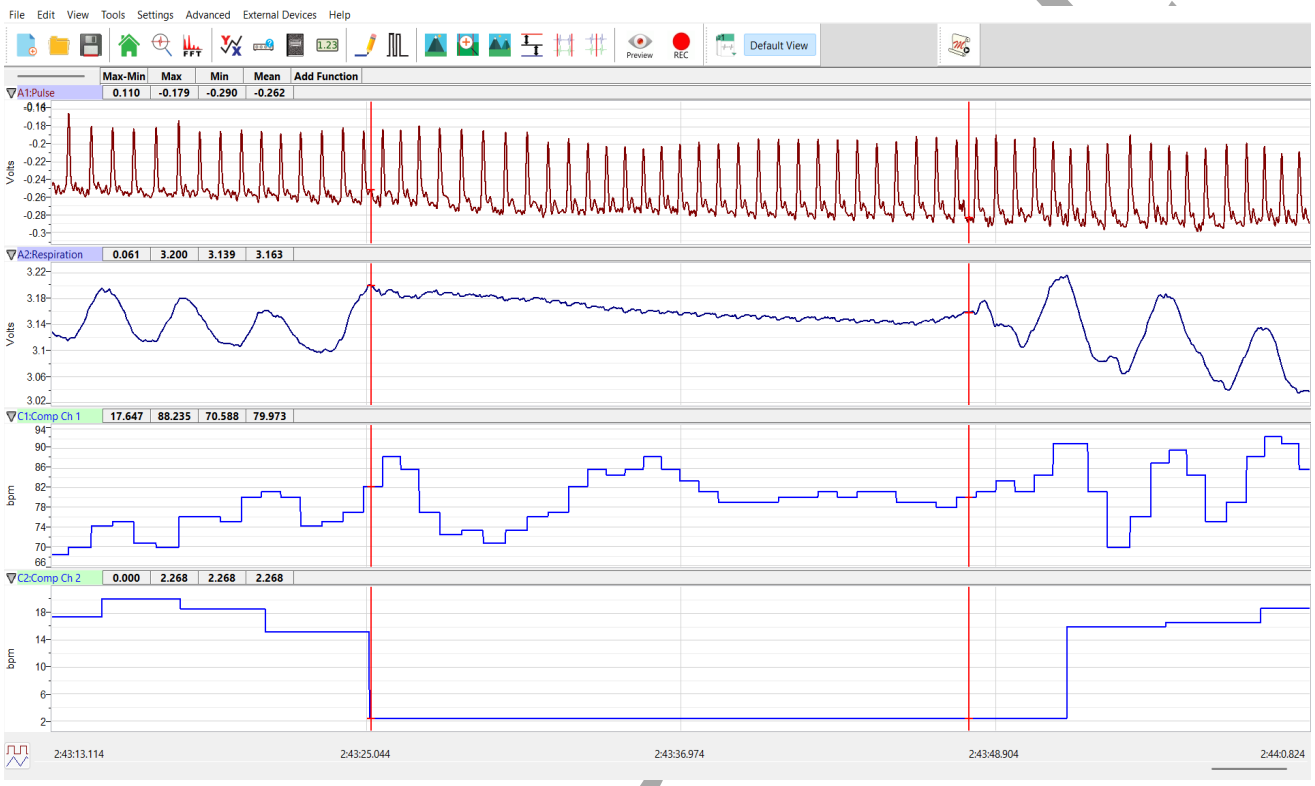

Figure ADS-BIA-1-L4: Pulse, respiration, heart rate, and breathing rate before, during, and after apnea displayed in the Analysis window.

5. Use the mouse to click on and drag one cursor to the trough on the Volume channel that precedes one of the subject's normal breath cycles, and the other cursor to the trough on the Volume channel that precedes the deep inhalation of apnea.
6. The values for the following parameters during normal breathing are determined when the cursors are placed at the two positions described in Step 6:
    - **Maximum Heart Rate - Normal Breathing**, which is the value for Max on the Heart Rate channel.
    - **Minimum Heart Rate - Normal Breathing**, which is the value for Min on the Heart Rate channel.

- **RSA Prominence (Max-Min) - Heart Rate-Normal Breathing**, which is the value for Max-Min on the Heart Rate channel.
- **Mean Heart Rate - Normal Breathing,** which is the value for Mean on the Heart Rate channel
- **Mean Breathing Rate- Normal Breathing**, which is the value for Mean on the Breath Rate channel

8. Record the values in the Journal using one of the techniques described in Exercise 1. Record the breath and heart rates in Table 3.
9. Use the mouse to click on and drag the left cursor to the trough on the Volume channel that follows the subject's exhalation at the end of apnea.
10. The values for the following rates during apnea are determined by the positions of the cursors:
    - **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.
    - **RSA Prominence (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.
11. Record the values in the Journal using one of the techniques described in Exercise 1. Record the heart rates in table.
12. Use the mouse to click on and drag the left cursor to a time point after the subject's return to normal breathing displayed on the Volume channel.
13. The values for the following rates during the recovery to normal breathing are determined by the positions of the cursors:
    - **Minimum Heart Rate - Recovery to Normal Breathing**, which is the value for Min on the Heart Rate channel.
    - **Maximum Heart Rate - Recovery to Normal Breathing**, which is the value for Max on the Heart Rate channel.
    - **RSA Prominence (Max-Min) --Recovery to Normal Breathing**, which is the value for Max-Min on the Heart Rate channel.
    - **Mean Heart Rate - Recovery to Normal Breathing**, which is the value for Mean on the Heart Rate channel.
    - Mean Breathing Rate- Recovery to Normal Breathing, which is the value for Mean on the Breath Rate channel.
14. Use the same techniques to record the values for these parameters in the Journal and on the table.

Table ADS-BIA-1-L3: Heart Rates before, during, and after Apnea

Breathing Pattern	Heart Rate (bpm)				Mean Breath Rate (bpm)
	Max	Min	RSA (Max-Min)	Mean	
Normal					
Apnea					
Recovery					

Questions

1. How did the heart rate of the subject change during apnea and recovery from apnea?
2. How did the RSA prominence of the subject change during apnea and recovery from apnea?
3. How does the normal breathing before apnea compare to the first breaths in the recovery segment?
4. How does the breathing rate in the recovery segment correlate to the heart rate in that same segment?

Exercise 3: Shallow Abdominal Breathing and Heart Rate

Aim: To determine the effect of shallow abdominal breaths on the subject's heart rate.

Approximate Time: 20 minutes

Procedure

1. The subject should sit quietly and breathe normally before the recording begins. Also, remind the subject to sit erect and quietly during the recordings, and to breath normally at the beginning of the exercise.
2. Tell the subject to breathe normally until a regular breathing pattern is established. Then, the subject takes shallow (not full) breaths at the rate of 40 to 50 breaths per minute, using the diaphragm as the primary force for moving air in and out of the lungs. Record shallow breathing for 30 seconds. Finally, the subject returns to breathing normally.
3. Type **Normal** in the Mark box.
4. Click on the Record button. Click the mark button to mark the recording. Click AutoScale All. Record until the subject's breathing is regular and predictable.
5. Type **Shallow** in the Mark box. Click the mark button as you instruct the subject to start shallow abdominal breathing for 30 seconds.

6. Type **Recovery** in the Mark box. Click the mark button as the subject returns to breathing normally. Continue to record until the subject's breathing has returned to a normal pattern. Click Stop to halt the recording. Your data should look like the image below.
7. Click on Save in the File menu.

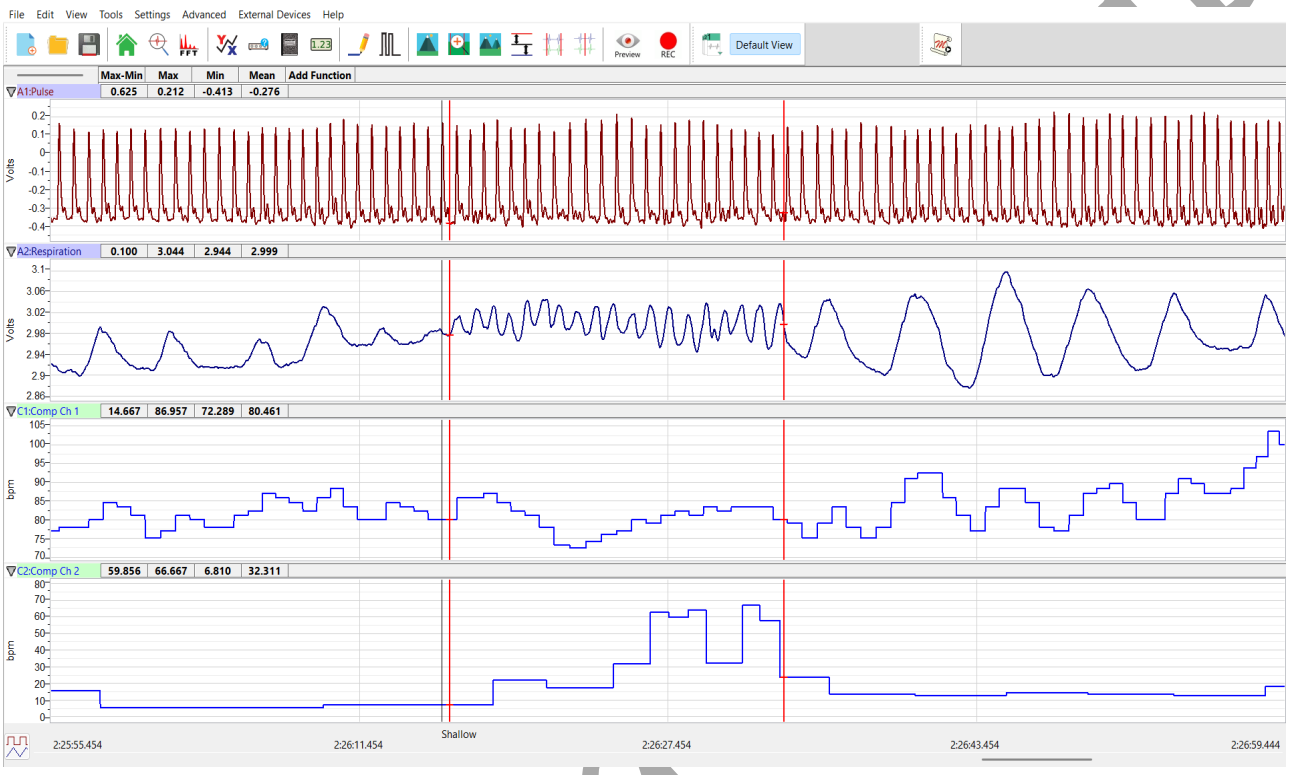

Figure ADS-BIA-1-L5: Pulse, respiration, heart rate, and breathing rate before, during, and after shallow abdominal breathing, displayed in the Analysis window. The average breath rate during shallow abdominal breathing was 82 breaths per minute.

Data Analysis

1. Use the same techniques used in Exercise 2 to determine the breathing and heart rates before, during, and after shallow abdominal breathing.
2. Use the same techniques to record the values for these parameters in the Journal and on Table 4.

Questions

1. How did the heart rate of the subject change during shallow abdominal breathing and recovery from shallow abdominal breathing?
2. How did the RSA prominence of the subject change during shallow abdominal breathing and recovery from shallow abdominal breathing?

3. How does the normal breathing before shallow abdominal breathing compare to the first breaths in the recovery segment?
4. How does the breathing rate in the recovery segment correlate to the heart rate in that same segment?

Table ADS-BIA-1-L4: Heart Rates before, during, and after Shallow Abdominal Breathing.

Breathing Pattern	Heart Rate (bpm)				Mean Breath Rate (bpm)
	Max	Min	RSA (Max-Min)	Mean	
Normal					
Shallow					
Recovery					

Exercise 4: Bellows Breathing and Heart Rate

Aim: To determine the effect of very rapid breathing, often referred as the Bellows Breathing Technique on the subject's heart rate.

Approximate Time: 15 minutes

Procedure

1. The subject should sit quietly and breathe normally before the recording begins. Also, remind the subject to sit erect and quietly during the recordings, and to breath normally at the beginning of the exercise.
2. Tell the subject that in this exercise, breathes normally until a regular breathing pattern is established. Then, the subject breaths as rapidly as possible for 10 to 15 seconds, moving air in and out through the nose while the mouth is gently closed. Bellows breathing can be as rapid as 2 to 3 breaths per second and can lead to dizziness. Finally, the subject returns to breathing normally.
3. Type **Normal** in the Mark box.
4. Click on the Record button. Click the mark button to mark the recording. Click AutoScale All button and record until the subject's breathing is regular and predictable.
5. Type **Bellows** in the Mark box. Click the mark button as you instruct the subject to start bellows breathing for 15 seconds.

6. Type **Recovery** in the Mark box. Click the mark button as the subject returns to breathing normally. Continue to record until the subject's breathing has returned to a normal pattern. Click Stop to halt the recording.
7. Click on Save in the File menu.

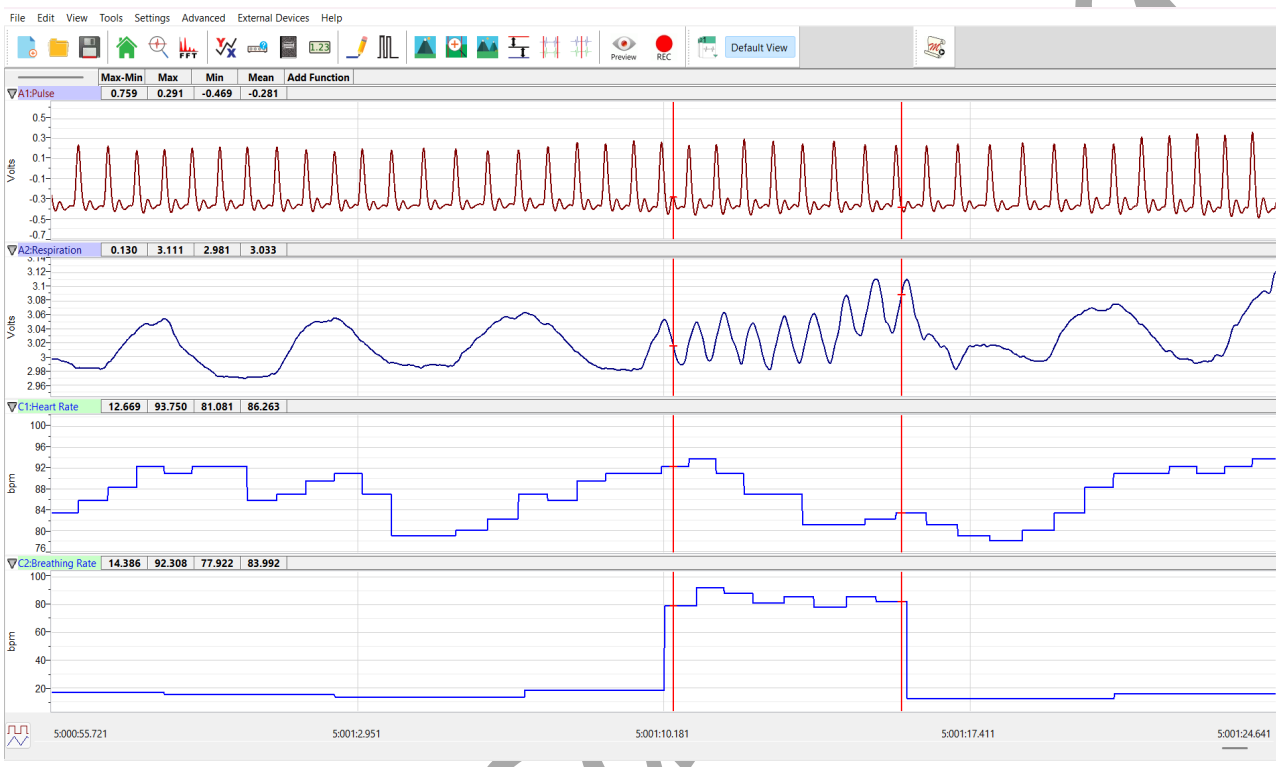

Figure ADS-BIA-1-L6: Pulse, respiration, heart rate, and breathing rate before, during, and after bellows breathing, displayed in the Analysis window. During a section of bellows breathing, the maximum breath rate was 92 breaths per minute.

Data Analysis

1. Use the same techniques used in Exercise 2 to determine the subject's breathing and heart rates before, during, and after bellows breathing.
2. Use the same techniques to record the values for these parameters in the Journal and on Table 5.

Questions

1. How did the heart rate of the subject change during bellows breathing and recovery from bellows breathing?
2. How did the RSA prominence of the subject change during bellows breathing and recovery from bellows breathing?

3. How does the normal breathing before bellows breathing compare to the first breaths in the recovery segment?

4. How does the breathing rate in the recovery segment correlate to the heart rate in that same segment?

Table ADS-BIA-1-L5: Heart Rates before, during, and after Bellows Breathing.

Breathing Pattern	Heart Rate (bpm)				Mean Breath Rate (bpm)
	Max	Min	RSA (Max-Min)	Mean	
Normal					
Bellows					
Recovery					

Exercise 5: Deep Abdominal Breathing and Heart Rate

Aim: To determine the effect of deep abdominal breathing on the subject's heart rate.

Approximate Time: 15 minutes

Procedure

1. The subject should sit quietly and breathe normally before the recording begins. Also, remind the subject to sit erect and quietly during the recordings, and to breathe normally at the beginning of the exercise.
2. Tell the subject that in this exercise, to breathes normally until a regular breathing pattern is established. Then, the subject breaths slowly and deeply, inhaling through the nose and exhaling through the mouth for 1 minute. Finally, the subject returns to breathing normally.
3. Type **Normal** in the Mark box.
4. Click on the Record button. Click the mark button to mark the recording. Click AutoScale All and record until the subject's breathing is regular and predictable.
5. Type **Deep Breathing** in the Mark box. Click the mark button as you instruct the subject to start deep abdominal breathing for a minute.
6. Type **Recovery** in the Mark box. Click the mark button as the subject returns to breathing normally. Continue to record until the subject's breathing has returned to a normal pattern. Click Stop to halt the recording.
7. Click on Save in the File menu.

Data Analysis

1. Use the same techniques used in Exercise 2 to determine the subject's breathing and heart rates before, during, and after deep abdominal breathing.
2. Use the same techniques to record the values for these parameters in the Journal and in Table 6.

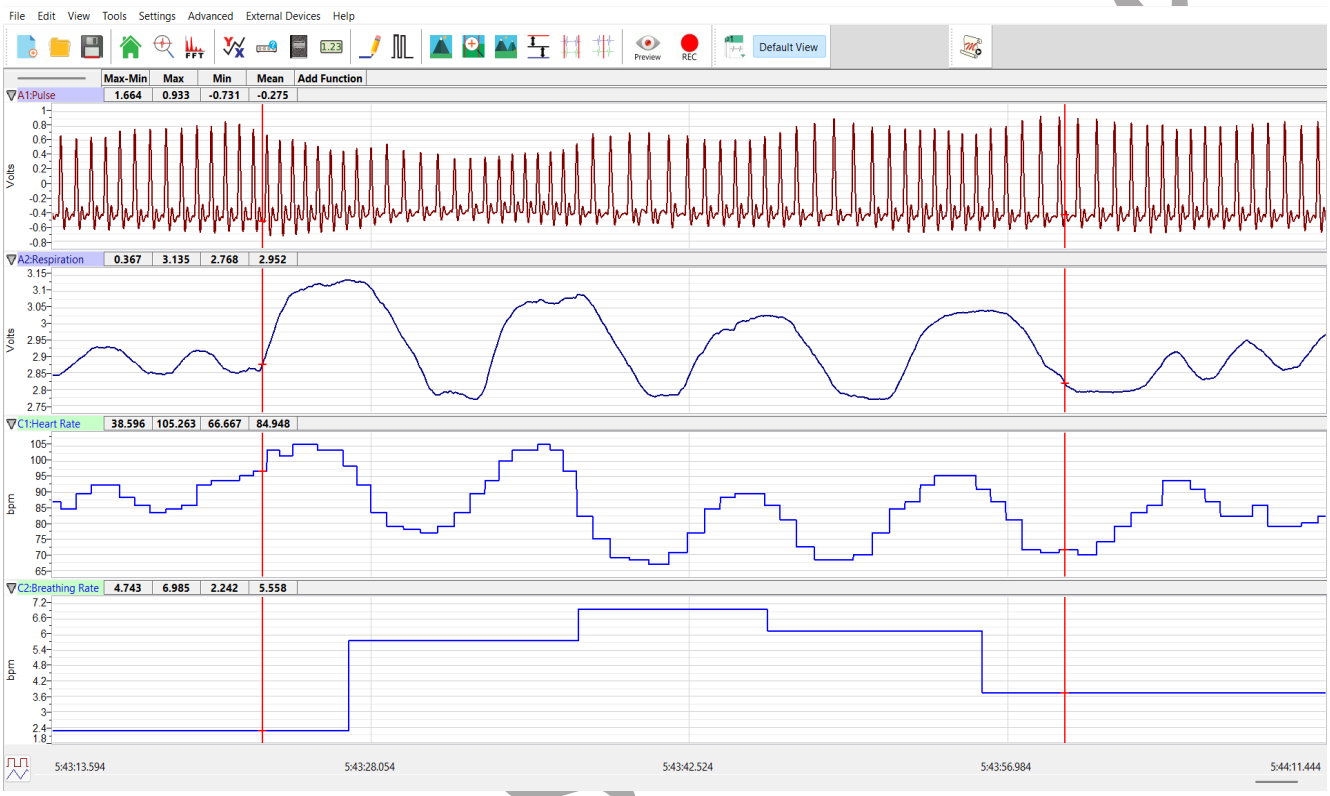

Figure ADS-BIA-1-L7: Pulse, respiration, heart rate, and breathing rate before, during, and after deep abdominal breathing, displayed in the Analysis window.

Table ADS-BIA-1-L6: Heart Rates before, during, and after Deep Abdominal Breathing.

Breathing Pattern	Heart Rate (bpm)				Mean Breath Rate (bpm)
	Max	Min	RSA (Max-Min)	Mean	
Normal					
Deep Ab					
Recovery					

Questions

1. How did the heart rate of the subject change during deep abdominal breathing and recovery from deep abdominal breathing?
2. How did the RSA prominence of the subject change during deep abdominal breathing and recovery from deep abdominal breathing?
3. How does the normal breathing before deep abdominal breathing compare to the first breaths in the recovery segment
4. How does the breathing rate in the recovery segment correlate to the heart rate in that same segment?
5. How do the heart rates of the four breathing techniques compare? How do the RSA prominences of the four breathing techniques compare?