Experiment HS-5: Breathing Techniques and Heart Rate

Equipment Required

PC Computer

IXTA, USB cable, IXTA power supply

RM-220 – Nasal Cannula

PPG-320 Pulse plethysmograph

Optional - RM-204 Respiration monitor

Pulse Plethysmograph and Respiration Monitor Setup

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

1. Locate the PPG-320 pulse plethysmograph and the RM-220 nasal cannula.
2. Plug the PPG-320 into the PT input of the IXTA. Plug the connector to the RM-220 into the white Channel A1 input.

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

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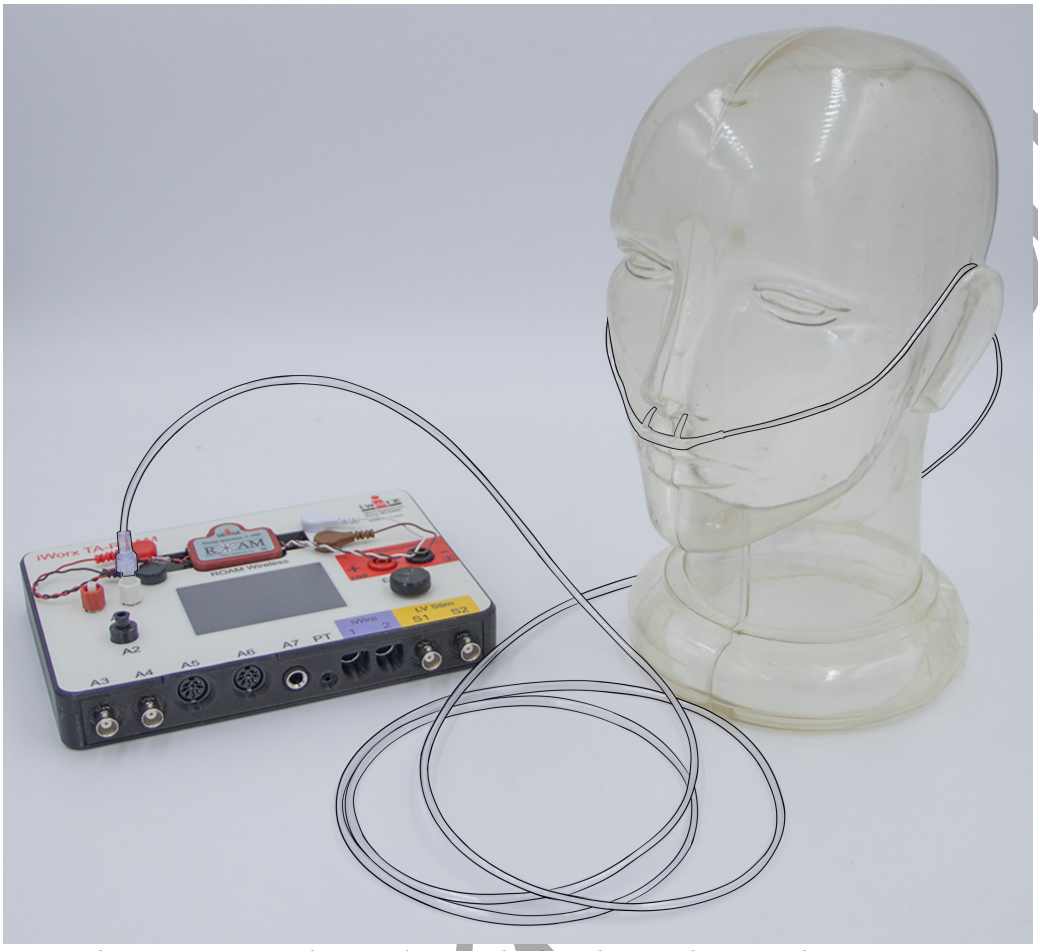

Figure HS-5-S2: The RM-220 nasal cannula attached to the TA showing the correct position on the head.

3. 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.
4. Place the plethysmograph 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.
5. Place the cannula on the subject as shown above.

   It is not necessary to place it inside the nostrils.

   You will get the best results if the cannula is just below the nostrils.
6. 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.
7. Make sure your subject is only breathing through the nose.

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NOTE: If using the optional RM-204 respiration belt instead of the nasal cannula:

- Plug the RM-204 into channel A6 on the front of the IX-TA
- Click Edit → Preferences
  - Uncheck channel A1 – Respiration AND channel C2 – Breathing Rate
  - Place a check mark in channel A6 – name it Respiration by typing in the box
  - Click OK
- To create a new Breathing Rate channel, on the <u>new</u> Respiration channel
  - Click Fx → Periodic → Rate → OK
  - Click on the title of the new channel and rename it – Breathing Rate
  - Click on V2-V1 on the right hand side of the channel and change to Mean
- 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.

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Experiment HS-5: 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 HS-5-L1: The pulse, respiration, heart rate, and breathing rate of a subject using abdominal breathing while at rest, displayed in the Main window.

Sample Lab

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.

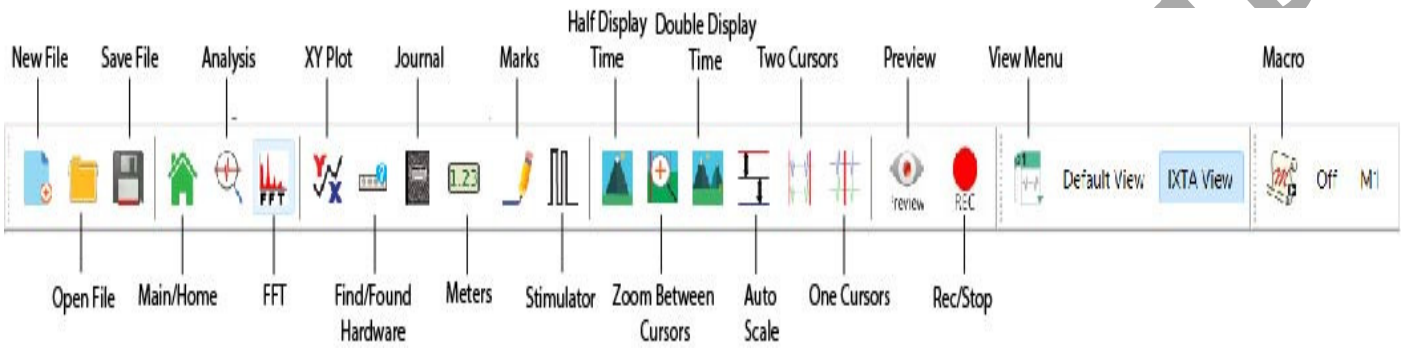

Figure HS-5-L2: The LabScribe toolbar.

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.

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Figure HS-5-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.

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Table HS-5-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?

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Table HS-5-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.					

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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 HS-5-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.

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- **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.

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Table HS-5-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.

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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.

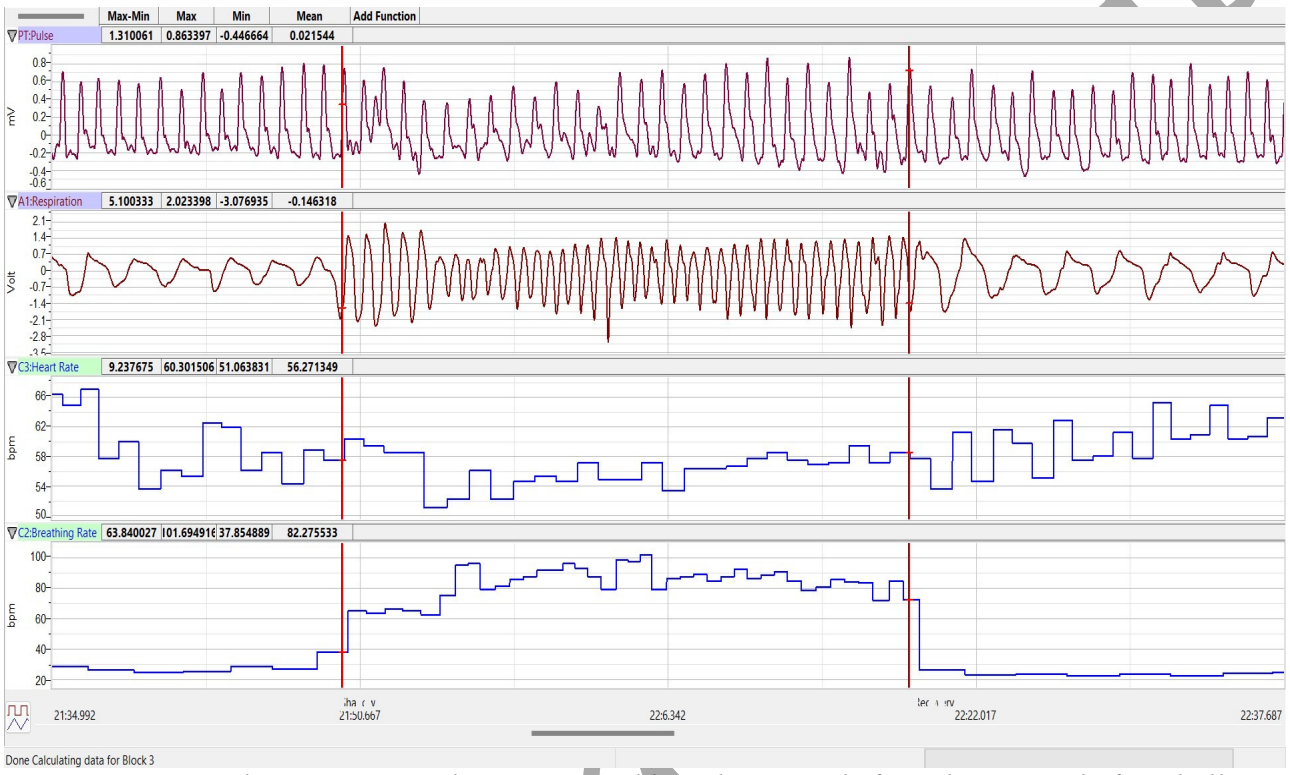

Figure HS-5-L5: Pulse, respiration, heart rate, and breathing rate before, during, and after shallow abdominal breathing, displayed in the Analysis window. The average breath rate during shallow abdominal breathing was 82 breaths per minute.

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?

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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 HS-5-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.

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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.

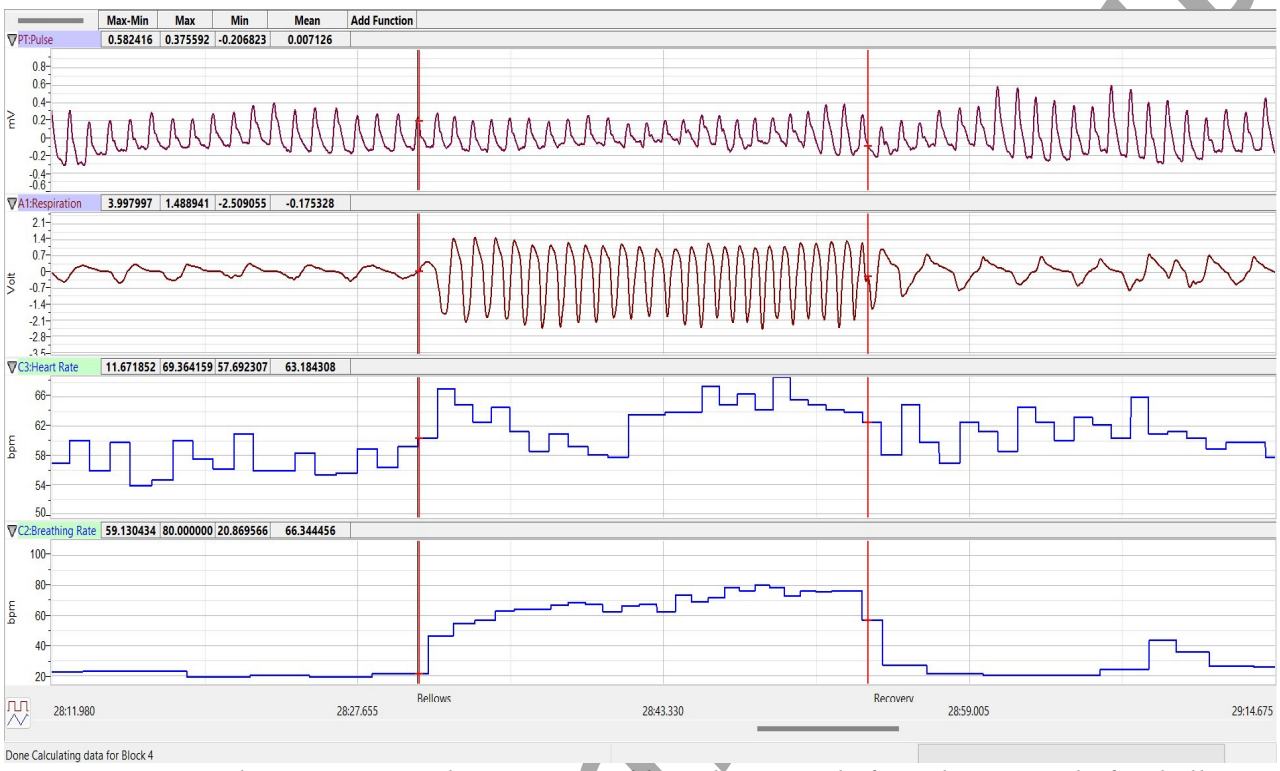

Figure HS-5-L6: Pulse, respiration, heart rate, and breathing rate before, during, and after bellows breathing, displayed in the Analysis window. During a section of bellows breathing, the maximum breath rate was 80 breaths per minute.

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?

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

Table HS-5-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 breath 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.

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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.

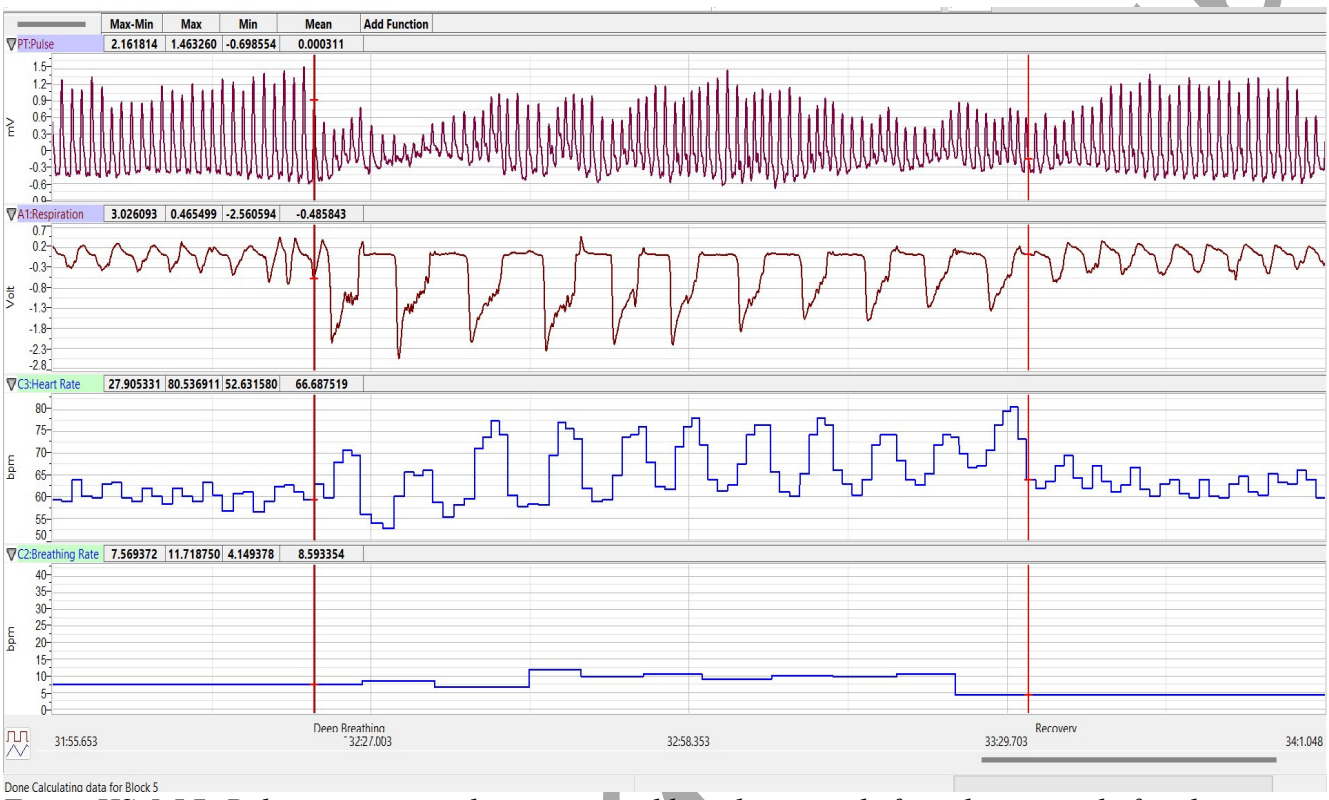

Figure HS-5-L7: Pulse, respiration, heart rate, and breathing rate before, during, and after deep abdominal breathing, displayed in the Analysis window.

Table HS-5-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					

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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?

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