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 his or her 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 "Breathing at Rest" in the Mark box to the right of the Mark button. Press the mark button to attach the comment to the data.
3. Click the AutoScale All button. Notice the slowly moving wave on the Lung Volume channel. Record five to six breaths, which normally takes about forty-five seconds to record.
4. Click Stop to halt recording. Your data may look like Figure HS-6-L1.
5. 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.
2. 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 on the Main window.
3. Click AutoScale All.
4. Sections of the data displayed on the Breath Rate channel may be calculated incorrectly if breaths on the raw data channel has low amplitudes. Breaths used in the rate calculation can be properly identified by either adjusting the position of the trace on the Resp Monitor 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.

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- To raise the level of the trace on the Resp Monitor channel, use the mouse to click on and drag the trace higher on the screen. If the trace is moved up by the proper amount, the peaks of the missed breaths will intersect the invisible threshold level set by the rate function dialogue window. The waves that used to be missed in the rate calculation will now be included in the calculation. On the Breath Rate channel, the revised plot of the rate calculation will be displayed automatically. If the rate is still not displayed properly, the trace can be moved up again.
- To adjust the level of the threshold parameter for the Breath Rate channel, click on the **black** words (P Rate) to the right of the channel title. Select Setup Function from the menu. 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 data at the bottom of the dialogue window, up or down.

Note: *Setting the proper threshold level also prevents small artifacts in the data from being counted.*

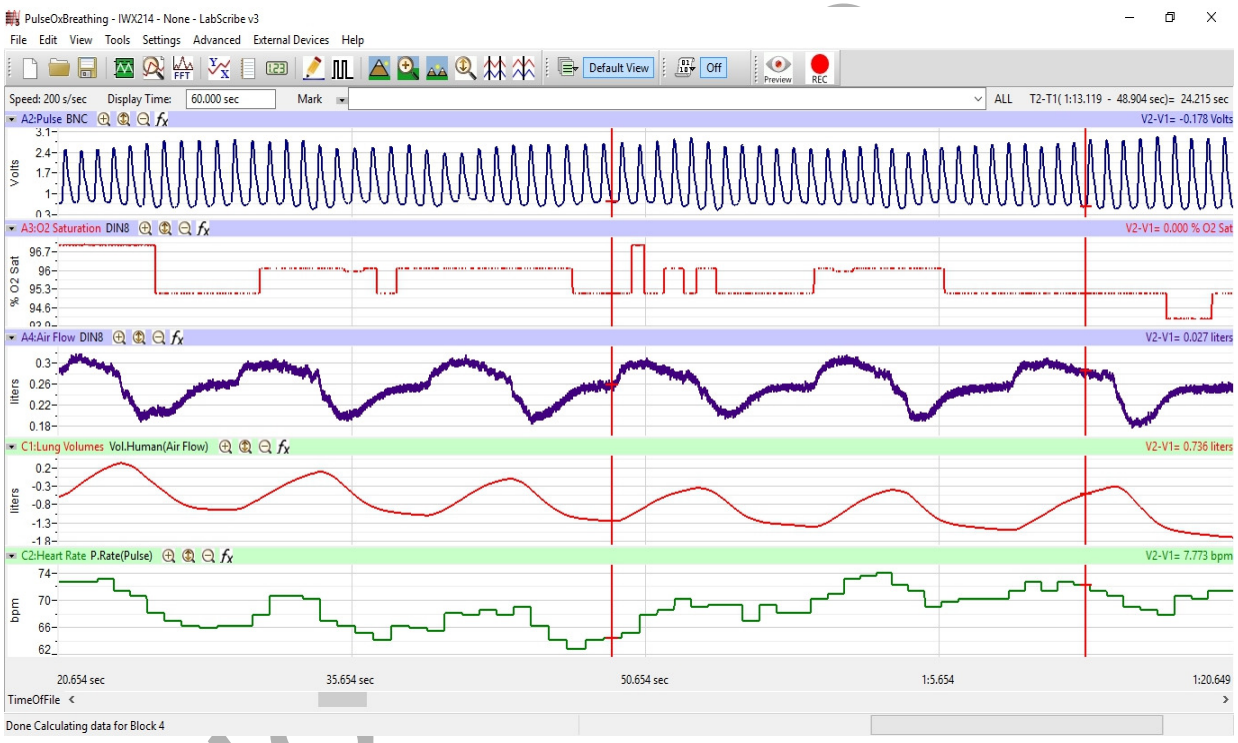

Figure HS-6-L1: Pulse, oxygen saturation level, air flow, lung volumes, and heart rate during breathing at rest, displayed on the Main window.

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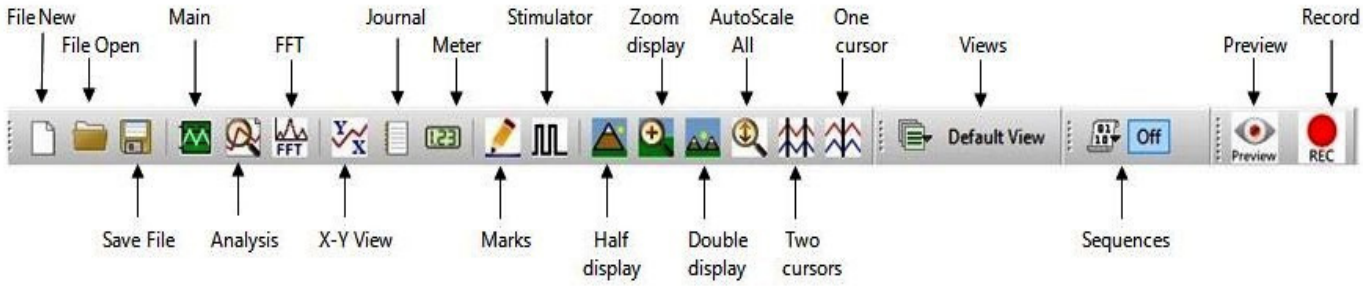

Figure HS-6-L2: The LabScribe toolbar.

5. Click on the Analysis window icon in the toolbar (Figure HS-6-L2) or select Analysis from the Windows menu to transfer the data displayed in the Main window to the Analysis window (Figure HS-6-L3).
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.
7. 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.
8. 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:
9. Place the cursors at the locations used to measure the oxygen saturation levels and the heart rate in each breath.
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.
11. 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.

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

12. Record the values in the Journal using the one of the techniques described in Steps 7 or 8, and on Table HS-6-L1.
13. Repeat Steps 8 through 10 for two additional breath cycles.
14. Average the values obtained for each parameter and enter the means in the Journal and on Table HS-6-L1.

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?

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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						

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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 breath 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 his or her breath as long as possible.
    - When the subject resumes breathing, he or she should continue to breath through the flow head until the breathing pattern is back to normal.
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 his or her mouth and begin breathing.
4. Type "Rest" in the Mark box to the right of the Mark button. Press the mark button to attach the comment to the data.
5. Click the AutoScale All button. Notice the slowly moving wave on the Lung Volume channel. Record three breaths, which normally takes about twenty seconds to record. Type "Apnea" in the Mark box.
6. Press the mark button as the subject inhales as deeply as possible. After reaching his or her maximum inhalation, the subject should hold his or her breath as long as possible.
7. While the subject is holding his or her breath, type "Resume Breathing" in the Mark box. Press the mark button to mark the recording when the subject resumes breathing.

8. The subject should continue to breathe through the spirometer until his or her 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.

Data Analysis

1. Scroll to the recording of the subject's breathing before, during and after apnea 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 normal breath before apnea, the period of apnea, and a couple of normal breaths after apnea in the Main window.
3. Click AutoScale All.
4. Click on the Analysis window icon in the toolbar or select Analysis from the Windows menu to transfer the data displayed in the Main window to the Analysis window (Figure HS-6-L5).

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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.
    - 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 on Table HS-6-L2.
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.

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- 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.

8. Click the Save button to save the file.

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

	%O2 Saturation			Heart Rate (BPM)		
Breathing	Max	Min	Δ	Max	Min	Δ
Resting						
Apnea						
Hyperventilation						
Valsalva						
Chest Expansion						

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.
   - The subject should hyperventilate by breathing as quickly and as deeply as possible for 15-20 seconds.

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- After the hyperventilation period, the subject resumes 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 his or her mouth and begin breathing.
4. Type “Rest” in the Mark box to the right of the Mark button. Press the mark button to attach the comment to the data.
5. Click the AutoScale buttons on all five channels. Record three normal breaths. Type “Hyperventilate” in the Mark box.
6. Press 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. Press 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 Figure HS-6-L6.
9. Select Save in the File menu.

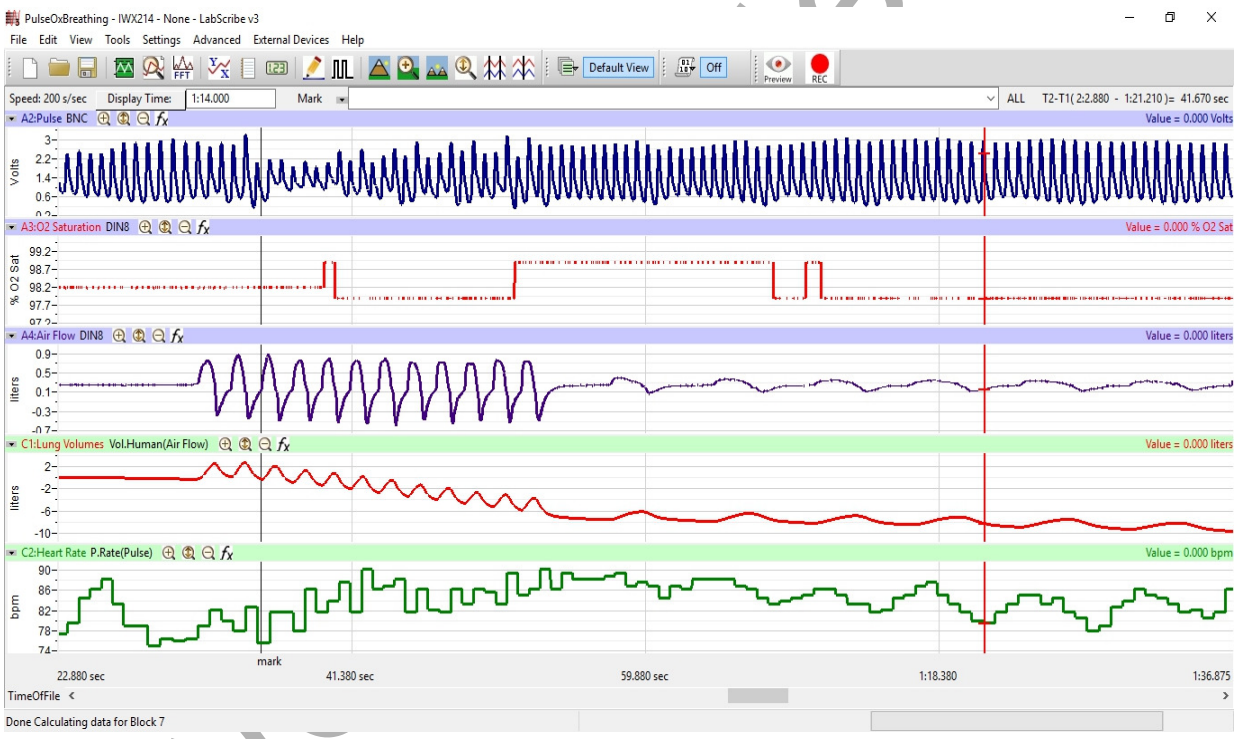

Figure HS-6-L6: Pulse, oxygen saturation level, air flow, lung volumes, and heart rate before, during and after hyperventilation, displayed in the Main window.

Data Analysis

1. Scroll to the recording of the subject’s breathing before, during and after hyperventilation that is displayed in the Main window.

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2. 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 in the Main window.
3. Click AutoScale All
4. Click on the Analysis window icon in the toolbar or select Analysis from the Windows menu to transfer the data displayed in the Main window to the Analysis window (Figure HS-6-7).
5. 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.

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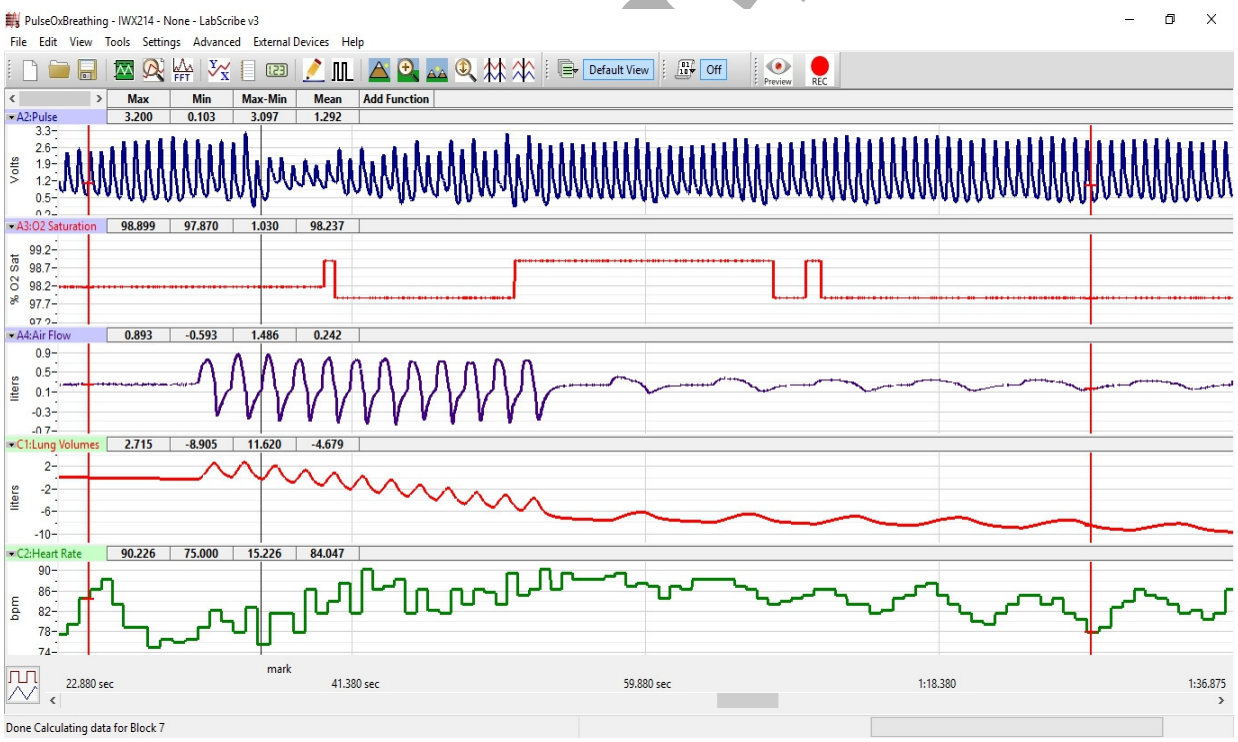

Figure HS-6-L7: Pulse, oxygen saturation level, air flow, lung volumes, and heart rate before, during and after hyperventilation, displayed in the Analysis window.

6. Record the values in the Journal using the one of the techniques described in Exercise 1, and on Table HS-6-L2.
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 depth 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.
    - 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.
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?

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

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.

Approximate Time: 20 minutes

Procedure

1. This exercise is performed without using a spirometer. The subject should breathe normally before performing the Valsalva maneuver.
2. Click on the Record button to record the subject's heart rate and oxygen saturation level while resting. "Rest" in the Mark box that is to the right of the Mark button. Press the mark button.
3. Click the AutoScale buttons on the Heart Rate, Pulse, and Oxygen Saturation channels. Type "Valsalva" in the Mark box.

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4. Press 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. Press 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.
2. 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 in the Main window.
3. Click AutoScale on all five channels displayed on the Main window.
4. Click on the Analysis window icon in the toolbar or select Analysis from the Windows menu to transfer the data displayed in the Main window to the Analysis window (Figure HS-6-L8).

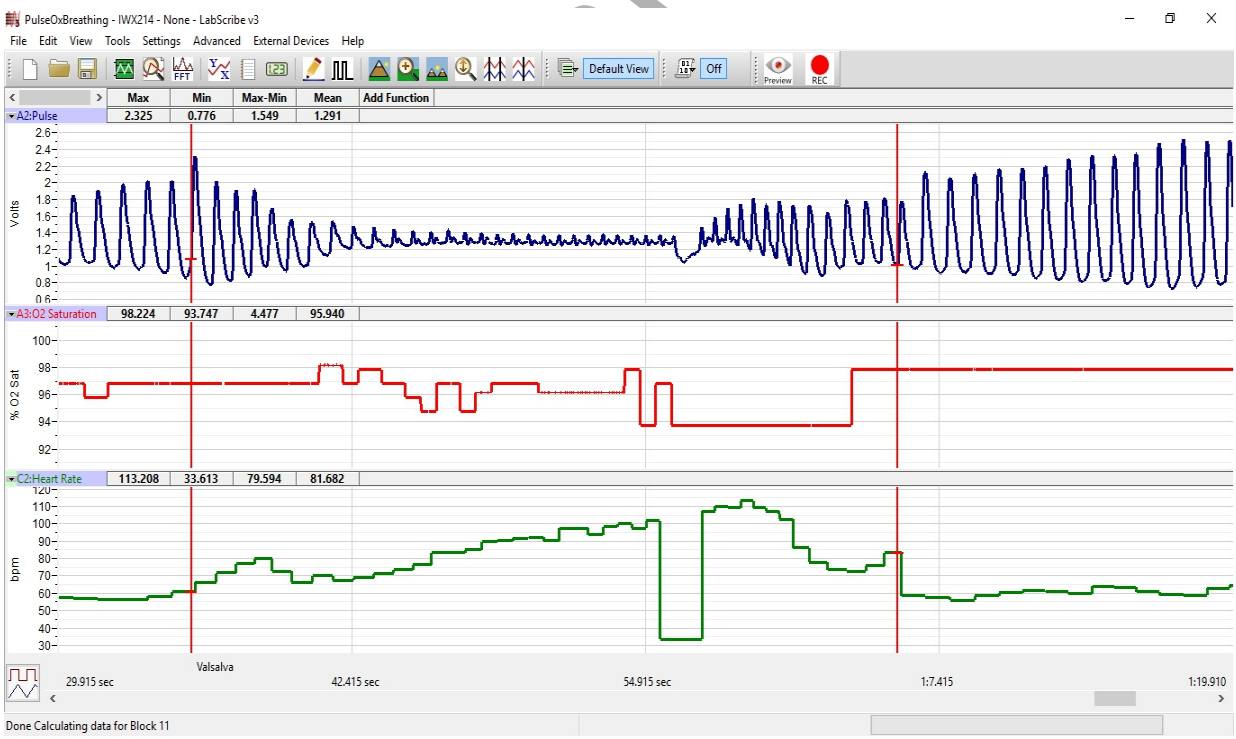

Figure HS-6-L8: Pulse, oxygen saturation level, and heart rate before, during and after a Valsalva maneuver, displayed in the Analysis window.

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5. Use the mouse to click on and drag
6. 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.
7. Record the values in the Journal using the one of the techniques described in the previous exercises, and on Table HS-6-L2.
8. Select Save in the File menu.

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?

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

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

Procedure

1. This exercise is performed without using a spirometer. The subject should breath normally before performing the chest expansion.
2. Click on the Record button to record the subject's heart rate and oxygen saturation level while resting. Type "Rest" in the Mark box to the right of the Mark button. Press the mark button.
3. Click the AutoScale buttons on the all the channels. Type Chest Expansion in the Mark box.
4. Press 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.

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5. Type Normal Breathing in the Mark box. Press the mark button as the subject returns to breathing normally.
6. Click Stop to halt recording.
7. 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 HS-6-L2.

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

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?

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