

Experiment HS-2: Breathing and Gravity

[Instructor edits are in bright red type]

Background

Over a long time, the amount of oxygen (O₂) taken up and carbon dioxide (CO₂) given off at the tissues is matched with the amount of O₂ taken up and CO₂ given off at the lungs. Changes in the body's demand cause the respiratory control center in the medulla to change the depth and rate of breathing. This was seen in Experiment HS-1, when the effect of exercise was examined.

The exchange of O₂ and CO₂ at the lungs relies upon diffusion between the air and the blood. Any change in the rate of diffusion could produce a change in breathing parameters. One factor that influences the rate of diffusion is surface area. All other parameters being held constant, an increase in the surface area will increase the rate of diffusion and thus decrease the rate and depth of breathing. Gravity affects the amount of usable surface area in the lungs; this effect will be studied in this experiment.

Gaseous exchange between the alveolar air and the blood takes place at the pulmonary capillaries. These thin-walled vessels are distensible and easily collapse. The diameter of the pulmonary capillaries is determined by the transmural pressure—the pressure difference between the inside (blood pressure) and the outside (alveolar pressure) of the capillary. If the pressure in the alveoli is greater than the blood pressure, the pulmonary capillaries will collapse and blood will not flow through them. Under these conditions, while the diffusion gradients may be present for the exchange of O₂ and CO₂ between the air and the blood, the collapse of the vessels prevents gas exchange.

In this experiment, you will examine the effects of gravity on breathing by measuring the differences in lung volumes of a resting subject while he or she is sitting, standing, or lying down.

Equipment Required - same as HS-1

IWX/214 Setup - completed in HS-1

Start the Software

- 1 Close the HS-1 file and then load **IPLMv4.iwxgrp** as described for HS-1. Select **Settings** again, and then select **Human Spirometry** and open the **Breathing-Gravity-LS2** settings file.
- 2 For your information, the settings used to configure the **LabScribe** software and the IWX/214 unit for this experiment are listed in Table HS-2-1 (shown in the **LabScribe PDF**).

Spirometer Setup - completed in HS-1

Before Starting

- 1 The same precautionary statements provided in the HS-1 file are also applicable to HS-2. These statements concern the health of the subject, use of a nose clip, and orientation of the spirometer (the airflow tubing should point up from the FH-300 flowhead, particularly if the flexible plastic

tubing extension is not used, and the black SP-304 unit should not be held in your hand). Also, as in HS-1, please seal the lips completely around the mouthpiece. Please read the procedures for each exercise completely before beginning the experiment.

- 2 As in HS-1, enter the calibration voltage of your SP-304 spirometer into the Spirometry computed function used on the **Lung Volumes** channel: click **Vol.Human (AirFlow)** next to the title of the **Lung Volumes** channel, select **Setup Function** from this pull-down menu, and enter the calibration voltage into the equation that sets the calibration voltage equal to one liter of lung volume. Make sure the reset time is set to **180** sec, and the first 5 seconds of the recording are used to zero the baseline. Click **OK**.
- 3 Allow the SP-304 to warm up for 10 minutes, unless you are continuing from HS-1 (in which case it will have warmed up already).
- 4 Confirm that inhalation is displayed as an upward deflection. You should not need to switch to **Preview mode** again unless you are unsure which side of the flowhead you were breathing through (in which case, follow the directions on page HS-1-2 of the edited HS-1 file). Before proceeding, make sure **LabScribe** is in **Record** mode, with a green arrow on the **Save to Disk** button.

Exercise 1: Breathing While Sitting

Aim: To measure breathing parameters in a sitting 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 **mouthpiece** and hold it at mouth level in a position that prevents a breath from moving through the flowhead during the first five seconds of recording, while **LabScribe zeroes the Lung Volumes** channel.
- 2 Type **<Subject's Name> Sitting** in the **Mark** box.
- 3 Click **Record**. After waiting five seconds for the **Lung Volumes** channel to zero, have the subject place the **mouthpiece** in his or her mouth and begin breathing through the **mouthpiece**. Press **Enter** to mark the recording.
- 4 **AutoScale both** channels. Record five breaths.
- 5 Type **Forced** in the **Mark** box. Press **Enter** just before the subject inhales as deeply as possible. After reaching his or her maximum inhalation volume, the subject should **immediately** exhale as quickly and completely as possible.
- 6 After the forced exhalation is complete, the subject should continue to breathe normally through the spirometer for five breath cycles.
- 7 Click **Stop**. Your data may look like Figure HS-2-3 on page HS-2-2.
- 8 Select **Save As** in the **File** menu, type a name for the file, and save it in your **BMD 336.101 or 102** folder. Designate

the file type as *.iwxdata. Click **Save**, but **do not close the file**. Instead, complete the remaining exercises in experiment HS-2. Subsequently, complete experiment HS-4. Finally, return to this file to perform the data analysis.

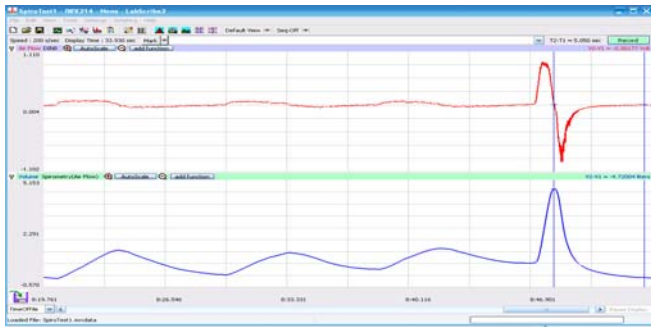


Figure HS-2-3: Air flow and lung volumes of the normal and forced breathing of a subject at rest.

Exercise 2: Breathing While Standing

Aim: To measure breathing parameters in a standing subject.

Procedure

Repeat Exercise 1 while the subject is standing.

Exercise 3: Breathing While Supine (face up)

Aim: To measure breathing parameters in a subject who is lying face up (supine).

Procedure

- 1 The subject should lie down on **his/her** back and relax. You may lie on the benchtop or the floor, using extra lab coats or your own blankets or other garments for padding. Please launder any such garments after leaving the laboratory.
- 2 Assist the subject when he or she is removing and replacing the flowhead in his or her mouth. Place the flowhead near the subject's head in a position that **keeps it clean and prevents any air from moving through the flowhead while LabScribe zeroes the Lung Volumes channel**.
- 3 Repeat Exercise 1 while the subject is supine.

Data Analysis

Exercise 1: Normal Breathing While Sitting

- 1 Perform the same types of measurements and calculations as were performed for Exercise 1 of Experiment HS-1. Report the values for all parameters in Table HS-2-2 on page HS-2-3.

Forced Expiration While Sitting

- 1 Perform the same types of measurements and calculations as were performed for Experiment HS-1. Record the volumes, rates and ratios in Table HS-2-3 on page HS-2-3.

Exercise 2: Breathing While Standing

- 1 Use the same techniques used in Exercise 1 to measure the data recorded in Exercise 2. Record the measurements and values for the calculated parameters taken from the

recordings of normal and forced breathing while standing on Table HS-2-2 and Table HS-2-3.

Exercise 3: Breathing While Supine (face up)

- 1 Perform the same types of measurements and calculations as were performed for Exercise 1. Record all values for the recordings of normal and forced breathing while supine on Table HS-2-2 and Table HS-2-3.

Questions

- 1 What effect does lying down have on the minute volume (the total amount of air breathed into the lungs in a minute)?

- 2 What effect does lying down have on the various lung volumes, including tidal volume? _____
- 3 Would the blood pressure in the pulmonary capillaries at the bottom of a lung be the same as the blood pressure in the capillaries at the top of a lung in the standing individual? _____ Which area would have the lower blood pressure?

- 4 With the answer to Question 3 in mind, if higher blood pressure allows more pulmonary capillaries to be open, where in the lung would you expect to find more collapsed capillaries, at the base (closest to the floor) or at the apex (closest to the head)? _____
- 5 If some capillaries are collapsed, what is the functional effect on the diffusion of O₂ and CO₂? _____
- 6 Would you expect that there would be any difference in capillary blood pressures between the apex and the base of the lungs in a subject who was lying down? Why or why not? _____
- 7 If the blood pressure in all pulmonary capillaries is the same, would you expect the capillaries to be open or collapsed? _____
- 8 Would you expect any difference in the level of CO₂ in the exhaled air of a subject when standing vs. lying down? Why or why not? _____

Edited 03/08

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

	Sitting	Sitting	Sitting	Sitting Mean	Stand	Stand	Stand	Stand Mean	Supine	Supine	Supine	Supine Mean
Tidal Volume (mL/breath)												
Max. Inspir. Flow Rate (mL/s)												
Max. Expir. Flow Rate (mL/s)												
Breath Period (sec/breath)												
Breath Rate (breaths/min)												
Minute Air Flow Rate (L/min)												

Table HS-2-3: Forced Expiration Volumes and Rates at Rest and after Exercise

	Sitting	Standing	Supine
Lung Volumes (mL)			
Tidal Volume (TV)			
Inspiratory Reserve Volume (IRV)			
Expiratory Reserve Volume (ERV)			
Forced Vital Capacity (FVC)			
Forced Expiratory Volume - 1 sec (FEV ₁)			
Forced Air Flow Rates (mL/sec)			
Forced Inspiratory Flow Rate			
Forced Expiratory Flow Rate			
FEV ₁ /FVC Ratio			