

INVESTIGATIONS OF RESPIRATORY SYSTEM IN MAN

A. Clinical Examination

In the clinical examination of the chest the usual sequence of inspection, palpation, percussion and auscultation are used. Strip one of your group members to the waist and perform the following examination.

Inspection. Note the shape and degree of expansion of the chest in its different diameters (upper, middle and lower zones) during quiet respiration. *Which region shows the greatest movement?*

Palpation. Place the palm of the hand on the back of the subject's chest and notice whether any vibrations are felt during normal respiration. Ask the subject to utter the words “nyama nyama” loudly while you place the ulnar edge of the hand in an intercostal space with the least amount of overlying muscles and feel for vibration transmitted to the surface. Check the equality of expansion of the two sides of the chest with inspiration. The technique of doing this will be demonstrated to you.

Percussion. Percuss over the upper front or back of the chest and note the character of the resonant sound produced by the normal air-filled lung.

Auscultation. The turbulence set up as air moves through the airways in the lung causes vibrations which can be heard by the application of the ear to the chest wall, or more conveniently through a stethoscope. These are called breath sounds. Listen with a stethoscope over the infrascapular region of the chest while the subject breathes normally. Carefully compare the inspiratory sound and the expiratory sound with regard to the following points. Note them down.

1. *Relative length of time for which each is heard*
2. *Whether the sound is it heard throughout the period of the mechanical movement*
3. *Loudness*
4. *Pitch*
5. *Whether there is a pause between inspiration and expiration sounds*

The type of breath-sounds you have heard is called **vesicular** breathing. Now listen over the trachea. And carefully observe the same four points. The type of breathing you hear now is called **bronchial** breathing. *How does it differ from vesicular breathing?*

B. Spirometry

Many important aspects of lung function can be determined by measuring airflow and the corresponding changes in lung volume. This can be done using a traditional **bell spirometer**, in which the level of a floating bell tank gave a measure of lung volume changes. Flow of air through the respiratory system, F , can then be calculated from the slope (rate of change) of the volume curve, V :

$$F = \frac{dV}{dt}$$

More conveniently, airflow can be measured directly with a **pneumotachometer** (from Greek roots meaning “breath speed measuring device”). The *PowerLab* pneumotachometer arrangement is shown in Figure 2. The flow head contains a fine mesh. Air breathed through the mesh gives rise to a small pressure difference proportional to flow rate. Two small plastic tubes transmit this pressure difference to the **Spirometer Pod**, where a transducer converts the pressure signal into a changing voltage that is recorded by the *PowerLab* and displayed with the Chart software. The volume, V , is then calculated as the integral of flow:

$$V = \int F dt$$

Familiarise yourself with the working of the *pneumotachometer* and how the subject is connected to the apparatus. These will be pointed out to you and consist of the following:

A computer system

Chart software

Spirometry extension

PowerLab

Spirometer Pod

Respiratory flow head (1000 L/min) with connection tubes

Clean bore tubing

Disposable filters

Disposable vinyl mouthpieces

Nose clip

Tape measure or wall chart for measuring height

Vital capacity prediction tables

C. **Determination of lung volumes**

Setting up the apparatus

1. Connect the Spirometer Pod to the Pod Port for Input 1 on the PowerLab.
2. Since the Spirometer Pod is sensitive to temperature and tends to drift during warm-up, we recommend that the PowerLab and Spirometer Pod be turned on for at least 5-10 minutes before use. To prevent temperature drift, place the Spirometer Pod on the bench beside the PowerLab, away from the PowerLab power supply to avoid heating.
3. Connect the two plastic tubes from the respiratory flow head to the short pipes on the back of the Spirometer Pod, as shown in Figure 1
4. Attach clean bore tubing, a filter and mouthpiece to the flow head.

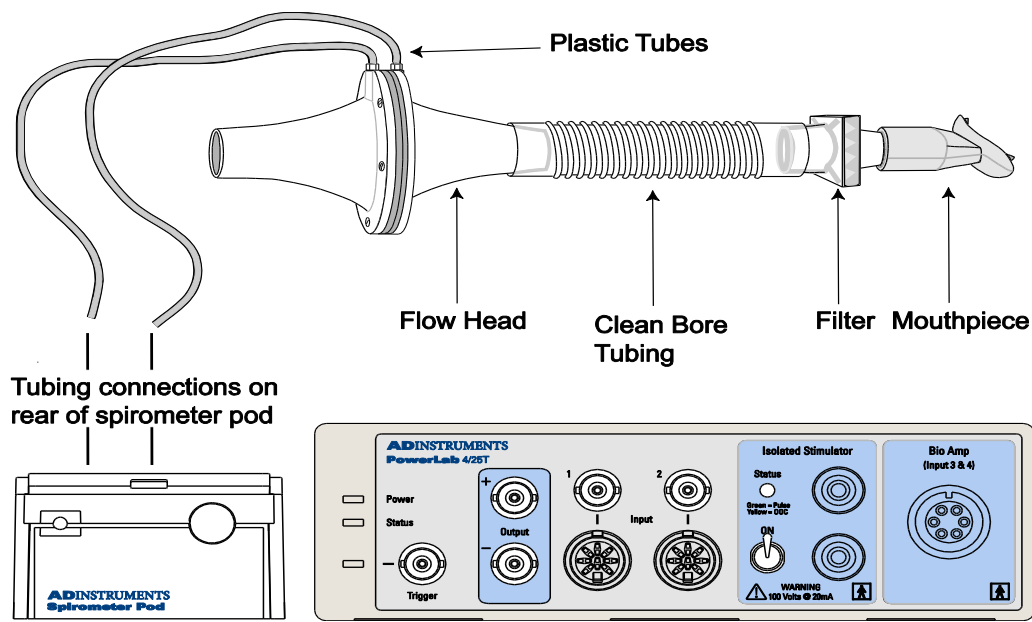


Figure 1. PowerLab pirometry assembly

- 5. Observe necessary hygiene by ensuring that a clean mouthpiece and air filter is used for each subject.

The technologist will start the software for you and supervise the operations of the equipment including the initial or pre-test calibration. Please follow his/her directions.

Connect the subject to the spirometer as shown in the diagram below (Figure 2) and have him/her breathe normally for about a minute to get accustomed to the set up. Note in particular that the subject must have his/her nose clipped to prevent any air going through the nose.

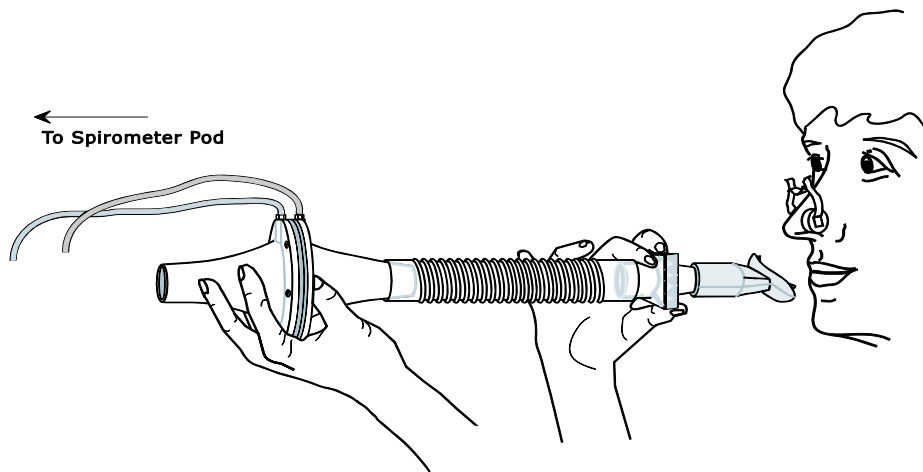


Figure 2. How to hold and position the spirometer assembly

Once the subject is accustomed to the equipment, make measurements of tidal volume for about 30 sec and then have the subject perform a full inspiration once followed by normal breathing. Annotate this on the chart as "IRV". Record the volunteer's tidal breathing for a further half a minute and annotate "Normal tidal volume" on the chart. Then have the subject perform a full expiration and annotate the tracing as "ERV". Use your measurements to calculate the subject's vital capacity (VC).

What other respiratory volume have you not measured?

Measure the average respiratory rate and calculate the minute volume.

Now ask the subject to make a maximal inspiration immediately followed by a maximal expiration. Measure the vital capacity (**slow vital capacity**) from this tracing and compare it with the value obtained earlier. *Account for any difference you observe.*

D. Determination of the Forced Expired Volume in 1 second (FEV₁).

Have the subject breath normally for about half a minute then ask him/her to inhale maximally and then exhale as forcefully and fully as possible then breathe normally. The subject should ensure that there is no pause between inhalation and expiration. Annotate the tracing appropriately as "Forced breathing". Repeat the procedure three times and take an average of the readings.

Do this for several members of either gender in your group and measure the forced expiration parameters (PIF, PEF, FVC and FEV₁) in all the subjects. The technologist will demonstrate how this can be obtained from the tracings.

What are the values of FEV₁ for your group?

What are the values of the ratio FEV₁/VC for your group?

How is FEV₁ and FEV₁/VC ratio affected by the introduction of

- (i) a resistance to air flow and*
- (ii) limiting chest expansion?*

This test is useful for assessing diseases which increase airways resistance by narrowing of the bronchiolar lumen.

F. Breath holding time

During this experiment, you will require a respiratory belt transducer in addition to the Power Lab assembly used in the other experiments.

Fasten the respiratory belt around the upper abdomen of a volunteer, as shown in Figure 3 and connect the other end to the Power Lab. The transducer should be at the front of the body, level with the navel, and the belt should fit snugly.

It is important when recording normal respiration that the volunteer is facing away from the computer screen, and is not consciously controlling breathing.

Note: The respiratory belt transducer can be used over clothing, and it doesn't matter whether the volunteer is sitting or standing, as long as they are comfortable (note that this is quite a long exercise). Because everyone's breathing patterns differ, the position of the transducer may need to be changed to get the best signal.

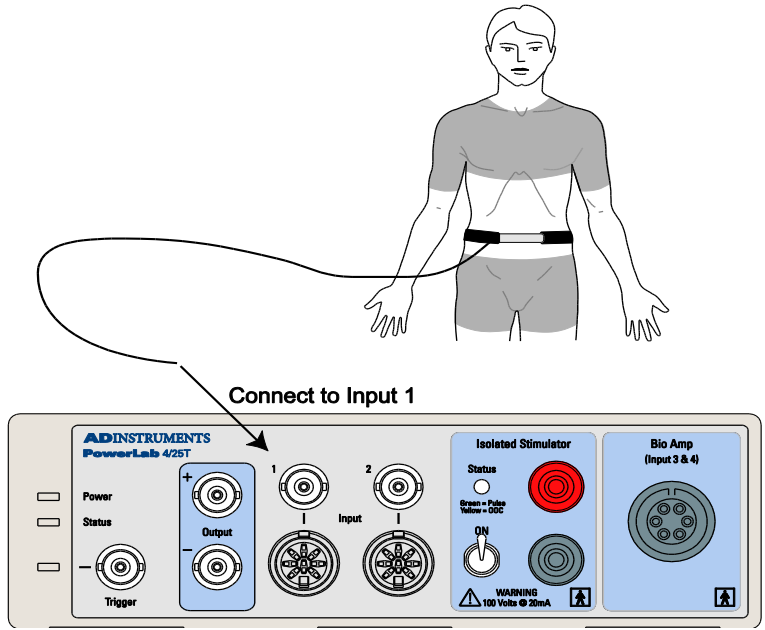


Figure 3. Attachment of the Respiratory belt. transducer

Ask the volunteer to take deep, strong breaths and observe the signal in the Input Amplifier dialog. Adjust the instrument settings such the trace occupies about 3/4 of the screen.

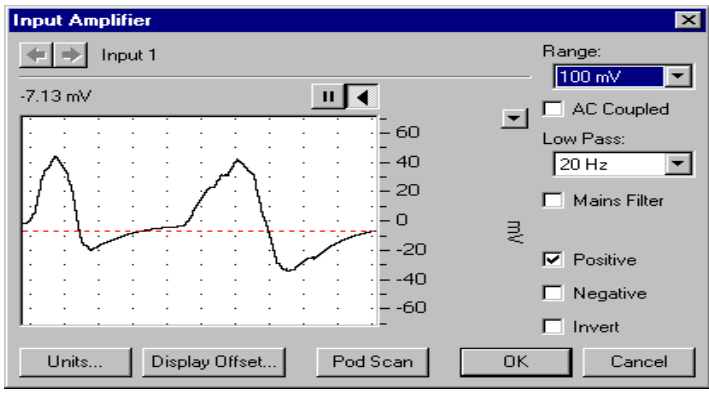


Figure 4. Input amplifier dialog box.

Record one minute of normal, quiet breathing and mark the trace as baseline. Ask the subject to take a deep breath and hold it in for as long as possible. Annotate the trace at the beginning of breath holding appropriately with comment "Inhale hold" and at the end with the comment "breathe". Continue recording until the baseline rate is re-established. Ask the subject to exhale fully and then hold the breath for as long as possible. Annotate the trace appropriately with "exhale hold" and "breathe" at the beginning and at the end of the breath holding exercise respectively.

Repeat the experiment as above and ask the subject to swallow repeatedly (three times) when he/she approaches the break-point determined earlier and observe the effects on the duration of the breath-holding.

Now ask the rested subject to breath as deeply and as fast as possible for 30 seconds then repeat the breath holding experiments in this sequence:

- Hyperventilate Inhale hold Rest
- Hyperventilate Exhale hold Rest

Safety Note:

Should the volunteer develop giddiness or dizziness while hyperventilating, stop the procedure, but continue to record the respiratory response.

If the volunteer feels unwell, have them re-breathe expired air by cupping hands over nose and mouth for a few minutes or breathing into the paper bag provided for the next exercise.

E. Resting oxygen consumption and metabolic rate

Insert the soda lime canister and fill the spirometer with pure oxygen. Connect the subject through the rubber mouth piece to the apparatus, clip the nose and leave the subject to breathe in and out from the atmosphere so that he becomes accustomed to the situation. Now turn the tap so that the subject's lungs are connected to the bell of the spirometer and obtain a record over a period of 6-10 mins with the subject at rest. The record shows an upward trend. What is the reason for this? Draw the best possible straight line to indicate the slope of the tracing and calculate the subject's oxygen consumption per min. Assuming that a litre of oxygen at S.T.P. yields 4.8 kilocalories², calculate the subject's energy expenditure at rest.

From the subject's height and weight obtain his surface area from the nomogram provided. Express his energy expenditure in Kcals/m²/Hr. Compare the resting energy expenditure in kilocalories and Kcals/m²/Hr for the group. Which of these shows the greater degree of variability? What is the difference between the resting metabolic rate (which you have measured) and the basal metabolic rate? What do you expect to observe in the recording if the soda lime canister was not working adequately?

G. Oxygen consumption during exercise

Examine the cycle ergometer. Note that the load against which the subject has to work can be varied by tightening the braking strip against the driven wheel. The force (F) exerted by the subject at the periphery of the driven wheel is then indicated by the position of the weighted pendulum. (This scale reads in kilopounds)

1 kilopound = the force acting on the mass of 1kg. at the normal acceleration of gravity. The total amount of external work done by the subject (Force X distance) assuming frictional losses are minimal) $2r \times F \times C$. Kilopound meters per min (Kpm/min)

Where r = radius of the driven wheel in metres

F = force exerted at periphery of the wheel in kilopounds

C = number of revolutions per minute of the driven wheel.

Ask the subject to turn the pedals to the rhythm of the metronome which is set to tick at 60 times per minute such that 1/2 a turn of the pedal is made for every tick (i.e. 30 pedal turns per minute; the driven wheel turns more because of the gearing ratio). Adjust the tension of the braking band such that the force indicated by the pendulum indicator is about 1 Kilopond, Connect up the subject ready for recording his oxygen consumption as in experiment E. With the tap open to the atmosphere let the subject pedal at the predetermined rate (30 revs/min) and against the predetermined force (1 Kilopond) for about 2 minutes. This permits the cardiorespiratory apparatus of the subject to adjust to the new conduction and for him to reach a steady state. Now determine his oxygen consumption over a 2 min. period by turning the tap and making him breath in and out of the sprimeter filled with pure oxygen. Determine his pulse rate while still pedalling steadily. Repeat, if necessary after a brief rest, as slightly higher forces (e.g. 2 kilopond and 2 1/2 kilopond). Plot pulse rate against oxygen consumption and extrapolate to a pulse rate of 170.

The oxygen consumption at a pulse rate of 17 is an indication estimate of the subject maximum aerobic capacity, i.e. the maximum rate of transfer of oxygen to muscle and is an of the total capability of the cardio-respiratory apparatus. It can be taken as a measure of physical fitness.

Calculate mechanical efficiency as:-

External work done in 1 min in Kilopounds x 100

O₂ consumption in 1 min x 4.8 x 426.85

1 Kilocalorie = 426.85kpm. = 4186 joules = 4.816 x 10¹⁰ ergs).

