Experiment HS-10: Vital Capacity – Hypothesis Testing

Equipment Required

PC or Mac Computer

IXTA, USB cable, IXTA power supply

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

A-SRK Student Respiratory Kit

The nose clip is optional. You can just hold your nose if that is easier. ONLY breathe through your mouth.

Spirometer Setup

1. Locate the A-FH-300L flow head and the airflow tubing in the iWorx kit Firmly push the two air flow tubes onto the two outlets on the A-FH-300L flow head.
2. 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.

Figure HS-10-S1: The student respiratory kit and A-FH-300L flow head and the airflow tubing. The blue filter attaches to the flow head.

Before Starting

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 or bacterial filter attached to the flow head.

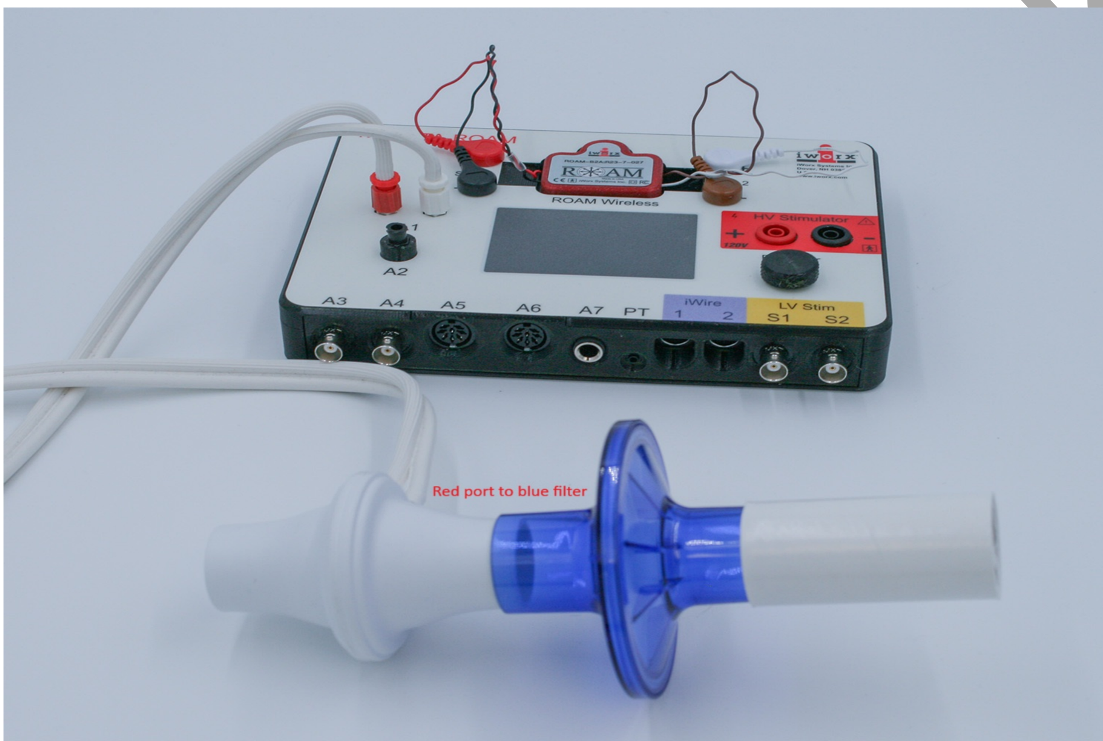

Figure HS-10-S2: The flow head connected to the internal spirometer of the IXTA unit.

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 **black** 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 and the flow head is the 300L.
   - 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.**
8. Make sure the subject is breathing through the **<u>red port side</u>** of the flow head.

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Sample Hypotheses for Vital Capacity Study

1. Group-Based Differences

- H1: Athletes will have significantly higher vital capacity than vapers and smokers, regardless of posture.
- H2: Vapers and smokers will show no significant difference in vital capacity between each other, but both will be lower than athletes.
- H3: Long-term vaping impairs vital capacity to a similar extent as smoking, as measured in both sitting and standing positions2.

2. Posture-Based Effects

- H1: Vital capacity will be significantly higher in the standing position compared to sitting across all participant groups.
- H2: The posture effect (standing vs. sitting) will be more pronounced in athletes due to better postural muscle control and lung expansion.

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Experiment HS-10: Vital Capacity – Hypothesis Testing

> ***Note: Make sure you have separated out your testing subjects and know what group you are testing. Data will be compared after all information is collected.***

Exercise 1: Breathing While Sitting

Aim: To measure breathing parameters in a sitting subject.

Approximate Time: 20 minutes

Procedure

1. Instruct the subject to:
    - Sit quietly and become accustomed to breathing through the spirometer flow head.
    - Make sure to breathe through the red port side of the 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 Lung Volumes channel during the first ten seconds of recording. No air should be moving through the flow head during this time.***

2. Type **Sitting** in the Mark box.
3. Click Record. After waiting <u>at least ten seconds</u> for the Lung Volumes channel to zero, have the subject place the flow head in their mouth and begin breathing. Click the mark button to mark the recording.
4. Click the AutoScale All button. Notice the slowly moving wave on the Lung Volumes channel. Record five or six breaths, which normally takes about forty-five seconds to record.
5. Type **Forced** in the Mark box. Click the mark button as the subject inhales as deeply as possible to reach their maximum inhalation volume. Do not hold it in. Then, as quickly as possible the subject should exhale as much as possible and do another inhale before returning breathing to normally. Make sure to blow out all the air from the big breath.
6. After the forced exhalation is complete, the subject should continue to breathe normally through the spirometer for five to six breath cycles.
7. Click Stop to halt recording. Your data may look like the image below.
8. Select Save As in the File menu, type a name for the file. Click on the Save button to save the data file.

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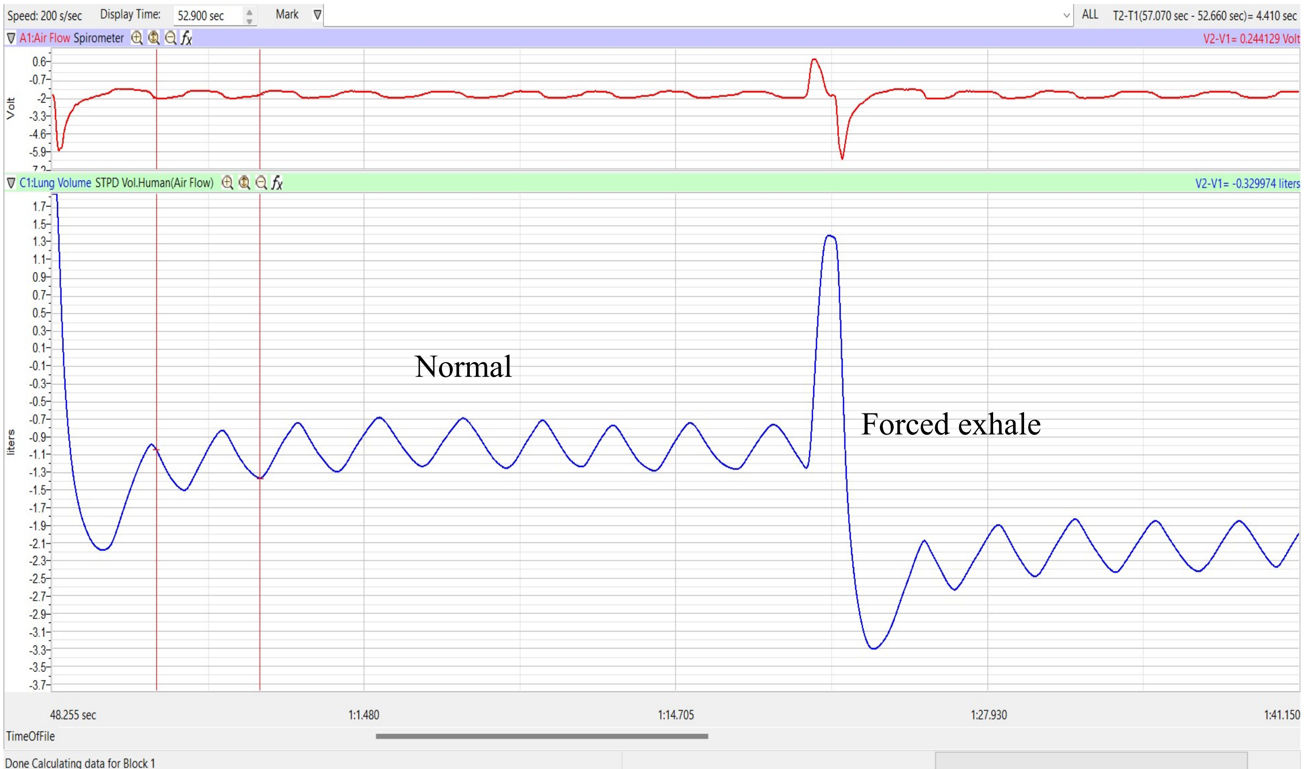

Figure HS-2-L1: *Air flow and lung volumes of the normal and forced breathing of a subject at rest.*

Data Analysis-Normal Breathing While Sitting

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 the complete breathing cycles on the Main window. The breathing cycles can also be selected by:
    - Placing the cursors on either side of a group of complete breathing cycles; and
    - Clicking the Zoom between Cursors button on the LabScribe toolbar to expand the selected breathing cycles to the width of the Main window.

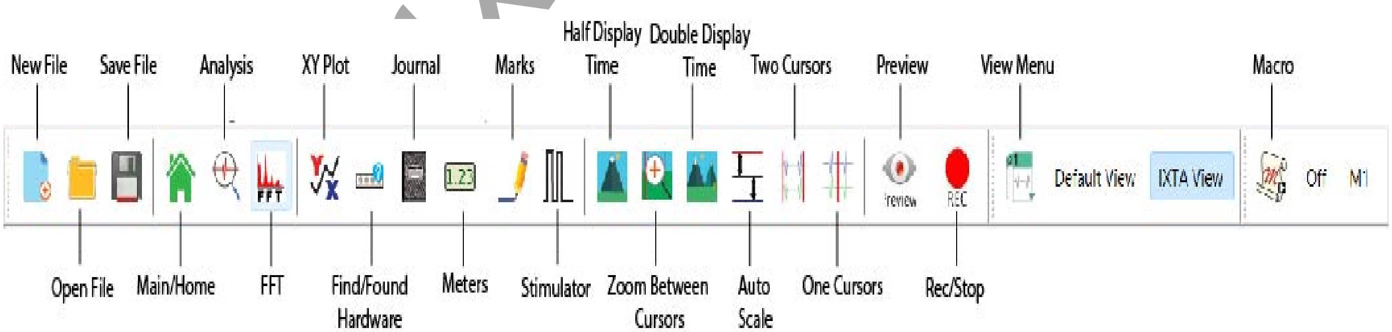

Figure HS-2-L2: The LabScribe toolbar.

3. Click on the Analysis window icon in the toolbar to transfer the data displayed in the Main window to the Analysis window.
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. 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. 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.

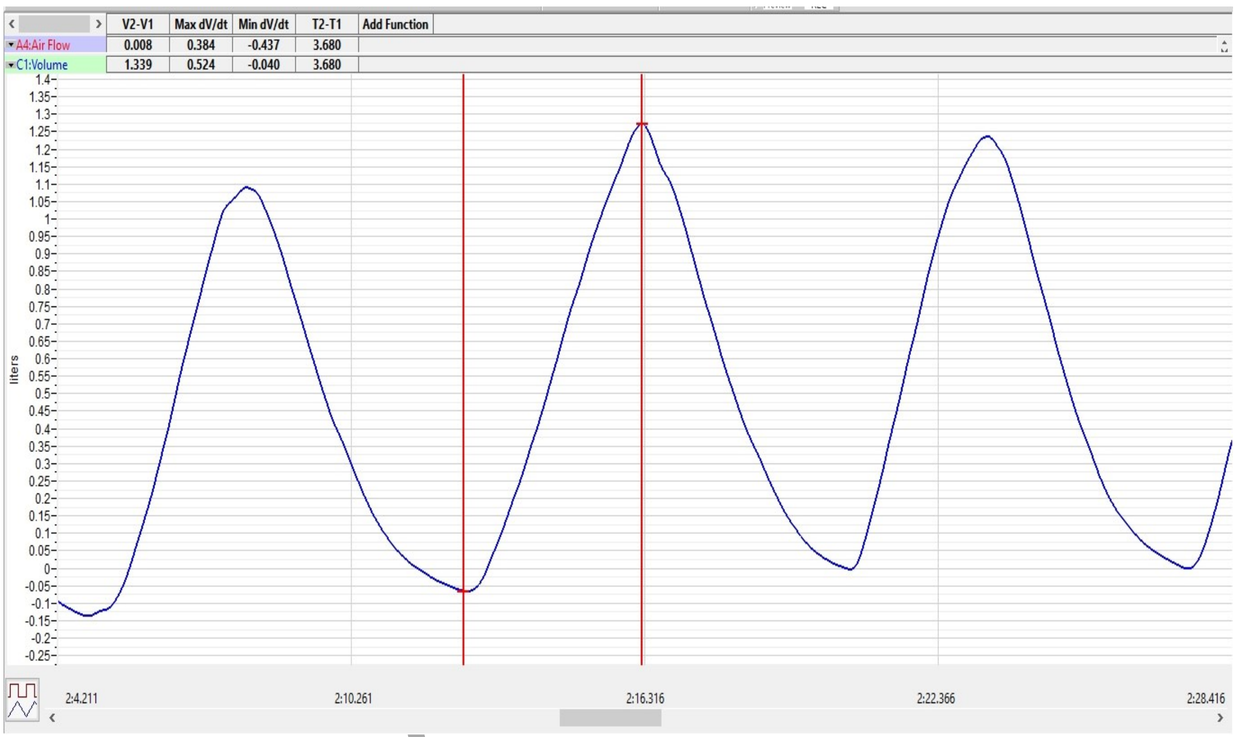

Figure HS-2-L3 Breathing pattern of a sitting subject, displayed on the Lung Volumes channel in the Analysis window. The cursors are positioned on the trough and the peak of the breath cycle to measure the tidal volume (TV) with V2-V1 function and the maximum inspiratory flow rate with the Max_dv/dt function.

   - **Breath Period**, which is the duration of each breathing cycle. 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.

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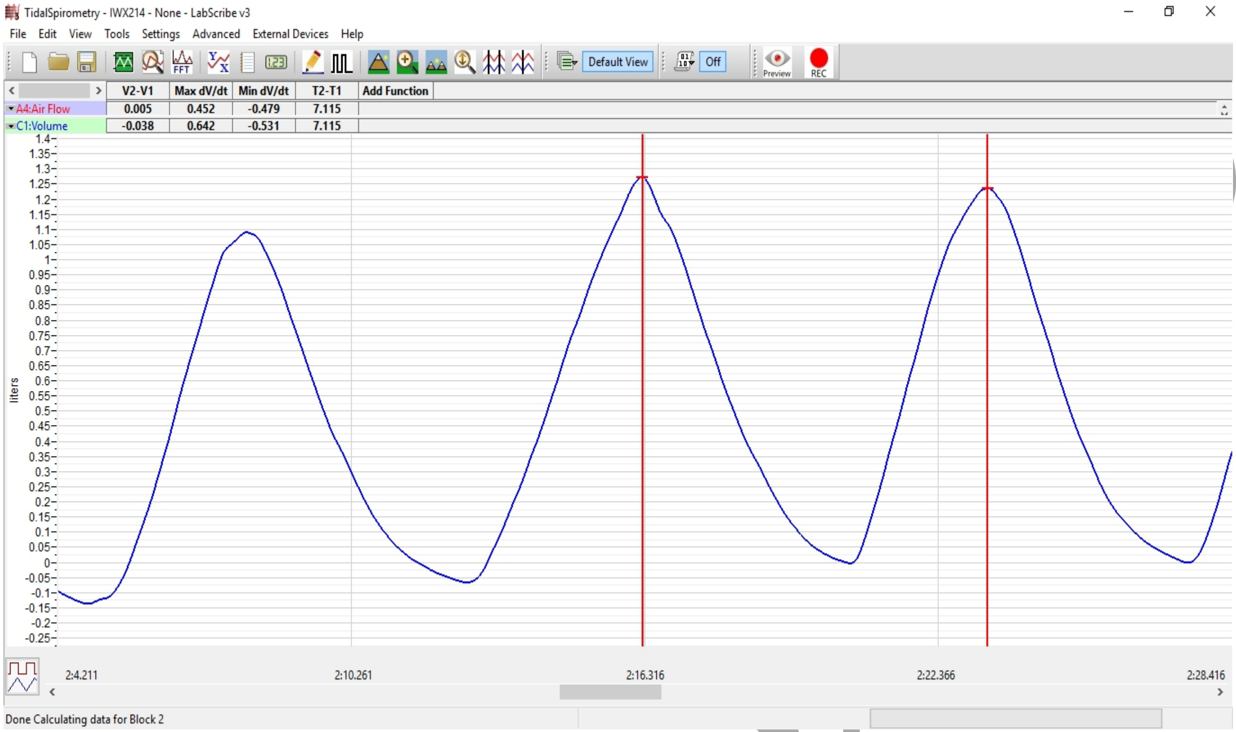

Figure HS-2-L5: Breathing pattern of a sitting subject, displayed on the Lung Volumes channel in the Analysis window. The cursors are positioned on the peaks of successive breath cycles to measure the breath period with the T2-T1 function.

6. Once the cursors are placed in the correct positions for determining the tidal 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, or on a separate data table.
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 tidal 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.

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8. Record the values in the Journal using the one of the techniques described in Step 7.
9. Repeat the measurements of tidal volume and breath period on four additional normal breath cycles.
10. Average the five 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.
11. Record the means for the tidal volume and breath period in Table 1.
12. Calculate the normal breathing rate of the sitting subject using the following equation:

Breath Rate (breaths/minute) = 60 seconds/minute / 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 data table.

Data Analysis-Forced Expiration While Sitting

1. Use the slider or the arrows on the scroll bar, at the bottom of the Analysis window, to position the Forced expiration in the window.
2. 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 forced expiration curve, on the same window.
3. Place the cursors on the forced expiration data 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 below to identify the volumes and rates that you will measure:
    - **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 their lungs. The value for the V2-V1 function on the Lung Volumes channel is the forced vital capacity.
    - **Forced Expiratory Volume at 1 Second (FEV_1)**, by placing one cursor on the peak of the maximum inhalation 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.
    - **Forced Expiratory Volume at 3 Seconds (FEV_3)**, by placing one cursor on the peak of the maximum inhalation 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.

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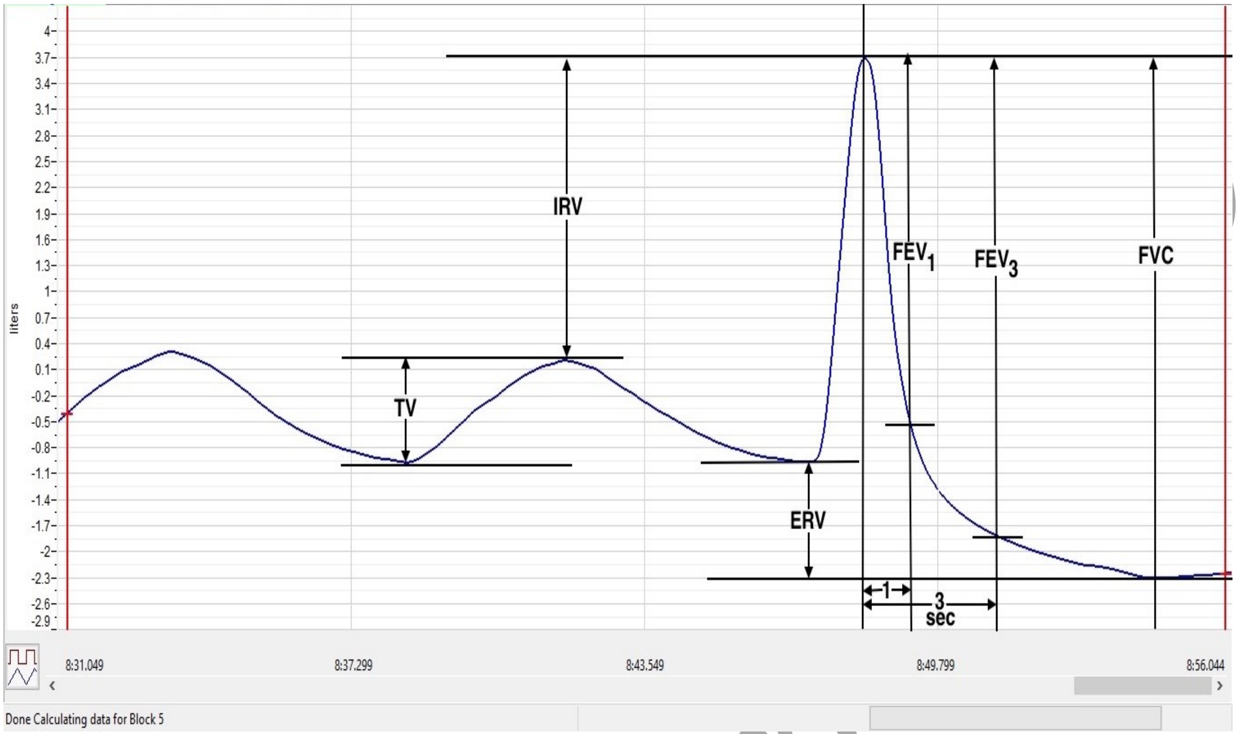

Figure HS-2-L6: Normal and forced lung volumes from a subject at rest, and displayed in the Analysis window. Lines and labels were added to figure to indicate to volumes that should be measured for each subject: Tidal Volume (TV), Inspiratory Reserve Volume (IRV), Expiratory Reserve Volume (ERV), Vital Capacity (VC), and Forced Expiratory Volume at 1 Second (FEV_1).

4. Record these volumes and rates in Table 2.
5. Calculate the subject's FEV_1/FVC ratio by dividing the subject's FEV_1 value by their FVC value.
6. Calculate the subject's FEV_3/FVC ratio by dividing the subject's FEV_3 value by their FVC value.
7. 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).
8. Record the FEV_1/FVC and FEV_3/FVC ratios in the table.

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Exercise 2: Breathing While Standing

Aim: To measure various breathing parameters in a standing subject.

Approximate Time: 15 minutes

> **REMINDER:** ***No air should be moving through the flow head during the first 10 sec.***

Procedure

Repeat Exercise 1 while the subject is standing.

Data Analysis

1. Use the same techniques used in Exercise 1 to measure the data recorded in Exercise 2. Record the measurements in the Journal. Report the appropriate measurements in the tables.
2. Determine the values for the calculated parameters taken from the recordings of normal and forced breathing while standing. Report these values on the tables.

Table HS-2-L1: Normal Breathing Volumes and Rates While Sitting, Standing, and Reclining

	Sit	Stand
Mean Breath Period (sec/breath)		
Breathing Rate (breaths/min)		
Mean Tidal Volume (mls/breath)		
Minute Air Flow Rate (liters/min)		

Table HS-2-L2: Forced Expiration Volumes and Rates at Rest and after Exercise

	Sit	Stand
Lung Volumes (liters)		
Tidal Volume (TV)		
Vital Capacity (VC)		
Forced Expiratory V-1sec (FEV_1)		
Forced Expiratory V-3sec (FEV_3)		
FEV_1/VC Ratio		

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FEV_3/VC Ratio		

Questions

1. What was the participant's highest recorded vital capacity (VC) in the standing position?
2. How did the participant's VC change between the sitting and supine positions?
3. Which body position resulted in the lowest VC for your participant, and what physiological factors might explain this?
4. Compare the average VC of athletes and vape/smoke participants in the standing position. What trend do you observe?
5. Was the difference in VC between positions consistent across all participants in your group? Provide an example.
6. Did any participants fail the repeatability criteria (VC values within 150 mL)? If so, what might have caused this?
7. Based on your group's data, is there evidence of a Group × Position interaction? Explain briefly.
8. What was the mean VC for athletes in the supine position? How does this compare to the vape/smoke group?
9. Based on your data, what is the most likely explanation for reduced VC in the supine position? Did one group have a more reduced VC when supine?

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