Measuring Lung Capacity

Applications

Monitoring of ventilation in humans at rest and after mild and vigorous exercise. (Practical 6)

Background:

In an investigation of the effect of exercise on ventilation, the type or intensity of exercise is the independent variable and the ventilation parameter that is measured is the dependent variable.

A simple approach for the independent variable is to choose levels of activity ranging from inactive to very active, such as lying down, sitting and standing, walking, jogging and sprinting. A more quantitative approach is to do the same activity at different measured rates, for example running at different speeds on a treadmill. This allows the ventilation parameters to be correlated with work rate in joules per minute during exercise.

Ventilation of the lungs is carried out by drawing some fresh air into the lungs and then expelling some of the stale air from the lungs. The volume of air drawn in and expelled is the **tidal volume**. The number of times that air is drawn in or expelled per minute is the **ventilation rate**. It is possible to inhale more deeply and exhale more forcefully than usual. The maximum amount of air moved in and out of the lungs when the deepest possible inspiration is followed by the strongest possible expiration is called **vital capacity**.

Tidal volume or ventilation rate can be the dependent variable in an investigation of the effect of exercise on ventilation rate. They should be measured after carrying on an activity for long enough to reach a constant rate.

Aim:

To practice measuring ventilation rates, tidal volumes, and vital capacities.

Research Question:

What are my resting ventilation rates, resting tidal volume, and resting vital capacity and how will they change after exercise?

Hypothesis: (fill in)

Measuring Lung Capacity

Procedure

1. **Measuring Ventilation Rate:**
   The most straightforward way to measure ventilation rate is by simple observation. Count the number of times air is exhaled or inhaled in a minute. Breathing should be maintained at a natural rate, which is as slow as possible without getting out of breath. Ventilation rate can also be measured by data logging. An inflatable chest belt is placed around the thorax and air is pumped in with a bladder. A differential pressure sensor is then used to measure pressure variations inside the belt due to chest expansions. The rate of ventilations can be deduced and the relative size of ventilations may also be recorded. (Record in Table 1)

2. **Measuring Tidal Volume:**
   Balloon Method
   a) Stretch a round balloon lengthwise several times.
   b) Inhale normally and then exhale normally into the balloon. (**Do Not Force Your Breathing)**
   c) Immediately pinch the end of the balloon so that no air escapes.
   d) Measure the diameter of the balloon at its widest point.
   e) Complete two more trials and record all data in Table 2.

   f) Convert the balloon diameters into a measurement of lung capacity by using figure 2. Find your average balloon diameter on the X-axis and extrapolate the Lung Volume on the Y-axis. Record in Table 2.

Figure 1 : Measuring balloon diameter

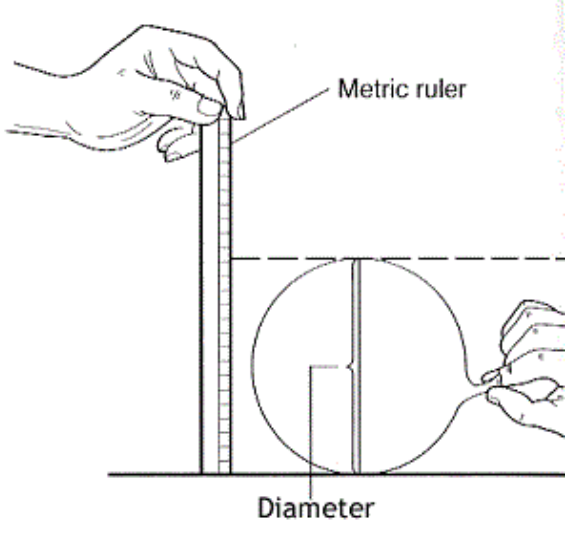
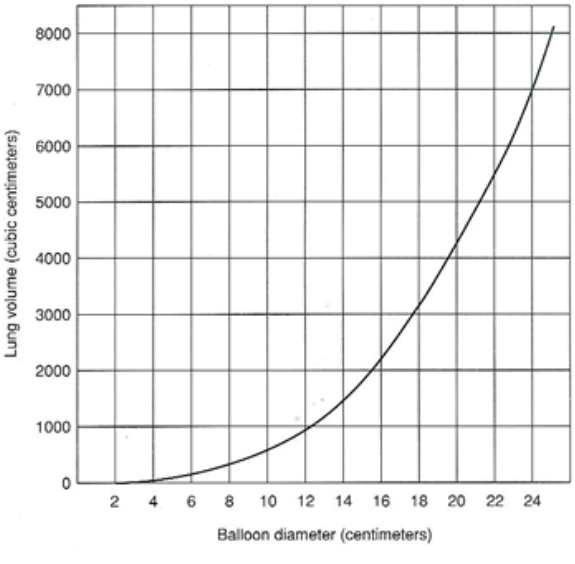


Figure 2: Balloon diameter to Lung Volume conversion.



Measuring Lung Capacity

3. Measuring Vital Capacity

Balloon Method

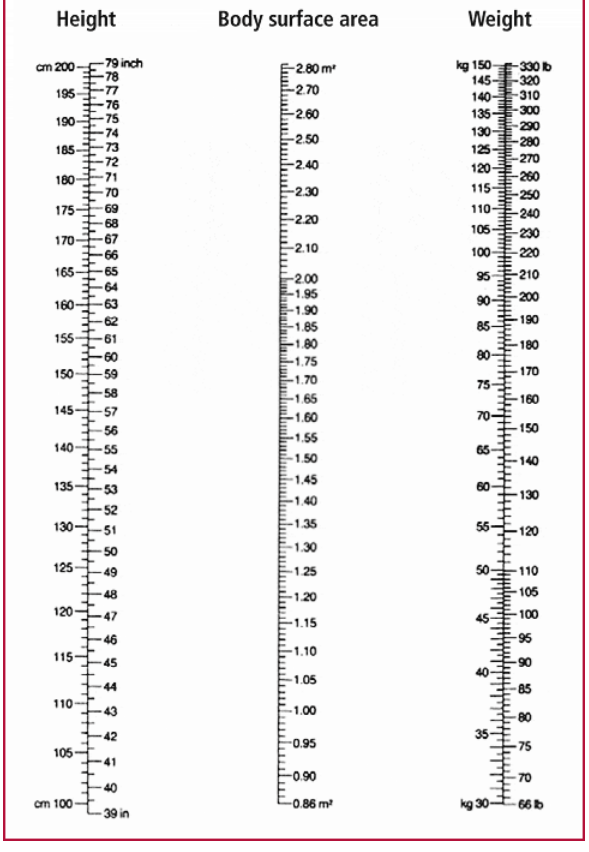
a) After breathing normally, inhale as much air into your lungs as possible. Exhale as much air as you can from your lungs into the balloon.
b) Immediately pinch the end of the balloon so that no air escapes.
c) Measure the diameter of the balloon at its widest point.
d) Complete two more trials and record all data in Table 3.
e) Convert the balloon diameters into a measurement of lung capacity by using figure 2. Find your average balloon diameter on the X-axis and extrapolate the Lung Volume on the Y-axis. Record in Table 3.

Estimated Vital Capacity Method

a) Research has shown that the capacity of a person's lung is proportional to the surface area of his or her body. To find your surface area, record in Table 4 your height in cm and mass in kilograms.

b) Use Figure 3 to estimate the surface area of your body. Find your height in centimeters on the left scale. Mark this point. Find your mass in kilograms on the right scale. Mark this point. **Use a ruler to draw a straight line to connect the points**. Where your line crosses the center scale is your surface area. Record this in Table 4.

Figure 3: Nomogram of Body Surface Area



Measuring Lung Capacity

c) To calculate your estimated vital capacity of your lungs, multiply your surface area by the ration of vital capacity to surface area. For males the ratio is 2500 ml per square meter. For females this ratio is 2000 ml per square meter. Record you calculation in Table 4.

Respirometer Method

a) Obtain a respirometer and place a disposable mouthpiece on the end of the respirometer.
b) Turn the dial to the 0 setting.
c) Place your lips firmly around the mouthpiece and blow as hard as possible. (It helps to pinch your nostrils to keep air from escaping)
d) Repeat two more trials and record in Table 5.

4. Perform an activity that changes your pulse rate then repeat the ventilation measurements and vital capacity with the balloon or respirometer. Record your data in Table 6.

Data/Observations

Table 1: Resting Ventilation Rate

Trial #	Breaths/Min
1	
2	
3	
Average	

Table 2: Tidal Volume Diameter/Lung Volume

Trial #	Diameter of Balloon (cm)	Lung Volume (cm^2)
1		
2		
3		
Average		

Measuring Lung Capacity

Table 3: Vital Capacity Balloon Diameter/Lung Volume		
Trial #	Diameter of Balloon (cm)	Lung Volume (cm^2)
1		
2		
3		
Average		

Table 4: Body measurements for calculating Vital Capacity	
Body Component	**Measurements**
Height (cm)	
Mass (kg)	
Surface Area (m^2)	
Vital Capacity (cm^3)	

Table 5: Vital Capacity of Respirometer	
Trial #	Respirometer Reading
1	
2	
3	
Average	

Table 6: Post-Exercise Ventilation Rate and Vital Capacity		
Trial #	Ventilation Rate (Breaths/Min)	Vital Capacity
1		
2		
3		
Average		

Measuring Lung Capacity

Analysis

Compare your subjects' vital capacity and variables listed (height, weight, sex..etc)

Subject	**Subject Statistics**					**Average Vital Capacity**		
	Sex	Age	Height	Weight	Activity Level (low, medium, high)	From Balloon	From Nomogram Calculation	From Respirometer
Me								

Conclusion:

1. Why is it important to measure tidal volume and vital capacity three times and calculate averages for these measurements?

2. How do your tidal volume and vital capacity compare with those of other class members?

3. Based on your limited data, which factors had the **greatest** impact on vital capacity?

Measuring Lung Capacity

4. How does your estimated vital capacity compare to your measured vital capacity?

5. Why might it be important to know a person's tidal volume or vital capacity?

6. How might an athlete's vital capacity compare to a non-athlete? Explain your reasoning.

7. Do you think the person with the greatest vital capacity can hold their breath longer than those with a lower vital capacity? (Consider the difference between internal respiration and external respiration and explain why lung capacity may not have a great effect on length of time you can hold your breath.)