

Experiment HS-8: Restrictive and Obstructive Airway Diseases

This lab was written in conjunction with Dr. Debra Mullikin-Kilpatrick of Boston College.

Exercise 1: Normal Breathing While Resting

Aim: To measure breathing parameters in a healthy, resting subject.

Procedure

1. Instruct the subject to:
 - Sit quietly and become accustomed to breathing through the spirometer flowhead.
 - Breathe normally before any recordings are made.
 - Hold the flowhead so that its outlets are pointed up.
 - Remove the flowhead from his or her mouth and hold it at the mouth level in a position that prevents a breath from moving through the flowhead.
- Note: The LabScribe software will zero the Lung Volumes channel during the first ten seconds of recording. No air should be moving through the flow head during this time.*
2. Type <Subject's Name> Resting in the Mark box that is to the right of the Mark button.
3. Click on the Record button. After waiting ten seconds for the Lung Volumes channel to zero, have the subject place the flow head in his or her mouth and begin breathing. Press the Enter key on the keyboard to mark the recording.
4. Click the AutoScale buttons of the Air Flow and Lung Volumes channels. Notice the slowly moving wave on the Lung Volumes channel.
5. Record breathing using this method:
 - Have the subject record ten normal breaths, which normally takes about forty-five to sixty seconds.
 - After the ten breaths have been recorded, coach the subject to take in a very large in-breath to fill the lungs completely.
 - After reaching his or her maximum inhalation volume, the subject should exhale as quickly and as completely as possible. Have the subject exhale completely, bending over to help force the air out of the lungs. The subject should try to exhale for 3 seconds.
 - Have the subject return to breathing normally.
6. Repeat the above steps three (3) times. The recording should have a cycle of ten breaths, big in/out, ten breaths, big in/out, ten breaths, big in/out, ten breaths.

Note: This breathing pattern is important and will be used throughout the lab exercises. If, at any time, the subject gets light headed during these exercises, remove the flow head and have the subject sit, relax and breath normally.

7. Click Stop to halt recording. Your data should look like [Figure HS-8-L1](#).

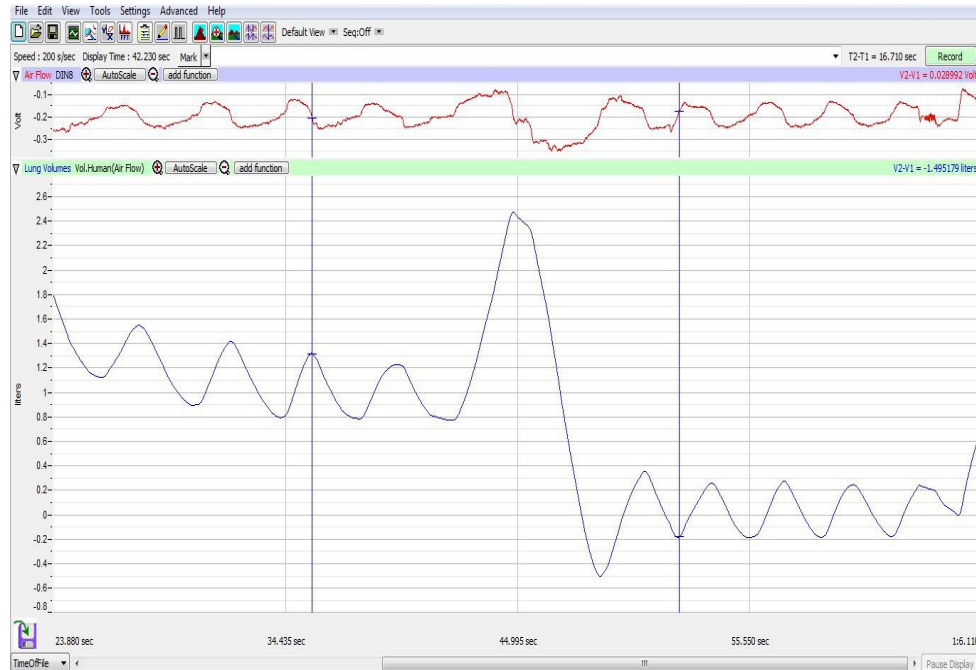


Figure HS-8-L1: Air flow and lung volumes of the normal and forced breathing of a subject at rest.

8. Select Save As in the File menu, type a name for the file. Choose a destination on the computer in which to save the file, like your lab group folder). Designate the file type as *.iwxdata.
9. Click on the Save button to save the data file.

Data Analysis-Normal Breathing at Rest

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 at least one complete breathing cycle on the Main window. One complete breathing cycle can also be selected by:
 - Placing the cursors on either side of the complete breathing cycle; and
 - Clicking the Zoom between Cursors button on the LabScribe toolbar to expand the breathing cycle to the width of the Main window. ([Figure HS-8-L2](#))

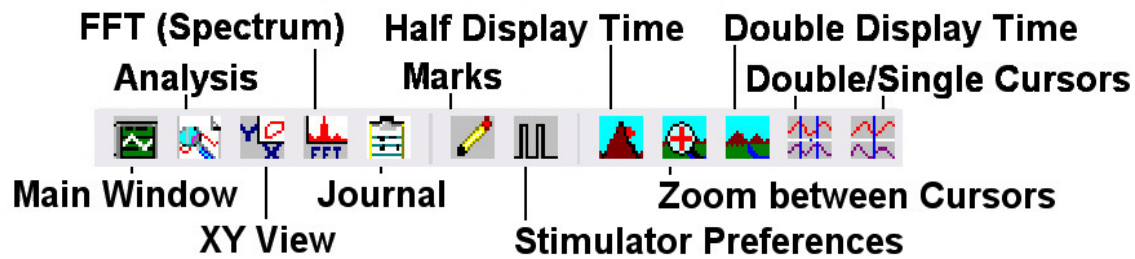


Figure HS-8-L2: The LabScribe toolbar.

3. 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-8-L3](#)).
4. Look at the Function Table that is above the uppermost channel displayed in the Analysis window. The mathematical functions, V2-V1, Max_dv/dt, Min_dv/dt, and T2-T1 should appear in this table. Values for V2-V1, Max_dv/dt, Min_dv/dt, and T2-T1 on each channel are seen in the table across the top margin of each channel.
5. Minimize the height of the Air Flow channel by clicking on the border between the channels and dragging the Lung Volumes channel upward. This will expand the Lung Volumes channel while making the Air Flow channel smaller.
6. Once the cursors are placed in the correct positions for determining the volumes and rates of each breath cycle, 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.
7. 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:
 - Place the cursors at the locations used to measure the volumes and rates of 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 Lung Volumes Channel pull-down menu.
 - Transfer the values for the volumes and rates to the Journal using the Add Ch. Data to Journal function in the Lung Volumes Channel pull-down menu.
8. On the Lung Volumes channel, use the mouse to click on and drag the cursors to specific points on the recording to measure the following volumes:
 - Tidal Volume (TV), which is the volume of air inhaled or exhaled during a normal breathing cycle. To measure the tidal volume of the subject during breathing at rest, place one cursor in the trough prior to inhalation, and the second cursor on the peak of the cycle. The value for the V2-V1 function on the Lung Volumes channel is the tidal volume.

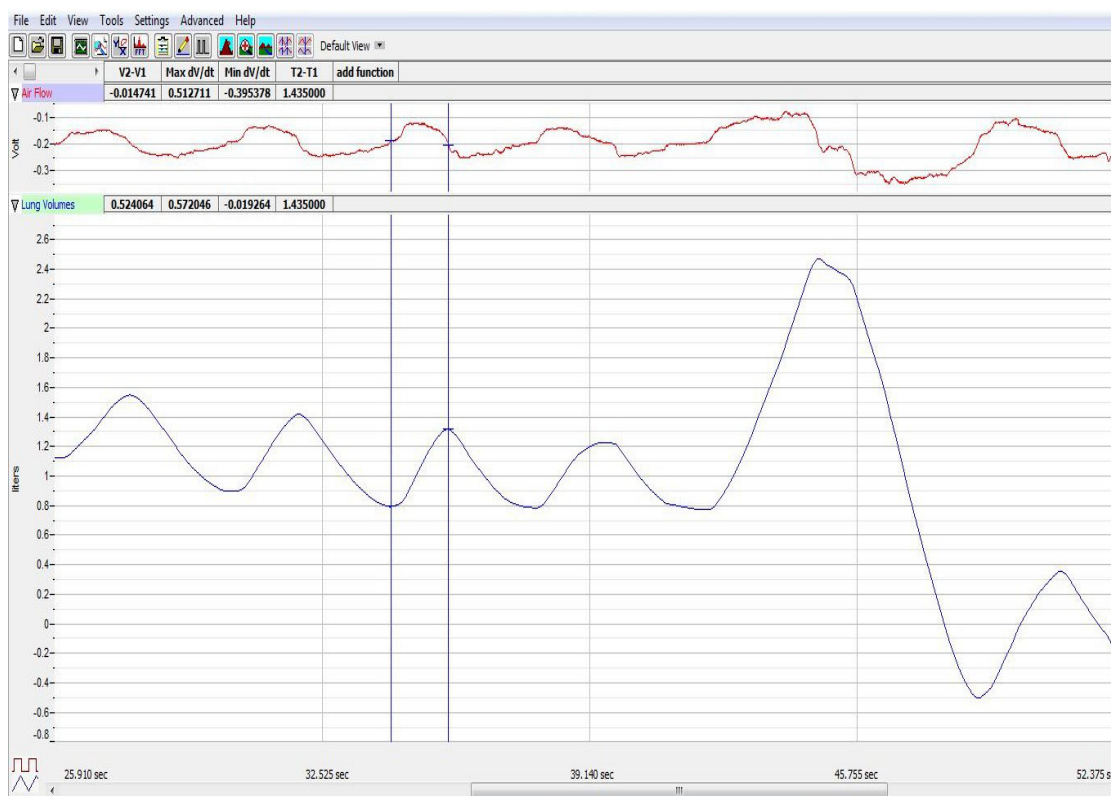


Figure HS-8-3: Breathing pattern of a subject at rest, displayed on the Lung Volumes channel in the Analysis window. The cursors are positioned on the trough and the peak of the breath cycle to measure the tidal volume (TV) with V2-V1 function and the maximum inspiratory flow rate with the Max_dv/dt function.

- Maximum Inspiratory Flow Rate, which is the maximum rate of air movement during inhalation. To measure the maximum inspiratory flow rate of the subject during breathing at rest, leave the cursors in the same positions used to measure the tidal volume. The value for the Max_dv/dt function on the Lung Volumes channel is the maximum inspiratory flow rate of that breath cycle ([Figure HS-8- L3](#)).
- Maximum Expiratory Flow Rate, which is the maximum rate of air movement during exhalation. To measure the maximum expiratory flow rate of the subject during breathing at rest, place one cursor on the peak of the breath cycle, and the second cursor in the trough to the right of that peak. The value for the Min_dv/dt function on the Lung Volumes channel is the maximum expiratory flow rate of that breath cycle ([Figure HS-8- L4](#)). This function is used since the exhalation portion of the breath cycle has a negative slope.

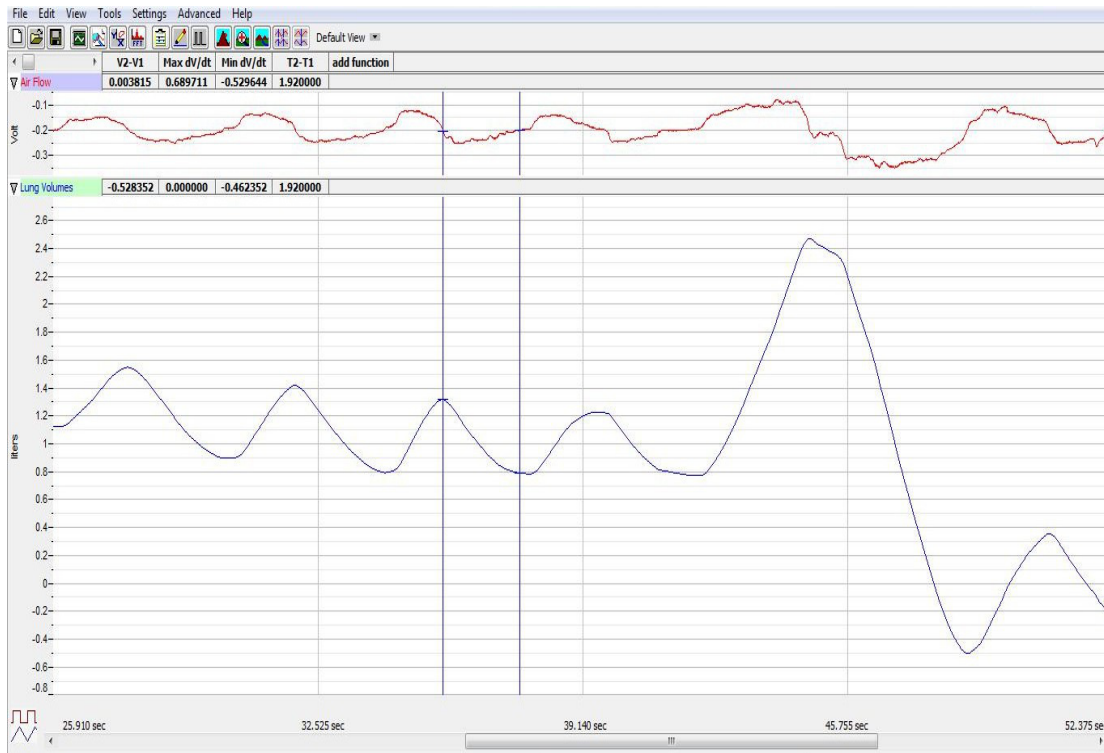


Figure HS-8-L4: Breathing pattern of a subject at rest, displayed on the Lung Volumes channel in the Analysis window. The cursors are positioned on the peak of the breath cycle and the trough of the succeeding cycle to measure the maximum expiratory flow rate with the Min_dv/dt function.

- Breath Period, which is the duration of each breathing cycle. To measure the breath period of the subject during breathing at rest, place one cursor on a peak of a breath cycle, and the second cursor on the peak of an adjacent cycle. The value for T2-T1 on the Lung Volumes channel is the period of that breath cycle ([Figure HS-8-L5](#)).
9. Record the values in the Journal using the one of the techniques described in Steps 7 or 8.
 10. Repeat the measurements of tidal volume, maximum inspiratory flow rate, maximum expiratory flow rate, and breath period on two additional normal breaths.
 11. Average the three values obtained for each parameter and enter the means in a table in the Journal. You can open and close the Journal by clicking on its icon on the LabScribe toolbar ([Figure HS-8-L2](#)).
 12. Record the means for the tidal volume, rates, and breath period in [Table HS-8-L2](#). Calculate the normal breathing rate of the subject at rest using the following equation:

$$\text{Breath Rate (breaths/minute)} = 60 \text{ (seconds/minute)} / \text{mean breath period (sec/breath)}$$
 13. Multiply the mean tidal volume by the breathing rate to calculate the volume of air passing in and out of the resting subject's lungs each minute.
 14. Record the values for these calculations in the table.

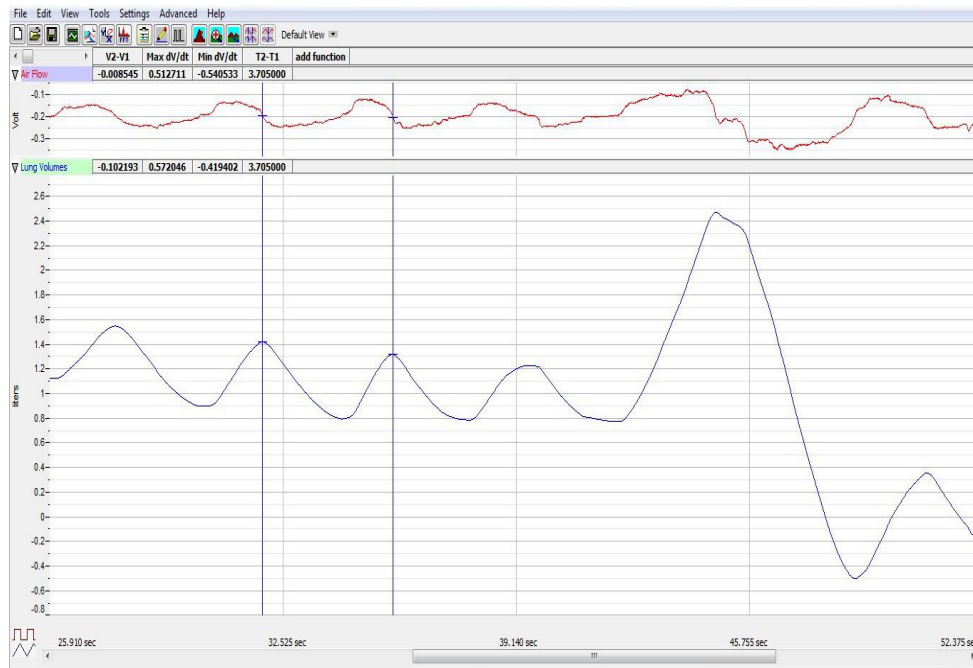


Figure HS-8-L5 Normal breathing pattern of a subject at rest, displayed on the Lung Volumes channel in the Analysis window. The cursors are positioned on the peaks of successive breath cycles to measure the breath period with the T2-T1 function.

Data Analysis-Forced Expiration at Rest

1. Use the slider or the arrows on the scroll bar, at the bottom of the Analysis window, to position data recorded when the subject exhaled with maximum force in the window.
2. If needed, use the Display Time icons to adjust the Display Time of the Analysis window to show the forced expiration curve and the two normal breaths that occur before the force expiration curve, on the same window.
 - Place the cursors on either side of the group of appropriate breathing cycles; and
 - Click the Zoom between Cursors button on the LabScribe toolbar to expand the selected breathing cycles to the width of the Main window. The segment of the recording displayed in the window should be like the recording in [Figure HS-8-L8](#).
3. Use the same techniques used earlier to record volumes and rates in the Journal by:
 - Typing the names and values of the parameters directly into the Journal, or;
 - Transferring the names and values of the parameters into the Journal by using the Add Title to Journal and the Add Ch. Data to Journal functions in the Lung Volumes Channel menu.
4. Place the cursors on the forced expiration data displayed on the Lung Volumes channel to measure the following volumes and rates using the V2-V1, T2-T1, Max_dv/dt, and Min_dv/dt functions. Check the labels on [Figure HS-8-L8](#) to identify the volumes and rates that you will measure:

- Inspiratory Reserve Volume (IRV), by placing one cursor on the peak of the normal breath prior to the maximum inhalation and the second cursor on the peak of the forced breath cycle. The value for the V2-V1 function on the Lung Volumes channel is the inspiratory reserve volume.
 - Forced Inspiratory Flow Rate, by keeping the cursors in the same positions used for measuring IRV. The value for the Max_dv/dt function on the Lung Volumes channel is the forced inspiratory flow rate.
 - Forced Vital Capacity (FVC), by placing one cursor on the peak of the forced breath cycle and the second cursor on the flat line after the subject has expelled all the air from his or her lungs. The value for the V2-V1 function on the Lung Volumes channel is the forced vital capacity.
 - Forced Expiratory Flow Rate, by keeping the cursors in the same positions used for measuring VC. The value for the Min_dv/dt function on the Lung Volumes channel is the forced expiratory flow rate.
 - Expiratory Reserve Volume (ERV), by placing one cursor in the trough before maximal inhalation and the second cursor on the flat line after subject has expelled all the air from his or her lungs. The value for the V2-V1 function on the Lung Volumes channel is the expiratory reserve volume.
 - Forced Expiratory Volume at 1 Second (FEV₁), by placing one cursor on the peak of the maximum breath cycle and the second cursor on the data point that is one second after the peak. Use the T2-T1 function to determine the data point that is one second after the peak. The value for the V2-V1 function on the Lung Volumes channel is the forced expiratory volume at one second.
 - If possible - measure the Forced Expiratory Volume at 3 Seconds (FEV₃), by placing one cursor on the peak of the maximum breath cycle and the second cursor on the data point that is three seconds after the peak. Use the T2-T1 function to determine the data point that is three seconds after the peak. The value for the V2-V1 function on the Lung Volumes channel is the forced expiratory volume at three seconds.
5. Record these volumes and rates in [Table HS-8-L3](#).
 6. Calculate the subject's FEV₁/FVC ratio by dividing the subject's FEV₁ value by his or her FVC value.
 7. Calculate the subject's FEV₃/FVC ratio by dividing the subject's FEV₃ value by his or her FVC value.

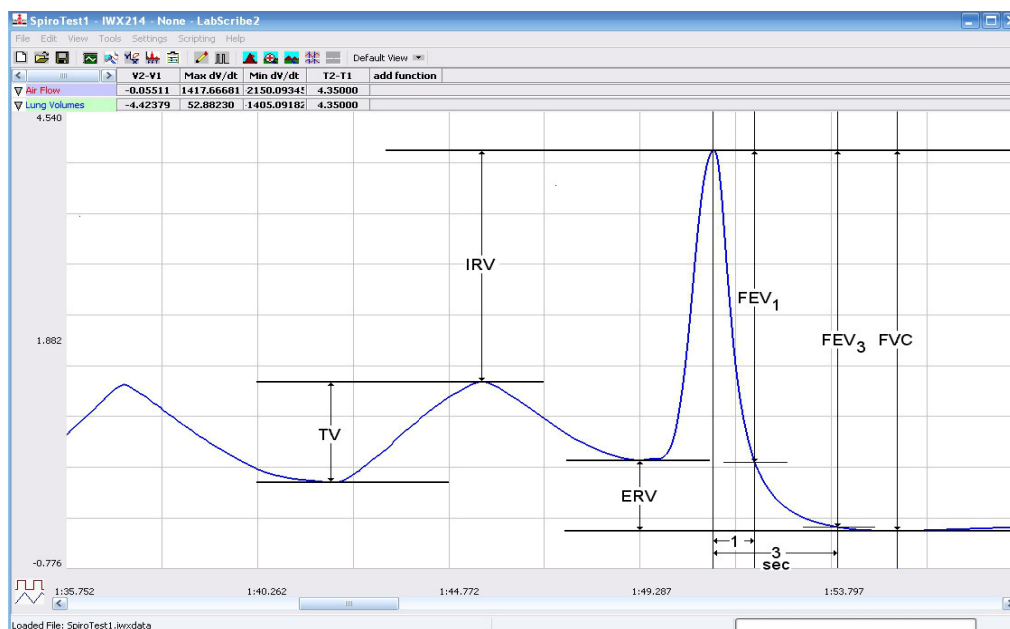


Figure HS-8-8: Recording of normal and forced lung volumes taken from a subject at rest, and displayed on the Lung Volumes channel in the Analysis window. The normal breathing cycles are to the left of the forced inspiration and expiration. Lines and labels were added to the figure to indicate volumes that should be measured for each subject: Tidal Volume (TV), Inspiratory Reserve Volume (IRV), Expiratory Reserve Volume (ERV), Vital Capacity (VC), and Forced Expiratory Volume at 1 Second (FEV_1).

8. Compare the FEV_1/FVC and FEV_3/FVC ratios of the subject to the normal values of 0.80 and 0.95, respectively, for young healthy adults. Both of these ratios decrease with age.
 - In obstructive airway diseases, like asthma, bronchitis, or emphysema, both FVC and FEV_1 are reduced, and FEV_1/FVC ratios are usually less than 0.70.
 - In restrictive lung diseases, like fibrosis, FVC is reduced. But, because of the low compliance and high recoil of the lungs, the FEV_1/FVC ratio may be normal (~ 0.80) or greater than normal (>0.85).
9. Record the FEV_1/FVC and FEV_3/FVC ratios in [Table HS-8-L3](#).
10. Record the volumes, rates, and ratios from your subject in the table being compiled for all the subjects in the class.

Table HS-8-L1: Lung Volumes for an Average- Sized Human Male (70kg).

Volumes	Volume (mls)
Tidal Volume (TV)	500
Inspiratory Reserve Volume (IRV)	3100
Expiratory Reserve Volume (ERV)	1200
Forced Vital Capacity (FVC)	4800
Residual Volume (RV)	1200

Exercise 2: Breathing Parameters in a Subject with Restrictive Airway Disease

Aim: To measure the breathing parameters of the same healthy subject with a corset on laced to imitate Restrictive Airway Disease.

Procedure

1. In this exercise, use the same healthy subject whose breathing parameters at rest were measured in Exercise 1.
2. Type Restrictive in the Mark box to the right of the Mark button.
3. Place a medical corset on the subject and either lace or velcro it closed so that the subject feels a snug tightness in his or her chest.

Note: *The corset should be tight but not uncomfortably so. However, it should be tight enough to restrict the expansion of the chest to some degree.*

4. Click on the Record button. After waiting 10 seconds for the Lung Volumes channel to zero, have the subject place the flow head in his or her mouth and begin breathing. Press the Enter key on the keyboard to mark the recording.
5. Click the AutoScale buttons of the Air Flow and Lung Volumes channels.
6. Follow the directions from Exercise 1 and record a series of three complete breathing cycles including the large in and out breaths.
7. Click Stop to halt recording.
8. Select Save in the File menu, and click on the Save button to save the data file.

Data Analysis

1. Perform the same types of measurements on the data recorded in Exercise 1. Record the measurements in the Journal. Report the appropriate measurements in [Table HS-8-L2](#) and [Table HS-8-L3](#).
2. Determine the values for the calculated parameters taken from the recordings of normal and forced breathing after exercise. Report these values on the tables.

Questions

Use your Anatomy and Physiology textbook to help determine the correct answers to the following questions.

1. Did tidal volume change while the subject had on the corset? Did inspiratory and expiratory reserves change while the subject was wearing the corset?
2. Explain your answers to Question #1.
3. Did chest restriction influence the time taken for each breathing cycle?
4. Did the rate of air flow during the inhalation phase increase or decrease with restriction of the chest? How can you account for the change?
5. Did the rate of air flow during the exhalation phase increase or decrease with restriction of the chest—how can you account for the change?
6. Did the volume of air passing in and out of the resting subject's lungs each minute increase or decrease while the subject's chest was restricted?
7. Did chest restriction influence the forced vital capacity of the individual?
8. If the forced vital capacity changed due to chest restriction, can this be accounted for by changes in the IRV, the ERV, or a combination of both?

Exercise 3: Breathing Parameters in a Subject with Obstructive Airway Disease

Aim: To measure the breathing parameters of the same healthy subject using different tube lengths and diameters to imitate Obstructive Airway Disease.

Note: If the subject feels light headed at any time during this experiment, discontinue recording and have the subject breathe normally.

Procedure

1. In this exercise, use the same healthy subject whose breathing parameters at rest were measured in Exercises 1 and 2.
2. Obtain a drinking straw and a clean cardboard mouthpiece.
3. Carefully tape the straw to the cardboard mouthpiece, so that the subject can easily breathe through it. Tape the rest of the opening on the mouthpiece so no air moves through any other location except through the straw.

4. Place the cardboard mouthpiece on the flow head.
5. Type Obstructive Narrow in the Mark box to the right of the Mark button.
6. Repeat Exercise 1 while breathing through the narrowed opening.

Data Analysis

1. Perform the same types of measurements on the data recorded in Exercise 3.
2. Record the measurements in the Journal. Report the appropriate measurements in the tables.
3. Determine the values for the calculated parameters taken from the recordings of normal and forced breathing. Report these values in the tables.

Exercise 4: Breathing Parameters in a Subject with Obstructive Airway Disease - part 2

Aim: To measure the breathing parameters of the same healthy subject using different tube lengths and diameters to imitate Obstructive Airway Disease.

Note: If the subject feels light headed at any time during this experiment, discontinue recording and have the subject breathe normally.

Procedure

1. In this exercise, use the same healthy subject whose breathing parameters at rest were measured in Exercises 1, 2 and 3.
2. Obtain a 6" length of smooth interior tubing.
3. Place one end of the tubing on the cardboard mouthpiece, and place the cardboard mouthpiece on the flow head.
 - Have the subject breathe through the 6" length of tubing.
 - If the breathing does feel labored, have the subject try the 8" length of tubing.
 - Keep increasing the length of tubing (up to 12") until the subject feels that it is difficult to breathe normally.
4. The other end of the tubing should be open and the subject should be able to breathe through the tubing.
5. Type Obstructive Long in the Mark box to the right of the Mark button.
6. Repeat the previous exercise while breathing through the lengthened tubing.

Data Analysis

1. Perform the same types of measurements as in the previous exercises on the data recorded in Exercise 4.

2. Record the measurements in the Journal. Report the appropriate measurements in the tables.
3. Determine the values for the calculated parameters taken from the recordings of normal and forced breathing. Report these values in the tables.

Questions

Note: *Both Restrictive and Obstructive Airway Diseases influence breathing parameters in different ways. It is important to understand how an individual's breathing patterns are affected when afflicted with one of these diseases.*

Use your Anatomy and Physiology textbook to help determine the correct answers to the following questions.

1. Did tidal volume change while the subject was breathing through the narrowed opening? The long tubing?
2. Did inspiratory and expiratory reserves change while the subject was breathing through the narrowed opening? The long tubing?
3. Explain your answers to Questions #1 and #2.
4. Did the length or diameter of the tubing influence the time taken for each breathing cycle?
5. Did the rate of air flow during the inhalation phase increase or decrease with obstruction of the chest? How can you account for the change?
 - Did the narrowed opening have different values than the long tubing?
6. Did the rate of air flow during the exhalation phase increase or decrease with obstruction of the chest—how can you account for the change?
 - Did the narrowed opening have different values than the long tubing?
7. Did the volume of air passing in and out of the resting subject's lungs each minute increase or decrease while the subject's chest was breathing through the narrowed opening? The long tubing?
8. Did the size of the tubing (narrow and long) influence the forced vital capacity of the individual?
9. If the forced vital capacity changed due to the tubing length and diameter, can this be accounted for by changes in the IRV, the ERV, or a combination of both?
10. Compare your data to what is supposed to happen physiologically. How do expected results compare to the observed results? Did you see what is expected?

Table HS-8-L2: Mean Breathing Volumes and Rates from a Healthy Subject at Rest and after Restriction and Obstruction.

	Resting	After Corset	Narrowed Opening	Long Opening
Mean Breath Period (sec/breath)				
Breathing Rate (breaths/min)				
Mean Tidal Volume (mls/breath)				
Minute Air Flow Rate (liters/min)				
Max. Normal Air Flow Rate (mls/sec)				
during inhalation				
during exhalation				

Table HS-8-L3: Forced Expiration Volumes and Rates from a Healthy Subject at Rest and after Restriction and Obstruction.

	Resting	After Corset	Narrowed Opening	Long Opening
Lung Volumes (liters)				
Tidal Volume (TV)				
Inspiratory Reserve Volume (IRV)				
Expiratory Reserve Volume (ERV)				
Vital Capacity (VC)				
Forced Expiratory Volume - 1sec (FEV ₁)				
Forced Air Flow Rate (mls/sec)				
during inhalation				
during exhalation				
FEV ₁ /VC Ratio				
FEV ₃ /VC Ratio				