

## ACTIVITY BRIEF

# Lung function testing

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### The science at work

Common respiratory complaints include asthma and COPD (chronic obstructive pulmonary disease). Peak flow meters and spirometers can be used by health professionals to diagnose and monitor the progress of these conditions.

Peak flow meters measure the fastest rate of air that you can blow out of your lungs. It is more convenient than spirometry and is commonly used to help diagnose asthma. Many asthmatics also use peak flow meters to monitor their asthma. For people with COPD, spirometry is a more accurate test for diagnosis and monitoring.

A spirometer can be used to determine how well the lungs receive, hold, and utilise air. They are also used to monitor and determine the severity of a lung disease and to determine whether the lung disease is restrictive (decreased airflow) or obstructive (disruption of airflow). After taking a deep breath, a person forcefully breathes out into the spirometer as completely and forcefully as possible. The spirometer measures both the amount of air expelled and how quickly the air was expelled from the lungs. The measurements are then recorded by the spirometer. Spirometry readings usually show one of four patterns:

#### *Normal*

Normal readings vary according to a variety of factors. They are published in charts or incorporated into computer programmes used to analyse spirometer readings. Doctors and nurses take the range of healthy readings into account when they check spirometry readings.

#### *Obstructive*

An obstructive pattern is caused by a narrowing of the airways. This is typically found in asthma and chronic obstructive pulmonary disease (COPD). The amount of air that you can blow out quickly is reduced, but the total capacity of your lungs is usually more or less normal.

#### *Restrictive*

With a restrictive spirometry pattern lung capacity is less than the predicted value for your age, sex and size. This is caused by a variety of conditions that affect the lung tissue or restrict the capacity of the lungs to expand and hold a normal amount of air. These include pneumoconiosis, which causes fibrosis (scarring) of the lungs.

#### *Combined obstructive / restrictive*

This may be caused by two conditions, for example, asthma plus another lung disorder. Or, some lung conditions have features of both patterns. In cystic fibrosis (CF) thick mucus causes narrowed airways and damage to the lung tissue tends to occur from repeated infections.

## **Your brief**

Medical professionals use lung function test to diagnose and monitor lung diseases. Your task is to investigate how these tests are carried out and to determine some of the factors which might affect the results. You will work with a partner to use a peak flow meter and a spirometer.

### **Task 1 Using a peak flow meter**

Follow a procedure to measure peak expiratory flow (PEF). Suggest factors that might have affected your results. Use *Study Sheet: Using a peak flow meter*.

### **Task 2 Using a spirometer**

Follow a procedure to obtain measurements of lung capacities such as vital capacity (VC) and forced expiratory volumes (FEVs). Suggest factors that might have affected your results. Use *Study Sheet: Using a spirometer*.

## STUDY SHEET

# Using a peak flow meter

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Peak flow is the highest rate at which gas can be expelled from the lungs via an open mouth. If anything is blocking the path of air out of the lungs then peak flow measurements will be lower than expected. Measuring peak flow is a simple procedure in which an individual takes a deep breath and blows out as forcibly as possible into an instrument called a peak flow meter. This measures the maximal gas flow during exhalation, usually in seconds or  $\text{dm}^3$  per minute.

### Requirements

You will need:

- peak flow meter and instructions (if available)
- disposable mouthpieces or sterilised mouthpieces
- disposal bag or beaker of sterilising fluid for mouthpieces
- metre rule or tape measure

### Health and Safety

A risk assessment must be carried out before starting any practical work. Check it with your teacher before you begin. Take particular care with the mouthpieces: ensure that they are sterilised between users or that a new disposable one is available for each student.

### Procedure

- 1 Work with a partner and take it in turns to act as medical technician and patient.
- 2 Measure and record your heights, to the nearest centimetre.
- 3 Read through these instructions. If necessary, modify them to suit any instructions supplied with the meter.
- 4 Attach a sterile or disposable mouthpiece.
- 5 Set to the zero mark.
- 6 Sit up straight or stand up.
- 7 Breathe in as far as you can.
- 8 Wrap your lips tightly around the peak flow meter mouthpiece and breathe out as forcibly as possible. Record the measurement.
- 9 Repeat the process a further two times ensuring that the meter is reset to the zero mark each time.
- 10 Dispose of the mouthpieces as instructed by your teacher: either re-sterilise for reuse or place in bag for disposal of biological waste.
- 11 Change roles to obtain a second set of measurements.

## Reference data

<b>Male</b>											
Height / cm	145	150	155	160	165	170	175	180	185	190	195
Age / years	Peak expiratory flow (PEF)/ dm <sup>3</sup> per second										
10	4.9	5.3	5.7	6.1	6.5	6.9	7.3	7.6	8.0	8.4	8.8
12	5.2	5.6	6.0	6.4	6.8	7.2	7.6	8.0	8.4	8.8	9.1
14	5.6	6.0	6.4	6.7	7.1	7.5	7.9	8.3	8.7	9.1	9.5
16	5.9	6.3	6.7	7.1	7.5	7.9	8.2	8.6	9.0	9.4	9.8
18	6.2	6.6	7.0	7.4	7.8	8.2	8.6	9.0	9.4	9.7	10.1
20	6.6	7.0	7.4	7.7	8.1	8.5	8.9	9.3	9.7	10.1	10.5
25	6.8	7.2	7.7	8.2	8.6	9.1	9.6	10.1	10.5	11.0	11.5
30	6.6	7.1	7.5	8.0	8.5	8.9	9.4	9.9	10.3	10.8	11.3
40	6.2	6.7	7.2	7.6	8.1	8.6	9.1	9.5	10.0	10.5	10.9

<b>Female</b>											
Height / cm	145	150	155	160	165	170	175	180	185	190	195
Age / years	Peak expiratory flow (PEF)/ dm <sup>3</sup> per second										
10	4.8	5.0	5.2	5.5	5.7	6.0	6.2	6.5	6.7	7.0	7.2
12	5.1	5.3	5.6	5.8	6.1	6.3	6.5	6.8	7.0	7.3	7.5
14	5.4	5.6	5.9	6.1	6.4	6.6	6.9	7.1	7.3	7.6	7.8
16	5.7	5.9	6.2	6.4	6.7	6.9	7.2	7.4	7.7	7.9	8.2
18	6.0	6.3	6.5	6.8	7.0	7.2	7.5	7.7	8.0	8.2	8.5
20	5.9	6.1	6.4	6.6	6.9	7.1	7.3	7.6	7.8	8.1	8.3
25	5.7	6.0	6.2	6.5	6.7	7.0	7.2	7.5	7.7	8.0	8.2
30	5.6	5.9	6.1	6.4	6.6	6.8	7.1	7.3	7.6	7.8	8.1
40	5.4	5.6	5.9	6.1	6.4	6.6	6.8	7.1	7.3	7.6	7.8

### For your file

- Make outline notes on the method that you used to obtain PEF.
- Suggest possible sources of error.
- Record your measurements.
- Identify and briefly suggest reasons for any differences that you observe between
  - you and your partner
  - your measurements and the reference data above (if necessary, convert the expected value in dm<sup>3</sup> per second to dm<sup>3</sup> per minute to match your readings).

## STUDY SHEET

# Using a spirometer

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### Option 1: Volume spirometer

A spirometer can be used to measure movement of air in and out of the lungs. Analysis of data on volume and flow can be used by doctors to distinguish different types of respiratory conditions. Measurements can be compared to expected values. Spirometers differ in the methods used to obtain breathing measurements and in the range of measurements that they can take. They also vary considerably in reliability, accuracy, size, ease of use and portability.

#### Requirements

You will need:

- volume spirometer with provision for charting results\* and instructions (if available)
- soft nose clip (optional)
- disposable mouthpieces or sterilised mouthpieces
- disposal bag or beaker of sterilising fluid for mouthpieces
- oxygen cylinder
- fresh soda lime [CORROSIVE] (self-indicating for preference)
- metre rule or tape measure to measure height in cm.

\* Results may be charted using a kymograph (revolving drum) or movement transducer and chart recorder or PC with appropriate software.

#### Health and Safety

A risk assessment must be carried out before starting any practical work. Check it with your teacher before you begin. Use of the spirometer must be directly supervised by your teacher/lecturer. Take particular care with the mouthpieces: ensure that they are sterilised between users or that a new disposable one is available for each student. Wear eye protection when handling soda lime and take care not to raise dust.

#### Procedure

- 1 Work with a partner and take it in turns to act as medical technician and patient.
- 2 Read through these instructions. If necessary, modify them to suit any instructions supplied with the meter.
- 3 The spirometer will have been set up and connected to an oxygen cylinder.
- 4 Check that fresh soda lime is in place.
- 5 Check that chart recorder or equivalent has been set up and calibrated for volume and time.
- 6 Measure and record your heights, to the nearest centimetre.

*Medical technician role:*

- 1 Attach a clean, sterilised or disposable mouthpiece.
- 2 Turn the two-way tap to fill the spirometer with oxygen from the cylinder.
- 3 Ask the participant to stand or sit straight with their chin up in a position where they can use the mouthpiece comfortably.
- 4 Explain that to find their vital capacity, you will ask them to breathe as normally as possible and then take the deepest possible breath in followed by the biggest possible breath out.
- 5 Give them a nose clip (if available) to use and then ask them to insert the mouth piece into their mouth.
- 6 Instruct them to:
  - relax and practise normal quiet breathing in and out a few times
  - breathe in and out normally for one minute.Record their tidal volume for the minute. If breathing is irregular, continue for while longer, but work within the time allowed by any recording device.
- 7 Continue recording and ask them to:
  - breathe in as far as possiblethen immediately
  - breathe out as far as they can.
- 8 Continue recording and repeat the procedure of following a short period of normal breathing with maximum inspiration and expiration.
- 9 Ask them to remove the mouth piece and nose clip.
- 10 Check that the recordings are satisfactory. If necessary repeat.
- 11 When you have the data that you require, dispose of the mouthpiece as instructed by your teacher: either rinse and re-sterilise for re-use or place in bag for disposal of biological waste.
- 12 Remove any chart paper, or record or print out your data as necessary.
- 13 Change roles to obtain a second set of measurements.

**For your file**

- Make outline notes on the method that you used to obtain your data.
- Make a glossary of key terms.
- Carry out any necessary calculations and record:  
TV = Tidal Volume  
Normal respiratory rate  
IRV = Inspiratory Reserve Volume  
ERV = Expiratory Reserve Volume  
VC = Vital Capacity

(see FACT SHEET: Lung function tests using spirometry for definitions of terms)

- Suggest possible sources of error.
- Identify and suggest reasons for any differences that you observe between:
  - you and your partner
  - your measurements and the normal values below:

breathing rate	12 - 15 breaths per minute
tidal volume	400 - 500 cm <sup>3</sup>
vital capacity (male)	6 dm <sup>3</sup>
vital capacity (female)	4.25 dm <sup>3</sup>

## Option 2: Flow spirometer

A spirometer can be used to measure movement of air in and out of the lungs. Analysis of data on volume and flow can be used by doctors to distinguish different types of respiratory conditions. Measurements can be compared to expected values. Spirometers differ in the methods used to obtain breathing measurements and in the range of measurements that they can take. They also vary considerably in reliability, accuracy, size, ease of use and portability.

Flow spirometers can measure the Forced Expiratory Volume in the first second of expiration (FEV<sub>1</sub>) and the FEV<sub>1</sub> as a Percentage of the Predicted Value (FEV<sub>1</sub>% predicted). The use of FEV<sub>1</sub> is a useful diagnostic tool for early detection of COPD (chronic obstructive pulmonary disease). This information can also help in the management and treatment of COPD. It can provide a powerful motivator to help susceptible smokers understand the damage caused by smoking and to give up.

### Requirements

You will need:

- flow spirometer able to measure at least the Forced Expiratory Volume in the First Second of Expiration (FEV<sub>1</sub>) and the FEV<sub>1</sub> as a percentage of the predicted value (FEV<sub>1</sub>% predicted) or as a percentage of the Forced Expiratory Volume (FEV<sub>1</sub>%/FVC)
- printer or other arrangements for obtaining hard copy of results, if available / possible
- manufacturer's instructions, if available
- disposable mouthpieces or sterilised mouthpieces
- disposal bag or beaker of sterilising fluid for mouthpieces
- metre rule or tape measure to measure height in cm.

### Health and Safety

A risk assessment must be carried out before starting any practical work. Check it with your teacher before you begin. Use of the spirometer must be directly supervised by your

teacher/lecturer. Take particular care with the mouthpieces: ensure that they are sterilised between users or that a new disposable one is available for each student.

### Procedure

- 1 Work with a partner and take it in turns to act as medical technician and patient.
- 2 Read through these instructions. If necessary, modify them to suit any instructions supplied with the meter.

#### *Medical technician role:*

- 1 Switch on and check the battery level. Replace with new batteries if necessary. Most electronic devices will display a 'bAt' or similar warning if the battery level is low. Otherwise, check display is normal.
- 2 Enter patient details using symbols or menu provided. These will usually include gender, height (cm) and age. The device may be calibrated for ethnicity or request that race be entered. This will enable the device to calculate a predicted normal value for FEV1.
- 3 Attach a clean, sterilised or disposable mouthpiece.
- 4 Set the device to 'blow' or equivalent.
- 5 Ensure that any displayed values are zeroed.
- 6 Instruct the participant to:
  - seal their lips around the mouthpiece
  - breathe in until their lungs are completely filled
  - then breathe out as hard and fast as they can until their lungs are as empty as possible.

**Important:** the participant must hold the device so that they do not block the airway behind the turbine.

- 7 The FEV1 and FEV1% predicted or FEV1%/FVC will normally be displayed. Obtain any other optional data that is available. This may include Peak Expiratory Flow (PEF), Forced Vital Capacity (FVC), FEV1/FVC and the % of the predicted values achieved.
- 8 Most devices will indicate if the test is of poor quality, e.g. blow is too slow. If so, set the device for a new 'blow' and repeat.
- 9 Record data. Use print out option if available. The most sophisticated (and expensive) spirometers will print charts of volume against time and flow-volume loops.
- 10 Obtain data for three correct forced expirations.
- 11 Check that the data are satisfactory. Retain the data associated with the maximum FEV1. If necessary run some more tests, but do not allow the participant to hyperventilate or become tired.
- 12 When you have the data that you require, dispose of the mouthpiece as instructed by your teacher: either rinse and re-sterilise for re-use or place in bag for disposal of biological waste.
- 13 Change roles to obtain a second set of measurements. Switch off the device and start by entering the new participant details.

### **For your file**

- Make outline notes on the method that you used to obtain your data.
- Keep a glossary of key terms.

(see FACT SHEET: Lung function tests using spirometry for definitions of some terms)

- Make any necessary calculations and record the data obtained for the maximum FEV1 and others as available, such as PEF, FVC, FEV1/FVC or FEV1%/FVC, and the % of the predicted values achieved. (See FACT SHEET: Lung function tests using spirometry' for definitions of abbreviations).
- Suggest sources of error, including possible reasons for any differences in the values obtained for different trials.
- Identify and briefly suggest reasons for any differences that you observe between:
  - you and your partner
  - your measurements and the predicted values.

## FACT SHEET

# Lung function tests using spirometry

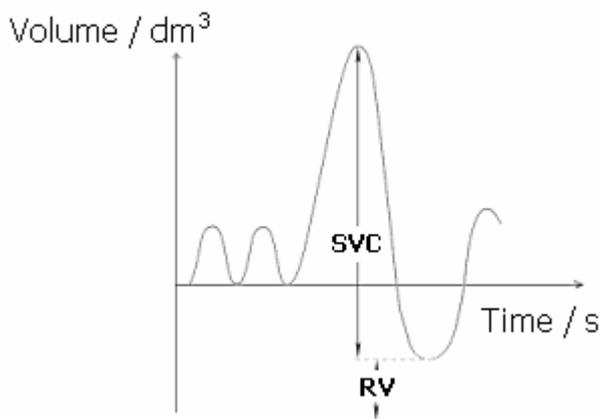
### Lung capacities and flow volumes

Volume displacement spirometers can be bellows, pistons or bells over water which move up and down as the patient breathes in and out of them. They can move a pen on a rotating drum (kymograph) to plot a chart of *breathing volumes against time*. Nowadays, electronic flow detection or turbine spirometers are replacing the older types. These produce computer generated charts of *flow* rates as well as volumes. For example, a spirometer can be used to find the vital capacity of the lungs.

### Slow Vital Capacity (SVC)

After a period of normal quiet breathing, the patient is asked to breathe in fully, then out slowly (or the other way round) to obtain the maximum total movement of air. A volume against time chart is plotted to give an "SVC curve". The residual volume (RV) of about 20-25% of the air is left in the lungs after full expiration. This cannot be measured using a spirometer. It requires a technique such as body plethysmography.

#### SVC curve



Lung volumes	
Inspiratory reserve volume IRV	Total lung capacity TLC
Tidal volume TV	
Expiratory reserve volume ERV	
Residual volume RV	

### Summary of lung volumes

- TV (Tidal volume) is the volume that flows in or out of the lungs with each breath during quiet breathing. (Normally about 7 cm<sup>3</sup>/kg)
- IRV (Inspiratory reserve volume) is the maximum amount of air that can be inspired in excess of the tidal volume. (Normally approximately 3.3 dm<sup>3</sup> in men and 1.9 dm<sup>3</sup> in women)
- ERV (Expiratory reserve volume) is the maximum amount of air that can be expired in excess of the tidal volume. (Normally approximately 1.0 dm<sup>3</sup> in men and 0.7 dm<sup>3</sup> in women).
- RV (Residual volume) is the volume left in the lungs after maximum expiration. (Normally approximately 1.2 dm<sup>3</sup> in men and 1.1 dm<sup>3</sup> in women).

- IC (Inspiratory capacity) is IRV + TV. FRC (Functional residual capacity) is ERV + RV ie volume remaining in the lungs at the end of a normal expiration.
- TLC (Total lung capacity) is IRV + TV + ERV + RV or SVC + RV. It is typically about 3 - 5 dm<sup>3</sup>. TLC increases when elasticity of the lungs is lost, e.g. in COPD, due to emphysema.
- VC or SVC (Vital capacity) is IRV + TV + ERV and is the maximum breath volume.

### Forced Vital Capacity (FVC)

Vital capacity can also be found for forced breathing. To measure the FVC the patient sits or stands, inspires fully, then expires all the air out of the lungs as fast as they can. Patients are often (but not always) also asked to complete the cycle by breathing in again as fast as they can.

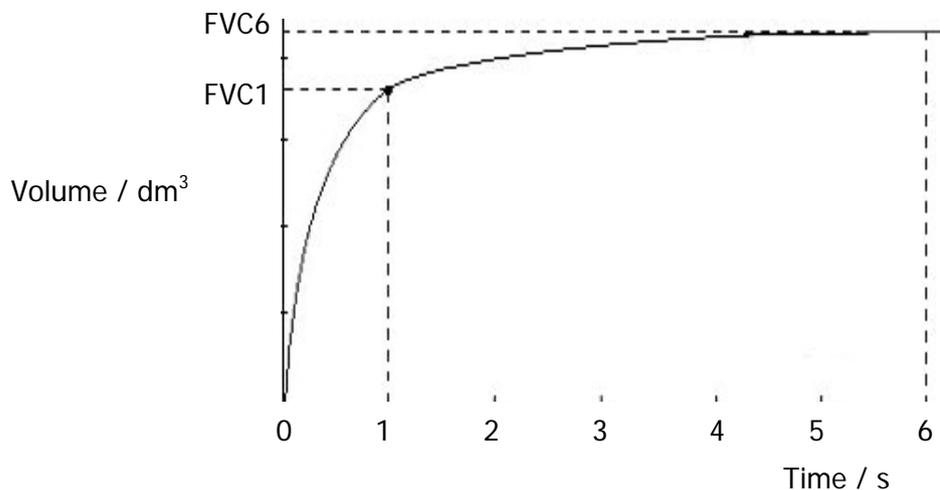
The test is usually repeated three times. The largest FVC value is used.

Normally FVC is similar to SVC, but it is often diminished with airflow obstruction. If the FVC is different to the SVC, a collapse of the small airways is suspected. This can occur in COPD, due to loss of elasticity in the lung tissue.

### Using flow rates for diagnoses

Using a flow spirometer, a *volume-time curve* and a *flow-volume loop* can be computer generated from the measurements of airflow made by the spirometer.

### The volume-time curve



The volume expired in the first second of the FVC test is called **FEV1**. It is a very important in spirometry.

The **FEV1%** (or FEV1%/FVC) is FEV1 divided by the **FVC** (Forced Vital Capacity) multiplied by 100:

$$\text{FEV1\%} = \text{FEV1/FVC} \times 100$$

Healthy patients expire between 70 and 90% of the air in the first second.

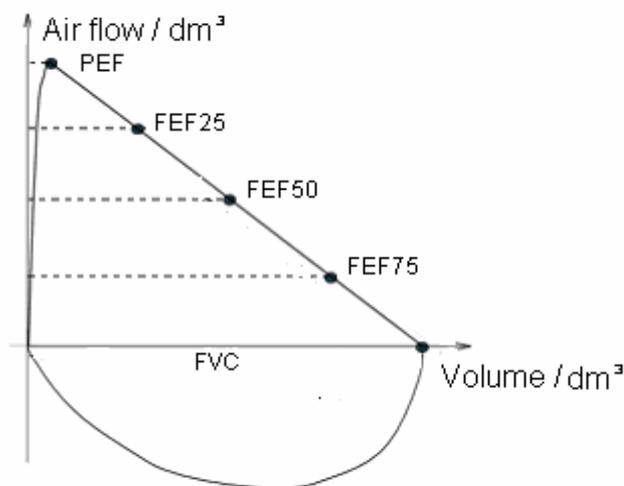
Note:

- a patient with an obstruction of the upper airways will show diminished FEV1%
- a FEV1% that is too high suggests a reduction of the lung volume.

**FEV1% predicted** can also be used, by calculating the value of the FEV1 as a percentage of the expected value for a healthy person of the same gender, height and ethnic origins.

**FEV6** is the volume of air expired after six seconds.

### The flow-volume loop



**FEV1%/FEV6** is increasingly being used by clinicians to replace FEV1%/FVC, as it gives more reliable results.

How much air is flowing is plotted against how much air has flowed. Time is **not** involved in the interpretation of the loop.

When the test starts, flow and volume are equal to zero.

As the patient exhales, the curve rises rapidly to the Peak Expiratory Flow (PEF). When performed correctly, this takes less than 150 milliseconds. The PEF is a measure for the air expired from the large upper airways (trachea-bronchi).

As flow diminishes the curve falls to FEF25, FEF50 and FEF75 as 25%, 50% and 75% of the total volume is expired.

The mean flow between the points FEF25 and FEF 75 is called the FEF25-75. This is often the first measurement that falls in many respiratory diseases, due to narrowing of small airways.

The **FVC** (Forced Vital Capacity) appears as the width of the widest part of the curve. The FVC is reached when the patient has breathed out all the air that they can, and the flow returns to zero (reaches the x-axis). If the patient breathes back in, the loop returns to the origin (negative air flow).

In a healthy patient, **FEV1** will occur when between 70 and 90% of the FVC has been exhaled. The remaining 10 to 30% of the FVC takes about five more seconds to exhale.

An airflow obstruction gives a concave curve. Rate of airflow out of the lungs decreases instead of remaining steady and the expiratory time is longer. This is found in 90% of COPD cases.

The results of the tests are compared to the predicted values that are calculated for age, height, weight, sex and ethnic group. These have been obtained from measurements of large numbers of people over many years. Airflow obstruction is defined as a reduced FEV1 (<80% of normal) and a reduced FEV1% (<70%). To diagnose COPD, the doctor must carry out a physical examination, consider the patient's medical history and confirm the presence of airflow obstruction using spirometry.

## FACT SHEET

# Spirometry

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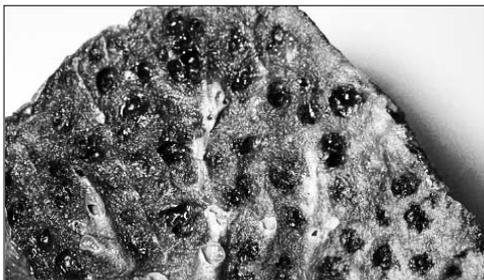
### Why use a spirometer?

A spirometer is a device for finding lung capacities and flow volumes. It provides a test of lung function based on the movement of air in and out of the lungs. It measures how much air and how quickly it can be moved. This gives a range of values which can be used to diagnose lung diseases and monitor their treatment.

A variety of spirometers is available. The latest versions use turbines. A sensor detects the rate of spin of the vanes and a computer converts this data into volumes. Their accuracy is unaffected by temperature, humidity and air pressure. It is possible to use them anywhere in the world without need for re-calibration.

### COPD

Chronic obstructive pulmonary disease (COPD) is characterised by airflow obstruction. The presence of airflow obstruction is confirmed by performing spirometry. The disease is predominantly caused by smoking. It has become one of the most important causes of death. It ranks as the fourth highest killer in Europe, seventh worldwide, and is rising up the table.



Most patients with COPD have a combination of chronic bronchitis and emphysema (see lungs, left). In emphysema, capillary and alveolar walls are destroyed, increasing the size of the airspaces in the lungs. This reduces the surface area to volume ratio for diffusion, so that blood fails to fully oxygenate.

Narrowing of the airways and increased secretion of mucus contribute to the obstruction. The body tries to compensate by increasing the lung volume and breathing rate. But, as the lungs become less elastic, increased effort compresses the airways so that breathing out takes longer.

COPD progresses slowly and early symptoms such as cough and sputum are usually insufficient for the patient to seek treatment. Consequently, a diagnosis is often not made until about half of the lungs' reserve capacity has been lost.

### COPD and spirometry

The National Institute for Health and Clinical Excellence (NICE) guidelines recommend that spirometry is performed on patients over the age of 35 who have a risk factor (generally smoking), exertion breathlessness, chronic cough, regular sputum production and frequent winter 'bronchitis' or wheeze.

Peak flow is often used as a measurement of lung function, but spirometry provides more accurate and comprehensive assessment. This makes it the early detection of COPD possible and allows its progress to be monitored. It also provides a means to distinguish COPD from asthma.

Faced with the facts revealed by spirometry, more smokers are persuaded to give up. This reduces the rate of decline of lung function and extends their life-expectancy.

## Teacher notes

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This activity links to **AQA A2 Unit 14: The Healthy body**

Here are the relevant sections of the specification that relate to this activity:

### **23.1 About this Unit**

*Those working in healthcare professions may be called on to take a number of measurements of the functions of human biological systems. These measurements can assist with diagnosis of disease, improvement of performance in sport, or recovery from illness or injury. In this unit you will consider some health and fitness measurements used to monitor the activity of the body.*

*In this unit you will learn about how monitoring the cardiovascular and pulmonary systems, and analysis of blood samples provides healthcare workers and sport scientists with information about a person's state of health and/or fitness.*

### **23.2 How you will be assessed**

*In this unit you will be required to complete an external examination of 1½ hours duration. The examination will consist of a series of compulsory short answer, structured questions and will be marked out of 80. You will be assessed on your knowledge, understanding and skills relating to the healthy body. You should ensure that you have a detailed knowledge and understanding of all the information in Section 23.3.*

*You must show that you know about **four** different indicators of physiological status for **at least two** individuals of different age, gender and lifestyle.*

### **23.3 You need to know, understand and be able to demonstrate**

#### **Cellular respiration**

*You should be able to explain methods of monitoring the respiratory system (breathing rate and volumes).*

### **Aims and teaching strategies**

This activity allows students to become familiar with the use of peak flow meters and spirometers to allow them to answer exam questions on methods for monitoring the respiratory system. The resources provide background information on the use of spirometers and procedures for the use of a peak flow meter, volume spirometer and turbine spirometer to measure flow rates and lung volumes.

The *Activity brief: Lung function testing* introduces the concepts of obstructive and restrictive breathing patterns and their causes. Students are set the tasks of working in pairs to use a peak flow meter and a spirometer. They are asked to investigate how these devices work and to suggest factors which affect the results. *Fact sheet: Spirometry* and *Fact sheet: Lung function tests using spirometry* provide background information on diagnosis of COPD (chronic obstructive disease) and lung volumes and capacities respectively. The former can be used to introduce the purpose of using spirometry and the latter can be referred to when discussing the results of the investigations.

*Study sheet: Using a peak flow meter* and *Study sheet: Using a spirometer* contain the procedures for using these devices. Either can be used first. Instructions are provided for using a volume displacement spirometer (Option 1) or a turbine spirometer (Option 2). If both are available and time permits, students could use both to contrast the results obtained

and their respective value in diagnoses. If you wish, class results could be combined for analysis. Results could be compared by plotting parameters against student height and /or gender, smokers versus non-smokers or athletes versus non-athletes.

As peak flow meters and spirometers are likely to be in short supply, the investigations would most easily be carried out over a period of time as part of a circus of investigations, including other aspects of human physiology such as those involving pulse rate, blood pressure and body temperature measurement. Peak flow measurement can be completed in about 10 minutes, including reading the instructions. Using a spirometer depends on the instrument available, but each pair will require about 30-60 minutes depending on competence and ease of use of the spirometer. Times taken can be reduced if the use of the instruments is demonstrated in advance.

The slope of the expiration on an FVC trace is comparable to the peak flow measurements obtained using a peak flow meter. The main difference is the time for the measurement: peak flow is recorded within 100 milliseconds of forced expiration, whereas the spirometry trace of FVC shows 80% of the total VC usually being expired in the first second.

Obtaining peak flow measurements is very quick and easy and the devices are cheap. But values can vary significantly and are very effort dependant. Use of peak flow to diagnose and follow up asthma is acceptable, if limited. It is valuable as an aid to sufferers, who can monitor their own peak flow at home. It is also often used in diagnosis and follow up of COPD, for which it is not adequate because peak flow is usually only affected in moderate or severe cases. COPD needs to be detected and treated as early as possible, and this demands spirometric testing.

The *Equipment and materials requirements* section below includes links to spirometer operating manuals and interactive demonstrations. These can be used to introduce the use and nature of turbine spirometers, if none are available at your centre.

Although dyspnoea (breathlessness) is an indicator of COPD and asthma, the value of respiratory rate as an indicator of potential respiratory dysfunction has been called into question. Its use as a vital sign is valuable when monitoring to assess if a change has taken place in the status of a patient, rather than as a diagnostic tool. Low oxygen saturation of the blood can occur without a noticeable increase in respiratory rate. Wikipedia reports one study of babies less than six months old, in which approximately half had a respiratory rate above 50 breaths per minute, despite the normal "cut-off" of 50 breaths per minute as the indicator of serious respiratory illness. (Not confirmed).

## **Equipment and materials requirements**

*Study sheet: using a peak flow meter*

Each pair need:

- peak flow meter and specific instructions if available
- disposable mouthpieces or sterilised mouthpieces
- disposal bag or container of disinfectant for used mouthpieces

*Study sheet: using a spirometer*

Each pair will need:

- volume displacement spirometer - various types exist based on the same principle
- kymograph or chart recorder or movement transducer, PC and software to suit device
- disposable mouthpieces or sterilised mouthpieces

- disposal bag or container of disinfectant for used mouthpieces
- nose clip (optional)
- oxygen cylinder
- soda lime [CORROSIVE]

### *Spirometers*

An enormous range of spirometers is available. Volume displacement spirometers can be obtained for about £500-800, but can be difficult to set up and use. They may require additional software and movement transducers for charting. See, e.g.

<http://www.griffinandgeorge.co.uk/>, <http://www.schools.plc.uk>.

Cheap but limited turbine spirometers are available from about £100 (e.g. Micro Medical Pulmo Life). See:

[http://www.micromedical.co.uk/products/proddetail1.asp?spiro\\_id=120#top](http://www.micromedical.co.uk/products/proddetail1.asp?spiro_id=120#top)

For an interactive demo:

<http://www.micromedical.co.uk/flashfiles/pulmolife/pulmolifedemo/PulmoLife3a.html>

For information on other hand-held spirometers and more interactive demos, see:

<http://www.micromedical.co.uk/products/prodgen5.asp?type=Handheld%20Spirometers>

The more sophisticated turbine types start at just over £500 (including software).

For links to operating manuals, see: <http://www.pmsinstruments.co.uk/spirometers.htm>

e.g. Micro GP manual includes examples of readouts and charts (page 8):

<http://www.pmsinstruments.co.uk/pdf/MICRO%20GP%20Operating%20Manual.pdf>

The Pasport school flow spirometer is available from Pasco:

[http://store.pasco.com/pascostore/showdetl.cfm?&DID=9&Product\\_ID=54397&Detail=1](http://store.pasco.com/pascostore/showdetl.cfm?&DID=9&Product_ID=54397&Detail=1)

Some advice is available from ASE, see [www.ase.org.uk](http://www.ase.org.uk)

Use of a spirometer in a Human Performance Laboratory to measure breathing volumes and gas exchange of an athlete is shown in a video clip in *the Scientists at Work* package (see <http://www.4science.org.uk/products-science-enhancement.htm>)

## **Health and safety**

Students should carry out risk assessments and these should be checked before they start any activity.

Students must always be supervised when using a spirometer. Take care if students have respiratory problems such as asthma: students may be advised not to take part in tests if they have reason to believe it may affect their health. Wear eye protection when handling soda lime and avoid raising dust. (Eye protection is not needed when using a spirometer).

### *Infection Control*

Precautions must be taken to minimise any risk of cross-infection. Disposable mouthpieces or those with more specialized filters are an option for some models. The use of low resistance barrier filters significantly reduces the risk of cross-infection and also helps protect the equipment. A new filter must be used for each user. Re-useable mouthpieces must be cleaned and disinfected between users. Make sure the mouthpiece is washed and sterilised for at least half an hour using Milton's fluid or equivalent, in between tests. It is useful to have several mouthpieces available. For detailed guidance on safety using spirometers, refer

to the CLEAPSS Laboratory Handbook (section 14.5.1). This is also available on CLEAPSS Science Publications CD-ROM (updated annually).

Students may be worried by their results. Take an opportunity to explain that there is wide individual variation for a large number of reasons, many of which are not health related. Diagnosis of conditions requires using other information including medical history. Some causes of variation are given in the table:

### Larger volumes

males

taller people

non-smokers

athletes

people living at high altitudes

### Smaller volumes

females

shorter people

heavy smokers

non-athletes

people living at low altitudes

People of African descent tend to give lower volume readings because of a shorter thorax compared to Europeans. Some devices can make ethnic corrections. If they do not, these can be calculated.

### Ethnic corrections

*% drop for standardised lung function testing* European Respiratory Society 1993

White European and Hong Kong Chinese as standard

Polynesians, Northern Indians and Pakistanis 10%

Japanese American 11%

Southern Indians and Africans 13%

### Other useful websites

[http://oac.med.jhmi.edu/res\\_phys/Encyclopedia/Spirometry/Spirometry.HTML](http://oac.med.jhmi.edu/res_phys/Encyclopedia/Spirometry/Spirometry.HTML)

<http://www.spirxpert.com/welcome.htm>

[http://www.nationalasthma.org.au/HTML/management/spiro\\_book/sp\\_bk001.asp](http://www.nationalasthma.org.au/HTML/management/spiro_book/sp_bk001.asp)

<http://www.nice.org.uk/nicemedia/pdf/CG012quickrefguide.pdf>

<http://www.asthma.org.uk/>

<http://www.nhsdirect.nhs.uk>

(e.g see <http://www.nhsdirect.nhs.uk/articles/article.aspx?articleId=540>)

[http://student.bmj.com/back\\_issues/0499/data/0499ed1.htm](http://student.bmj.com/back_issues/0499/data/0499ed1.htm)

[http://www.mortonmedical.co.uk/clement\\_clarke\\_All-Flow\\_Spirometer.htm](http://www.mortonmedical.co.uk/clement_clarke_All-Flow_Spirometer.htm) (spelling correct for URL)

<http://www.pmsinstruments.co.uk/acatalog/Spirometers.html>

<http://www.micromedical.co.uk/downloads/pdf/PulmoLife.pdf>