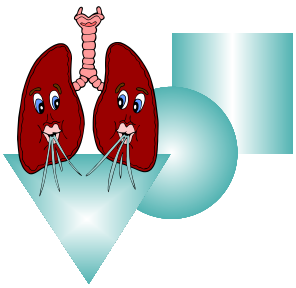
Pulmo-Park Pom-Pom Shooter:
Measuring the Effect of Restricted Breathing on Peak Expiratory Flow (PEF)
Activity 5D



Be sure to identify those students with asthma or other respiratory problems. They should not perform the breathing exercises in this activity because they involve repeated maximal inhalations and exhalations and use of a breathing restriction mouthpiece which could leave the students short of breath or, possibly, trigger an asthmatic episode. These students can observe and use data collected by their group.

Activity Objectives:

Using a PVC Pom-pom shooter and restriction adapters, students will be able to:

- relate *distance* traveled by a pom-pom after being shot through a *pom-pom shooter* to *peak expiratory flow* (PEF)
- explain the effect of simulated pulmonary *obstructive* and *restrictive* disorders on PEF
- identify independent and dependent variables
- formulate a hypothesis
- collect, tabulate, graph, and analyze data
- explain the difference between *obstructive* and *restrictive* pulmonary diseases and provide examples of each

Activity Description:

A *pom-pom shooter* is one of the easiest and most entertaining tools your students will ever use in science class. Students simply place a small *pom-pom* into the mouthpiece, and blow as hard as possible with *one breath*. Student "spotters" will measure the distance traveled by each *pom-pom* and record the information for the person using the *pom-pom shooter*. The process is repeated with "restriction mouthpieces" placed on the *pom-pom shooter*. Data is analyzed and students see, very graphically, how *restriction* or *obstruction* can affect their PEF.

Activity Background:

Pulmonary disorders are classified into two main categories, *obstructive* and *restrictive*. *Obstructive disorders* represent those in which the *flow* of air is impeded while *restrictive disorders* are those in which the *volume* of air is reduced. Measurements used to diagnose pulmonary disorders are not the actual *Pulmonary Function Tests (PFTs)* but rather the comparison of these figures to predicted normal values. Tables

Activity Overview

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detailing these values have been developed over years of collecting *PFT* data from thousands of "typical" adults and children. Several sources of actual tables can be found, however, including McGraw-Hill's Pocket Guide to Spriometry by David P. Johns and Rob Pierce.

Common Obstructive Lung Disorders

Chronic Obstructive Pulmonary Disease (COPD) – in the United States, *COPD* is defined as consisting of emphysema and chronic bronchitis. The primary cause is smoking, second-hand smoke, and long-term exposure to air pollution.

Emphysema – a condition in which the *walls between the air sacs (alveoli) lose elasticity*. Without elasticity, air becomes trapped in the air sacs, the exchange of oxygen and carbon dioxide is impaired, and support of the airways is lost, causing airflow obstruction. Symptoms include shortness of breath, cough, and a limited exercise tolerance. Smoking is the most common cause.

Chronic Bronchitis – airways are *inflamed and thickened*, and an *increase in the number and size of mucus-producing cells occurs*. Therefore, too much mucus is produced, causing cough and difficulty moving air in and out of the lungs. In *chronic bronchitis*, these symptoms last for a long period of time or recur many times. Cigarette smoking and second-hand smoke are the primary causes.

Asthma – a chronic disease characterized by *inflamed, swollen airways*. Inflammation makes airways sensitive so they react to allergens and irritants. When airways react, they get narrower, so less air flows to the lungs. Narrowed airways cause symptoms like *wheezing, coughing, chest tightness*, and *trouble breathing*, especially at night and in the morning. During an asthma attack, muscles around the airways tighten, making the airways narrower so less air flows through. Inflammation increases, and the airways become swollen and even narrower. Cells in the airways may also make more mucus than usual. This extra mucus also narrows the airways. *See Figure 1 Asthma*.

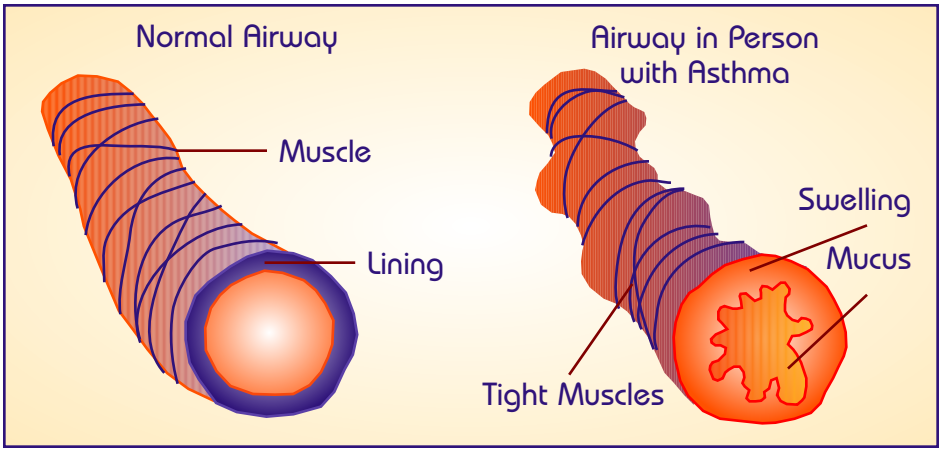


Image adapted from the National Heart, Lung and Blood Website

Figure 1 Asthma

Lung cancer – cancer is *abnormal, uncontrolled cell growth;* when it occurs in the lungs, it is lung cancer. Lung cancer is divided into two types, *non-small cell lung cancer* and *small cell lung cancer,* and each type looks different under a microscope. Each type of lung cancer grows and spreads in different ways and is treated differently. The main cause of lung cancer is cigarette smoking and second-hand smoke.

Cystic Fibrosis - inherited disease of mucus and sweat glands, affecting primarily the respiratory and digestive systems of your body. Typically, mucus is thin and watery, and keeps the linings of certain organs moist. Moisture is important to keep some organs from drying out and from getting infected. People with cystic fibrosis have an *abnormal gene that causes mucus to become thick and sticky*.

This thickened mucus builds up in the airways, causing blockage, bacterial growth, and repeated lung infections. Over time, these infections can cause serious damage to the lungs. The thick, sticky mucus can also block tubes, or ducts, in your pancreas and causes sweat to become extremely salty. Loss of salt through sweat can cause a heat emergency.

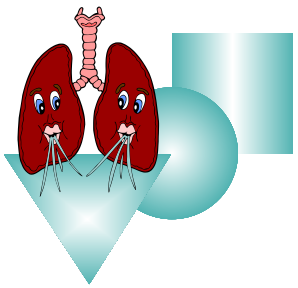
Common Restrictive Lung Disorders

Neuromuscular Disease – affects breathing in people with neuromuscular disorders such as muscular dystrophy, ALS (Lou Gehrig 's disease), Guillain-Barri Syndrome, Polio, Myasthenia Gravis and many others. Breathing problems include *frequent lung infections, difficulty coughing and clearing mucus, shortness of breath, and shallow breathing (hypoventilation)* particularly during sleep.

Obesity – reduced thoracic space due to increased mass in the abdomen and thorax. Breathing becomes harder because the size of the lungs becomes smaller and the chest wall is heavy and difficult to lift during breathing. Obesity does not cause asthma or bronchitis, but it interferes with breathing and may aggravate attacks. For severely obese people (over 350 pounds), *obesity hypoventilation* causes high levels of carbon dioxide in the blood.

Asbestosis – caused by *inhaling asbestos fibers*. When these fibers collect in the lungs they cause *scarring of lung tissue and reduced lung capacity*. The effects of asbestosis don't appear until years after exposure. As the condition progresses, it can lead to disability and even death.

Sarcoidosis - due to *inflammation* and can attack any organ in the body, although 90% of cases occur in the lungs. Small areas of inflamed cells occur, usually in the lungs. In the lungs, it causes reduced lung volume and loss of elasticity. The disease is thought to be an immune system disorder, but the cause is unknown. The effects of sarcoidosis include dry cough (without sputum), shortness of breath, and mild chest pain.



Tuberculosis (TB) – chronic *infection* with TB bacteria, *Mycobacterium tuberculosis*. *Mycobacterium tuberculosis* is spread through the air and usually affects the lungs, although other body organs can be affected as well. Many people infected with *M. tuberculosis* carry the bacterium without symptoms, but some (1 in 10) develop active TB disease. Symptoms of active TB include weight loss, fever, night sweats, and loss of appetite. With antibiotic drugs over a course of 6 to 12 months, TB can be cured in most people.

Measuring Peak Expiratory Flow

Peak expiratory flow (PEF) rate is a measure of how quickly a person can exhale air and is an indicator of how well your airways work. PEF is measured using a *Peak Flow Meter*, which is a hand-held device used to measure your ability to push air out of your lungs in one "fast blast". Using the *Peak Flow Meter*, a personal peak PEF can be established.

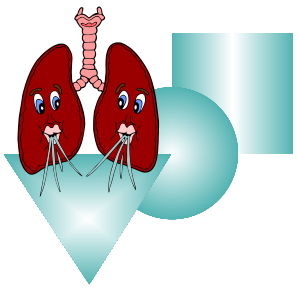
Activity Materials:

Per shooter (this is much easier than it seems!):

- 27″ of 1/2″ PVC pipe, cut into the following lengths:
- 4 4″ pieces of 1/2″ PVC pipe
- 2 2″ pieces of 1/2″ PVC pipe
- 1 7″ piece of 1/2″ PVC pipe
- 2 elbow connectors for 1/2″ PVC
- 2 T connectors for 1/2″ PVC
- 3 end-caps for 1/2″ PVC, drilled to restrict air flow
- 1 25% restriction (drill hole with 7/16″ bit)
- 1 50 % restriction (drill hole with 3/8″ bit)
- 1 75% restriction (drill hole with 1/4″ bit)
- 1 PVC pipe cutter
- Class set of instructions for making pom-pom shooters

For each lab station:

- 1 Peak Flow Meter
- 4 Nose clips (May be purchased from Morgan Scientific at http://www.morgansci.com/accessories/acctransflow.html or other supply stores)
- 1 *Set Instruction Cards*
- 1 250 ml Beaker (for cleaning mouth pieces)
- 500 ml Alcohol
- Paper towels
- 4 Goggles
- 30 Small pom-poms in various colors to fit inside 1/2″ PVC pipe
- 4 Metric Rulers
- 1 Mouthpiece for every student (if only a limited number of mouthpieces is available, they can be shared safely by sterilizing with alcohol and drying between uses)
- *Station Instruction Card* for each station (included in the *Teacher Information Pages* of this activity)
- 1 copy of *Student Data Pages* for each student to take to each station



Activity Management Suggestions:

Be sure to identify those students with asthma or other respiratory problems. They should not perform the breathing exercises in this activity because they involve repeated maximal inhalations and exhalations and use of a breathing restriction mouthpiece which could leave the students short of breath or, possibly, trigger an asthmatic episode. These students can observe and use data collected by their group.

Pom-pom shooters are very simple and inexpensive to construct. A science teacher may ask students to volunteer to construct them before of after class, have them made in industrial technology classes, or, with *parental and school permission* allow students to construct the *pom-pom shooters* at home and bring them to class. *Pom-pom shooters* (Marshmallow Shooters) can also be purchased over the Internet and used instead of building them. If this activity is done in stations, only 4 shooters are needed; if the activity is done as a whole-group activity, a class set of 16 pom-pom shooters will be needed. A big advantage for having students construct their own is pride of ownership! Students will enjoy custom-decorating their *pom-pom shooter*.

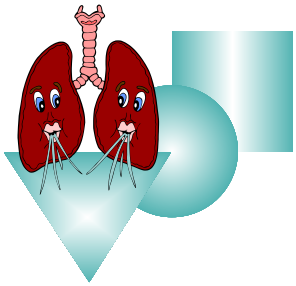
Tiny marshmallows can be used instead of *pom-poms* or *pom-poms* can be hand made rather than purchased. Use various colors and assign a specific color to each group for identification purposes.

Laminate the *Station Cards* so they can be used again.

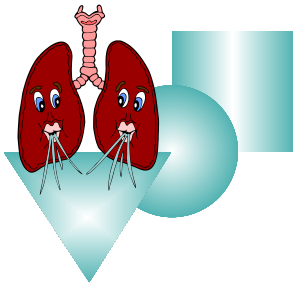
If a peak flow meter cannot be obtained from a drugstore or drug department of a department store, have students use the *Peak Flow Nomogram* included in the *Teacher Information Pages* of this activity to *estimate* their *Peak Expiratory Flow*.

Suggested Lesson sequence:

- ❒ 1. Make the *pom-pom shooters* (one-day production). Have student volunteers cut the PVC pipe into the required lengths before or after school. Arrange to have the PVC end caps drilled prior to class (Industrial Technology classes or hardware stores may help). If making their own *pom-pom shooters*, students can assemble the *pom-pom shooters* and add decorations at home.
- ❒ 2. Divide students into groups for the five stations.
- ❒ 3. Explain to students that their groups will rotate through the five stations.



4. Supply each station with needed supplies and ***Station Instruction Cards*** (included in the ***Teacher Information Pages*** of this activity).
5. Each student will need a copy of the ***Student Data Pages*** for collecting data and information at each station.
6. A class data sheet needs to be located in a convenient location for students to record their group data once they have completed all five stations. (Teacher should provide a large copy of the ***Table 2 Class Data Table*** to post on the wall or make a transparency to place on the overhead to help students collect class data. Also, check to make sure each group has recorded their data and that each student has recorded his or her name.)
7. Secure five areas where stations can be set up. **Station 1** can be done at a table in a small area. **Stations 2 – 5** will need an open area at least ***10 meters*** long and ***4 meters*** wide. Sidewalks or hall ways are best.
8. At **Stations 2 – 5**, create a starting line where students will stand. Students will mark off each section in increments of 50 cm (use sidewalk chalk if working on outdoor sidewalks or masking tape on the floors if working inside). Students can then count the number of centimeters each pom-pom is shot using a meter stick or ruler to measure the detail between the 50 cm increments.
9. Students will follow the procedure described in the Station Instruction Cards (included in the ***Teacher Information Pages*** of this activity) placed at each station.
10. Rotate groups when everyone is finished. Estimate about 10 minutes for each station. The first rotation is usually the longest as students become familiar with the ***pom-pom shooter***. Tell students that practice time will only be allowed during the first rotation or allow practice prior to releasing the groups to work at their stations.
11. "Process out" the lab by allowing students to complete their ***Student Data Pages*** and then discussing the group data as prompted by the ***Student Data Page***.
12. Discuss ***obstructive*** and ***restrictive*** lung disorders; divide students into groups and have each group member read the background information about one condition (included in the ***Student Information Page*** of this activity). Each student can give a 2 – 3 minute "brief" on the condition they read about, making sure to explain disease symptoms ***and*** causes and whether the disease is ***obstructive*** or ***restrictive*** and why.



Modifications:

For highly able students, assess prior knowledge with a KWL chart and allow these students to conduct the lab activity, process the results, and study pulmonary diseases in much fuller detail than that provided in this activity.

For students needing assistance, group students so they are working with student leaders who can help them participate fully in the lab. Monitor these students carefully to ensure their success.

Extension: :

1. Students can vary *the sizes of PVC* in the pom-pom shooter to see if these variables affect projection of the pom-pom. This would be an excellent scientific inquiry into the theories associated with catapulting and ballistics.

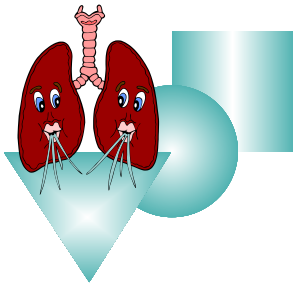
2. Have students correlate physics of the pom-pom shooter with *Newton's Laws of Motion*. They can turn in a written report with drawings and diagrams, or they can report to the class orally with models for demonstrations.

3. More advanced students may want to look at *Poiseuille's Law* and explore its relationship to this lab experiment.

4. Have students design a more *open inquiry* investigation by selecting their own variables to test and devising their own methods for conducting the experiment.

5. Students can collect data from all classes and possibly other classes to find a correlation between the distance traveled by the pom-poms and *Peak Expiratory Flow*. Such a calibration would allow the pom-pom shooter to be used as a device to measure PEF.

6. Have students collect height information on each students and input height and ***pom-pom*** distance traveled into a graphing calculator to create a correlation graph. Have students share findings with the class.



Activity References Used:

Johns, D. P. & Pierce, R. (2003) Pocket Guide to Spirometry. San Francisco: McGraw Hill.

Medline Plus from the National Institutes of Health
http://www.nlm.nih.gov/medlineplus/emphysema.html
http://www.nlm.nih.gov/medlineplus/tuberculosis.html

National Cancer Institute Website
http://www.nci.nih.gov/cancertopics/wyntk/lung

National Heart, Lung and Blood Institute
http://www.nhlbi.nih.gov/health/dci/Diseases/Asthma/Asthma_WhatIs.html

Peak Expiratory flow Rate Normal Values
http://www.peakflow.com/top_nav/normal_values/index.html

Possible sources for supplies for this activity:

Disposable mouthpieces available at:
http://www.chponline.com/CHPStore.asp?WCI=wciProduct&WCE=16

Nose clips. Purchase in stock for reuse. Call number #39290.
http://www.futuremedamerica.com/

Peak Flow Meter can be purchased at pharmacy:
http://www.omronhealthcare.com/enTouchCMS/app/viewCategory?catgId=39

Vernier website
http://www.vernier.com/physiology/