Experiment HS-6: Ventilation and Oxygen Saturation Levels, Part 1

Equipment Required

PC or Mac Computer

IXTA, USB cable, IXTA power supply

SP-304 Spirometer

A-FH-300L Spirometer flow head and plastic tubes

A-SRK Student Respiratory kit

PPG-320 Pulse Oximeter

Pulse Oximeter and Spirometer Setup

1. Locate the A-FH-300 flow head and the airflow tubing. Also, locate the pulse oximeter and its cables.

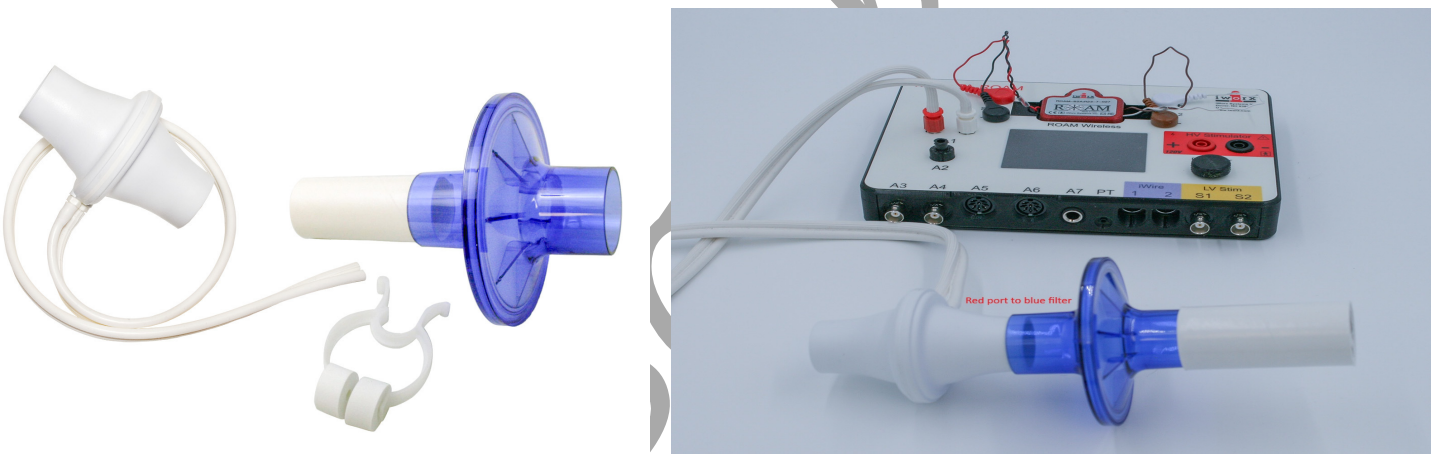

Figure HS-6-S1: The student respiratory kit and the FH-300 flow head and the airflow tubing. The blue filter will attach to the flow head.

2. Firmly push the two air flow tubes onto the two outlets on the FH-300 flow head.
3. Firmly push the two air flow tubes onto the two outlets on the A-FH-300L flow head.
4. Carefully connect the other ends of the two air flow tubes into the Channel A1 input of the IXTA. Connect the red port to the red connector on the tubing.
5. Connect the PPG-320 oximeter to the PT port on the front of the TA.
6. Place the pulse sensor on the subject's finger where the fingertips are located (volar surface of the thumb or middle finger).

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Figure HS-6-S3: A PPG-320 pulse oximeter and the flow head connected to the internal spirometer of the IXTA unit.

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Preparations Before Recording

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. The outlets on the flow head should always be in the upright position to avoid problems with condensation developing in the airflow tubes.
4. To reduce turbulence, the subject should place their lips around the outside of the opening of the flow head, or around the cardboard mouthpiece attached to the flow head.
5. Use a nose-clip to prevent air from entering or leaving the nose as the subject is breathing. Air that passes through the nose causes errors in the lung volume values.

6. Check the calibration of your spirometer on the Lung Volumes channel:
    - Click on the words Vol.Human (Air Flow), that are next to the title of the Lung Volumes channel, to open the computed function pull-down menu.
    - Select Setup Function from this pull-down menu to open the Spirometer Calibration Dialog window.
    - Check that the internal spirometer is being used by making sure the Type of Spirometer is the IXTA.
    - Make sure the reset time is set to “No Reset”, and the first 10 seconds of the recording are used to zero the baseline of the Lung Volumes channel.
    - Enter 37 for temperature of exhaled air.
    - Click OK.
7. Allow the IXTA to warm up for 10 minutes before recording for the first time.

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Experiment HS-6: Ventilation and Oxygen Saturation Levels, Part 1

Exercise 1: Oxygen Saturation Level While Breathing at Rest

Aim: To determine the effect of breathing on the oxygen saturation level in the blood of a subject at rest.

Approximate Time: 20 minutes

Procedure

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

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

2. Type **Resting** in the Mark box.
3. Click Record and then click the mark button.
4. Click the AutoScale All button. Notice the slowly moving wave on the Lung Volume channel. Record for 1 minute.
5. Click Stop to halt recording. Your data may look like the image below.
6. Select Save in the File menu.

Data Analysis

1. Scroll through the recording and find the section of data recorded when the subject was breathing while resting. Use the Display Time icons to adjust the Display Time of the Main window to show 30 seconds of breathing that are free of artifacts.
3. Click AutoScale All.

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Figure HS-6-L1: Pulse, oxygen saturation level, air flow, lung volumes, and heart rate during breathing at rest, displayed on the Main window.

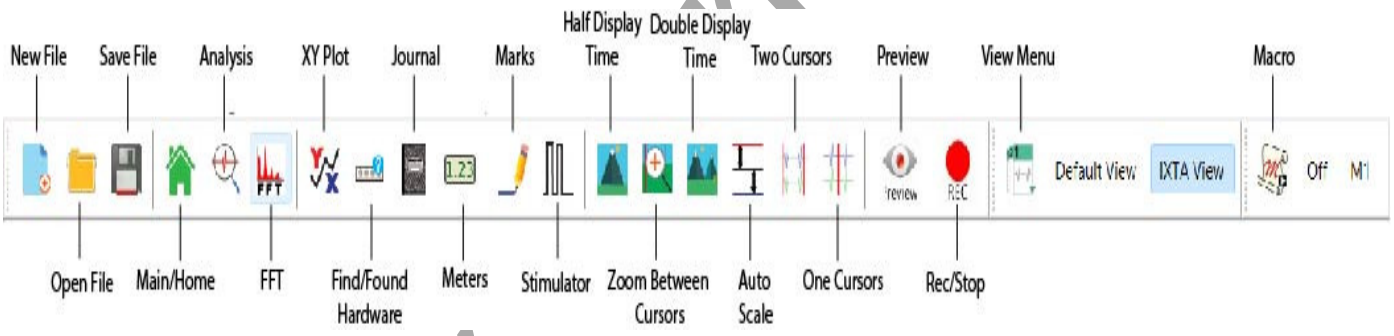

Figure HS-6-L2: The LabScribe toolbar.

5. Click on the Analysis window icon.
6. Look at the Function Table that is above the uppermost channel displayed in the Analysis window. The mathematical functions, Max, Min, Max-Min, Mean, and T2-T1 should appear on the Functions Table at the top of the Analysis window. Values for Max, Min, Max-Min, Mean, and T2-T1 on each channel are seen in the table across the top margin of each channel.

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7. On the Lung Volume channel, use the mouse to place a cursor at the beginning of the inhalation of the first breath being measured. Place the second cursor at the end of the exhalation of the same breath. Measure the following levels and rates.
    - **Maximum Oxygen Saturation Level**, the value for Max on the O2 Saturation channel.
    - **Minimum Oxygen Saturation Level**, the value for Min on the O2 Saturation channel.
    - **Mean Oxygen Saturation Level**, the value for Mean on the O2 Saturation channel.
    - **Maximum Heart Rate**, the value for Max on the Heart Rate channel.
    - **Minimum Heart Rate**, the value for Min on the Heart Rate channel.
    - **Mean Heart Rate**, the value for Mean on the Heart Rate channel.
8. Once the cursors are placed in the correct positions for determining the saturation levels and heart rate, the values of the parameters in the Function Table 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 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:
10. Transfer the names of the mathematical functions used to determine the values to the Journal using the Add Title to Journal function on the pull-down menu of any channel.

Figure HS-6-L3: Pulse, oxygen saturation level, air flow, lung volumes, and heart rate of a resting subject displayed in the Analysis window.

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11. Record the values in the Journal using the one of the techniques described in Step 10, and in Table 1.
12. Repeat these steps for two additional breath cycles.
13. Average the values obtained and enter the means in the Journal and in Table 1.

Questions

1. Does the subject's oxygen saturation level change in response to inhalation or exhalation?
2. Does the oxygen saturation level change during a normal breath? By how much?
3. Is there any significant difference in the mean oxygen saturation levels among the three breaths?

Table HS-6-L1: Oxygen Saturation Levels during Breathing at Rest.

Subject	%O2 Saturation			Heart Rate (BPM)		
_____	Min	Max	Mean	Min	Max	Mean
Breath 1						
Breath 2						
Breath 3						
Mean						

Exercise 2: Oxygen Saturation during Apnea

Aim: To measure the effect of apnea on the subject's oxygen saturation level.

Approximate Time: 20 minutes

Procedure

1. The subject should sit quietly and breathe normally before this exercise begins. The subject should already be accustomed to breathing through a flow head.
2. Before the recording begins, instruct the subject about the breathing pattern for this exercise:
    - After the 10 second calibration period, the subject should take 5 normal breaths through the flow head.
    - Then, the subject will take a deep inhalation and hold their breath as long as possible.
    - When the subject resumes breathing, they should continue to breathe through the flow head until the breathing pattern is back to normal.

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3. Click on the Record button. After waiting ten seconds for the Lung Volume channel to zero, have the subject place the flow head in their mouth and begin breathing.
4. Type **Resting** in the Mark box and then click the mark button.
5. Click the AutoScale All button. Notice the slowly moving wave on the Lung Volume channel. Record five breaths. Type **Apnea** in the Mark box.
6. Click the mark button as the subject inhales as deeply as possible and then their breath as long as possible.
7. While the subject is holding their breath, type **Resume Breathing** in the Mark box. Click the mark button to mark the recording when the subject resumes breathing.
8. The subject should continue to breathe through the spirometer until their breathing returns to normal.
9. Click Stop to halt recording. Your data should look like Figure HS-6-L4.
10. Select Save in the File menu.

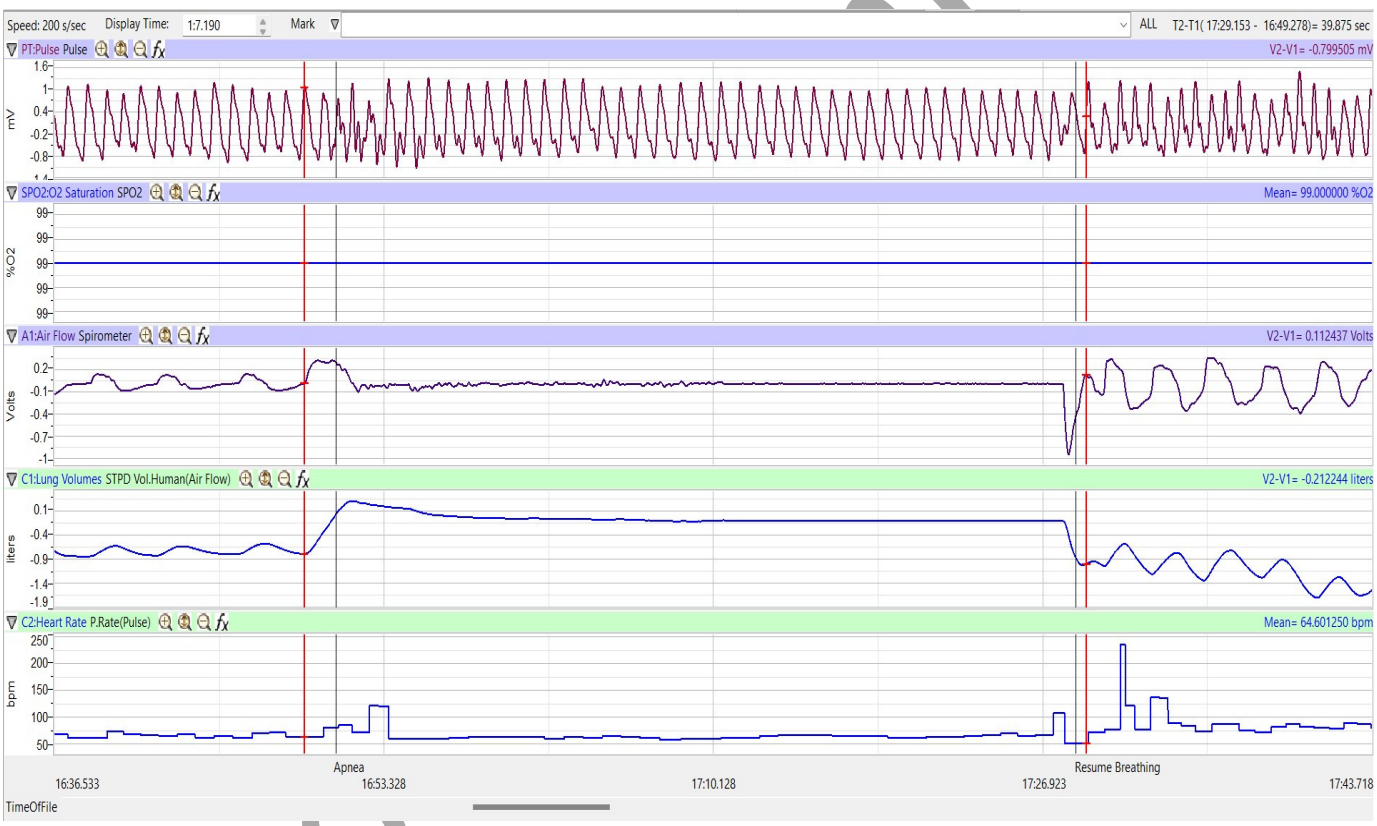

Figure HS-6-L4: Pulse, oxygen saturation level, air flow, lung volumes, and heart rate before, during and after apnea, displayed in the Main window.

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Data Analysis

1. Scroll to the recording of the subject's breathing before, during and after apnea that is displayed in the Main window. Use the Display Time icons to adjust the Display Time of the Main window to show the normal breath before apnea, the period of apnea, and a couple of normal breaths after apnea.
2. Click AutoScale All.
3. Click on the Analysis window icon.

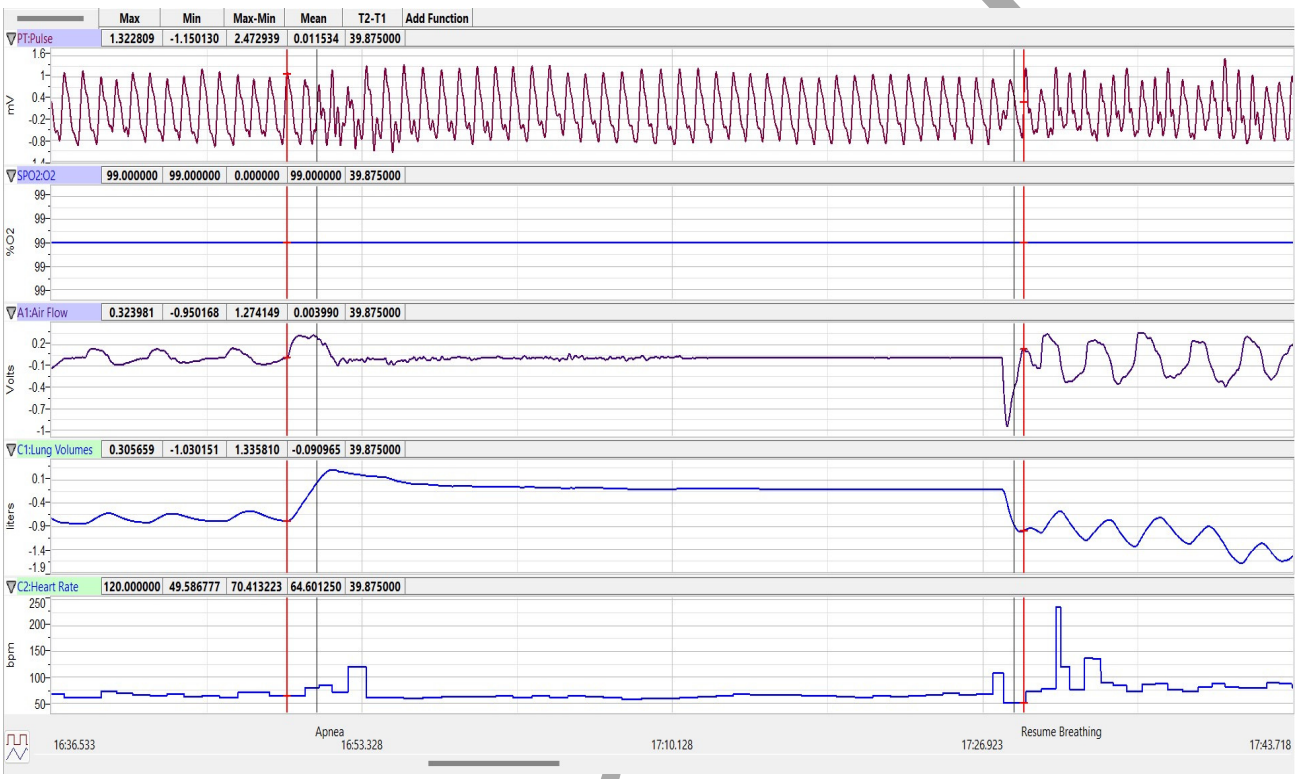

Figure HS-6-L5: Pulse, oxygen saturation level, air flow, lung volumes, and heart rate before, during and after apnea, displayed in the Analysis window.

5. On the Lung Volume channel, use the mouse to place a cursor at the beginning of the maximum inhalation that precedes apnea. Place the second cursor at the beginning of the first normal breath that follows apnea. Measure the following levels and rates.
    - **Maximum Oxygen Saturation Level**, the value for Max on the O2 Saturation channel.
    - **Minimum Oxygen Saturation Level**, the value for Min on the O2 Saturation channel.
    - **Change(Δ) in Oxygen Saturation Level**, the value for Max-Min on the O2 Saturation channel.
    - **Maximum Heart Rate**, the value for Max on the Heart Rate channel.
    - **Minimum Heart Rate**, the value for Min on the Heart Rate channel.

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- **Change(Δ) in Heart Rate,** the value for Max-Min on the Heart Rate channel.

6. Record the values in the Journal using the one of the techniques described in Exercise 1, and in Table 2.
7. Measure the following parameters and record their values in the Journal:
    - **Response Time to Apnea**. Place one cursor at the beginning of the maximal inhalation that precedes apnea, and the second cursor at the first change in the oxygen saturation level during apnea. The value for the T2-T1 function is the response time to apnea. Record the values in the Journal and in Table 2.

      Recovery Time from Apnea. Place one cursor at the end of apnea, when the subject starts to exhale, and the second cursor at the return of the oxygen saturation level to normal. The value for the T2-T1 function is the recovery time from apnea. Record the values in the Journal and in Table 2.
8. Click the Save button to save the file.

Questions

1. How does the oxygen saturation level during normal breathing compare to oxygen saturation level at the end of apnea? What causes the oxygen saturation levels to change?
2. How does the Response Time to Apnea compare to the Recovery Time from Apnea?
3. How does the heart rate during normal breathing compare to the heart rate at the end of apnea?

Exercise 3: Hyperventilation and Oxygen Saturation Levels

Aim: To measure the effect of hyperventilation on the subject's oxygen saturation level.

Approximate Time: 20 minutes

Procedure

1. The subject should prepare for the exercises just like the subjects in Exercises 1 and 2:
2. Before the recording begins, instruct the subject about the breathing pattern for this exercise:
    - After the 10 second calibration period, the subject should take 5 normal breaths through the flow head.
    - Then hyperventilate by breathing as quickly and as deeply as possible for 15-20 seconds.
    - After the hyperventilation period resume breathing normally.
3. Click on the Record button. After waiting ten seconds for the Lung Volume channel to zero, have the subject place the flow head in their mouth and begin breathing.
4. Type **Resting** in the Mark box and click the mark button.

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5. Click the AutoScale All button. Record five normal breaths. Type **Hyperventilate** in the Mark box.
6. Click the mark button as the subject inhales and exhales as quickly and as deeply as possible.
7. While the subject is hyperventilating, type **Normal Breathing** in the Mark box. Click the mark button to mark the recording when the subject returns to breathing normally.
8. Click Stop to halt recording. Your data should look like image below.
9. Select Save in the File menu.

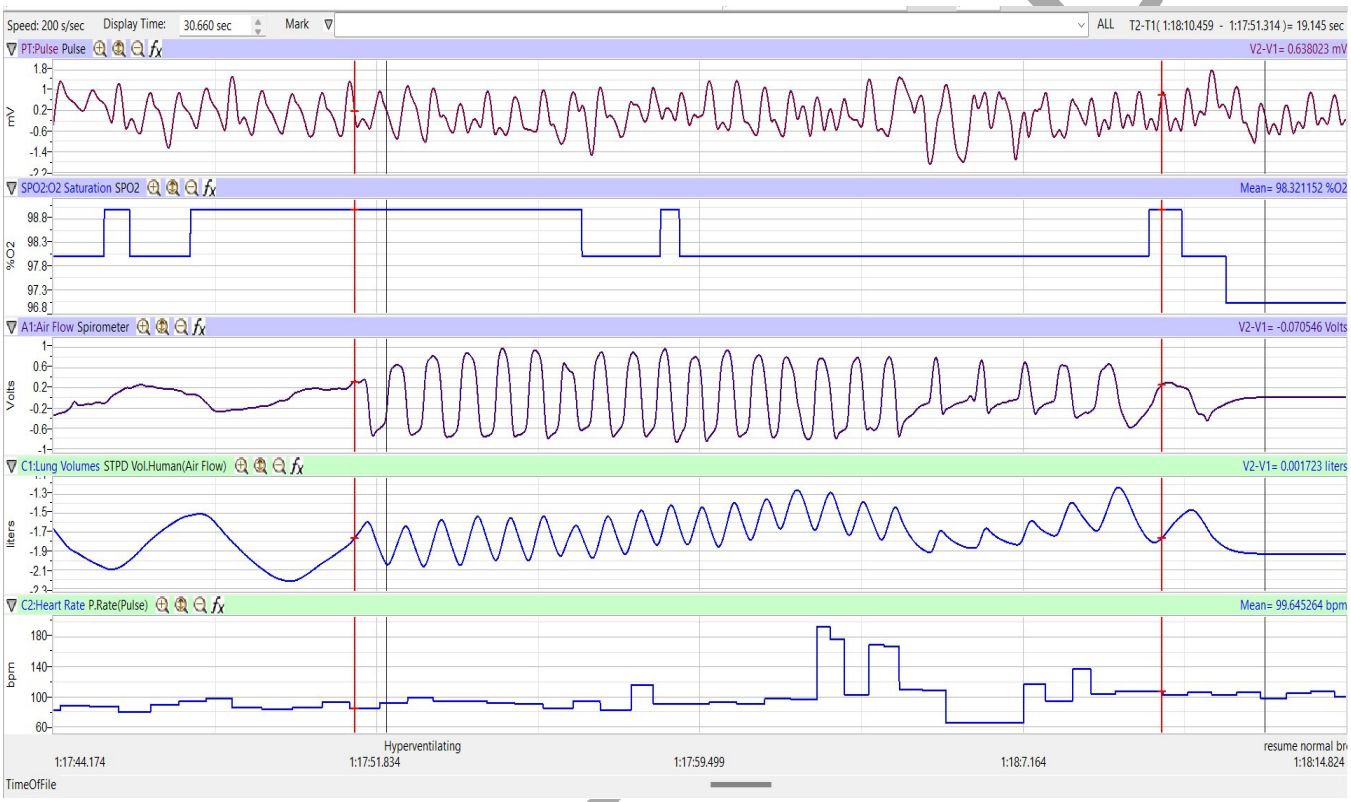

Figure HS-6-L6: Pulse, oxygen saturation level, air flow, lung volumes, and heart rate before, during and after hyperventilation, displayed in the Main window.

Data Analysis

1. Scroll to the recording of the subject's breathing before, during and after hyperventilation that is displayed in the Main window. Use the same techniques described in Exercise 2 to adjust the width of data to include the normal breath before hyperventilation, the period of hyperventilation, and a few normal breaths after hyperventilation.
2. Click AutoScale All.
3. Click on the Analysis window icon.

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4. On the Lung Volume channel, use the mouse to place a cursor at the beginning of the first deep breath of hyperventilation. Place the second cursor at the point where the oxygen saturation level after hyperventilation returns to normal. Measure the following levels and rates.
    - **Maximum Oxygen Saturation Level,** the value for Max on the O2 Saturation channel.
    - **Minimum Oxygen Saturation Level**, the value for Min on the O2 Saturation channel.
    - **Change(Δ) in Oxygen Saturation Level**, the value for Mean on the O2 Saturation channel.
    - **Maximum Heart Rate**, the value for Max on the Heart Rate channel.
    - **Minimum Heart Rate**, the value for Min on the Heart Rate channel.
    - **Change (Δ) in Heart Rate**, the value for Mean on the Heart Rate channel.

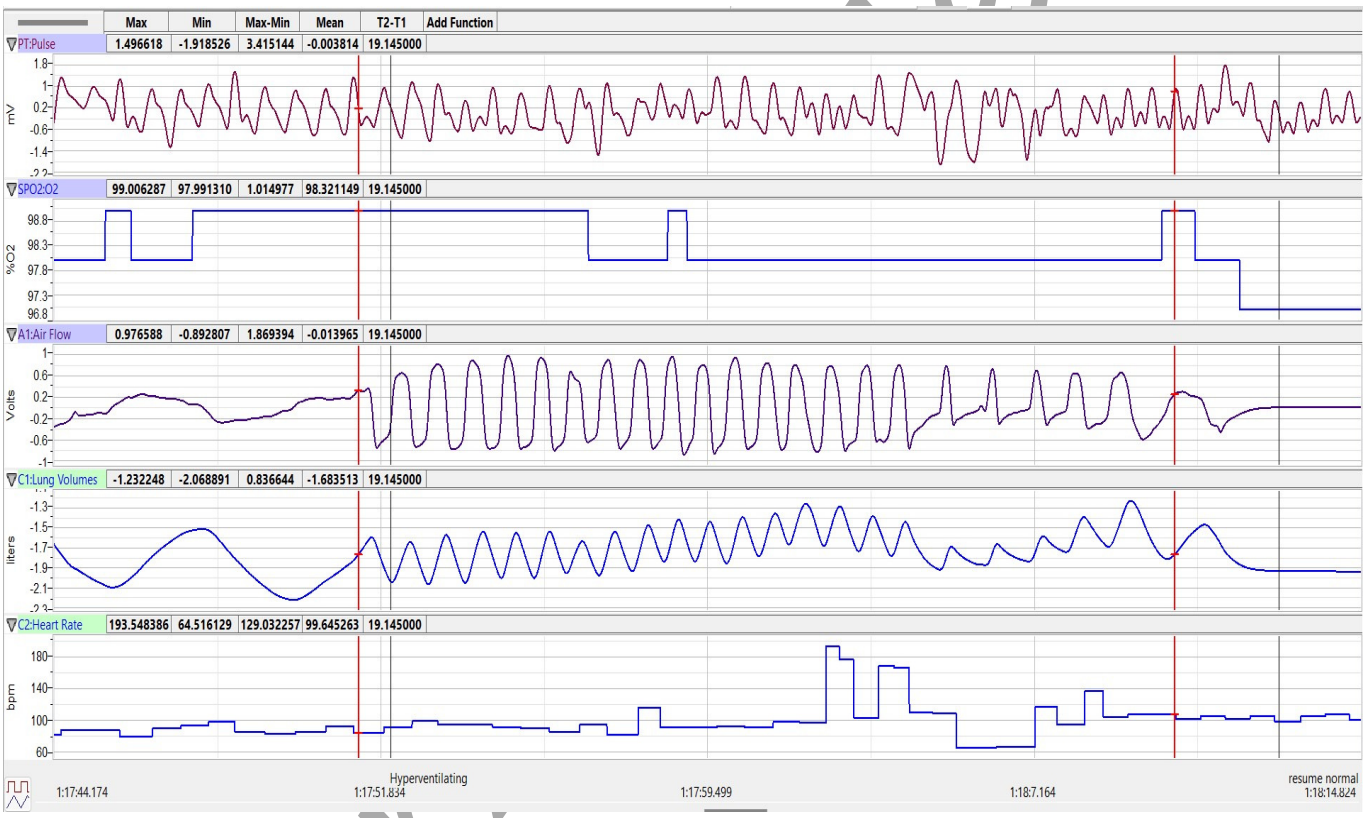

Figure HS-6-L7: Pulse, oxygen saturation level, air flow, lung volumes, and heart rate before, during and after hyperventilation, displayed in the Analysis window.

6. Record the values in the Journal using the one of the techniques described in Exercise 1, and in Table 2.

Work Lab

7. Measure the following parameters and record their values in the Journal:
    - **Response Time in Hyperventilation**. Place one cursor at the beginning of the first deep breath in hyperventilation, and the second cursor at the first change in the oxygen saturation level during hyperventilation. The value for the T2-T1 function is the response time to hyperventilation. Record the values in the Journal and in Table 2.
    - **Recovery Time from Hyperventilation**. Place one cursor at the end of hyperventilation, when the subject returns to normal breathing, and the second cursor at the return of the oxygen saturation level to normal. The value for the T2-T1 function is the recovery time from hyperventilation. Record the values in the Journal and in Table 2.
8. Select Save in the File menu.

Questions

1. How does the oxygen saturation level during normal breathing compare to oxygen saturation level during hyperventilation? What causes the oxygen saturation levels to change?
2. How does the Response Time to Hyperventilation compare to the Recovery Time from Hyperventilation?
3. How does the heart rate during normal breathing compare to the heart rate at the end of hyperventilation?

Exercise 4: Valsalva Maneuver and Oxygen Saturation Levels

Aim: To measure the effect of chest compression by the muscles involved in exhalation on oxygen saturation levels. In this exercise, air is not allowed to exit the lungs.

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

Approximate Time: 20 minutes

Procedure

1. This exercise is performed without using a spirometer. The subject should breathe normally before performing the Valsalva maneuver.

Valsalva Maneuver Procedure:
1) Sit down.
2) Take a breath.
3) Then, push that breath out against your closed mouth and nose while straining as if You're trying to poop. Hold for 15 to 20 seconds.
4) Open your nose or mouth and breathe out.

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2. Click on the Record button to record the subject's heart rate and oxygen saturation level while resting. Type **Resting** in the Mark box and click the mark button.
3. Click the AutoScale buttons on the Heart Rate, Pulse, and Oxygen Saturation channels. Type **Valsalva** in the Mark box.
4. Click the mark button as the subject:
    - inhales deeply.
    - closes the mouth and pinches the nose to prevent the flow of air from the lungs
    - raises the diaphragm and compresses the rib cage as if blowing up a balloon
    - performs this procedure for as long as possible before returning to breathing normally
5. Type **Normal Breathing** in the Mark box. Click the mark button as the subject returns to breathing normally.
6. Click Stop to halt recording. Select Save in the File menu.

Data Analysis

1. Scroll to the recording of the subject's breathing before, during and after the Valsalva Maneuver that is displayed in the Main window. Use the same techniques described in Exercises 2 and 3 to adjust the width of data to include the normal breath before the maneuver, the period of maneuver, and a few normal breaths after maneuver.
2. Click AutoScale All.
3. Click on the Analysis window icon.
4. On the Lung Volume channel, use the mouse to place a cursor on the mark that indicates the start of the Valsalva maneuver. Place the second cursor at the point where the oxygen saturation level after Valsalva maneuver returns to normal. Measure the same values as in the previous exercise.
5. Record the values in the Journal using the one of the techniques described in the previous exercises, and in Table 2.
6. Select Save in the File menu.

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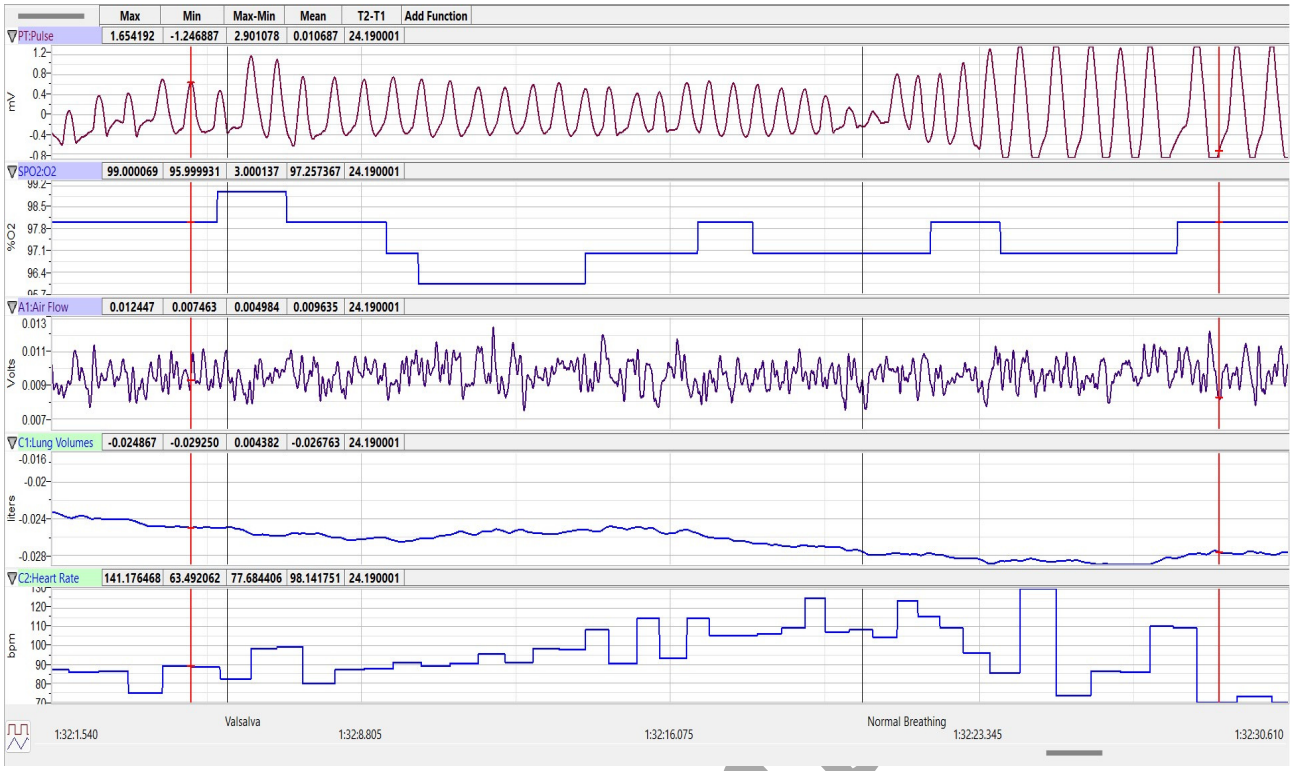

Figure HS-6-L8: Pulse, oxygen saturation level, and heart rate before, during and after a Valsalva maneuver, displayed in the Analysis window.

Questions

1. How does the change in oxygen saturation level during the Valsalva maneuver compare to the change in oxygen saturation level during apnea?
2. How does the change in oxygen saturation level during the Valsalva maneuver compare to the change in oxygen saturation level during hyperventilation?
3. How does the change in heart rate during the Valsalva maneuver compare to the change in heart rate during apnea and during hyperventilation?

Exercise 5: Chest Expansion and Oxygen Saturation Levels

Aim: To measure the effect of chest expansion by the muscles involved in inhalation on oxygen saturation levels. In this exercise, air is not allowed to enter the lungs.

Approximate Time: 20 minutes

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

Procedure

1. This exercise is performed without using a spirometer. The subject should breath normally before performing the chest expansion.

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2. Click on the Record button to record the subject's heart rate and oxygen saturation level while resting. Type **Resting** in the Mark box. Click the mark button.
3. Click the AutoScale buttons on the all the channels. Type **Chest Expansion** in the Mark box.
4. Click the mark button as the subject:
    - closes the mouth and pinches the nose to prevent the flow of air into the lungs.
    - lowers the diaphragm and expands the rib cage as if inhaling deeply.
    - performs this procedure for as long as possible.
5. Type **Normal Breathing** in the Mark box. Click the mark button as the subject returns to breathing normally.
6. Click Stop to halt recording. Select Save in the File menu.

Data Analysis

1. Scroll to the recording of the subject's breathing before, during and after the chest expansion that is displayed in the Main window.
2. Use the same techniques used in Exercises 3 and 4 to measure and record the oxygen saturation levels and heart rates before, during, and after chest expansion.
3. Record the values in Table 2.

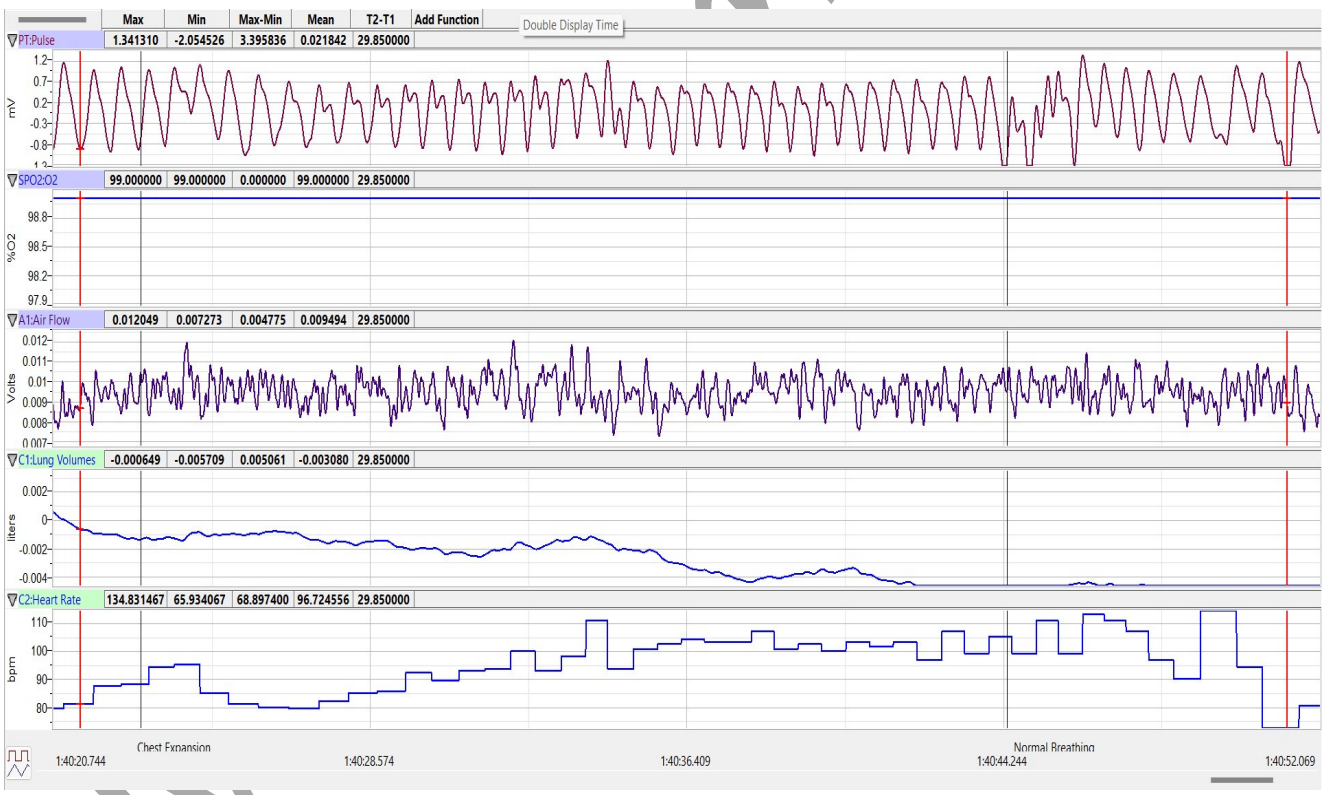

Figure HS-6-L9: Pulse, oxygen saturation level, and heart rate before, during, and after chest expansion, displayed on the Analysis window.

Sample Lab

Questions

1. How does the change in oxygen saturation level during chest expansion compare to the changes in oxygen saturation level during apnea? Hyperventilation? Valsalva Maneuver?
2. How does the change in heart rate during the chest expansion compare to the change in heart rate during apnea? Hyperventilation? Valsalva Maneuver?

Table HS-6-L2: Oxygen Saturation Levels and Heart Rate during Rest, Apnea, Hyperventilation, Valsalva Maneuver, and Chest Expansion.

	%O2 Saturation			Heart Rate (BPM)			Response Time to Apnea (sec)	Recovery Time from Apnea (sec)
Breathing	Max	Min	Δ	Max	Min	Δ		
Resting								
Apnea								
Hyperventilation								
Valsalva								
Chest Expansion								

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