Physiology Lab.
Pulmonary function tests

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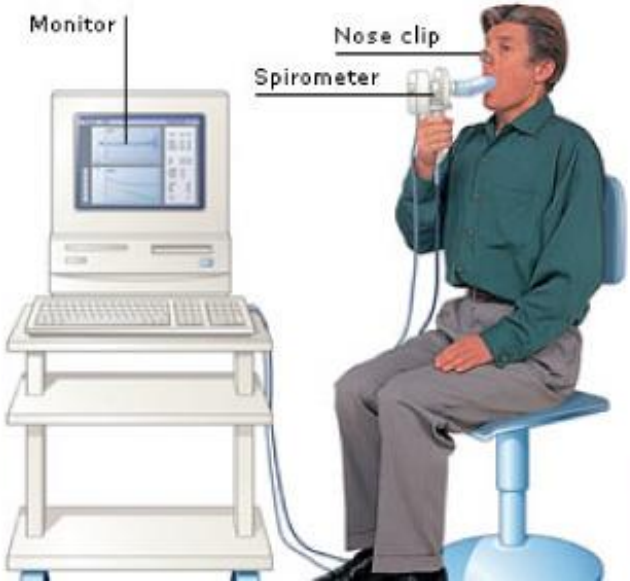
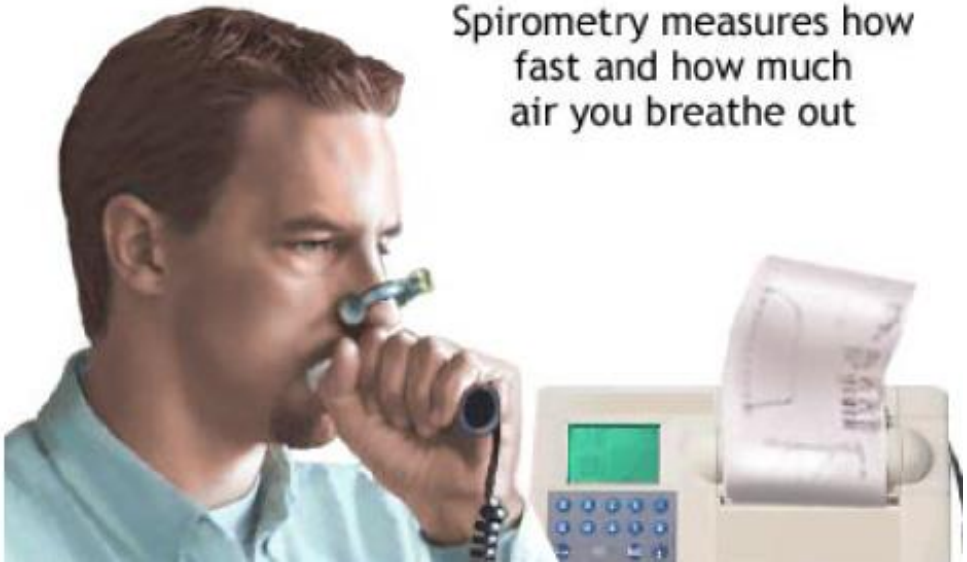
Spirometry

- A common test used to assess how well your lungs work by measuring how much air you inhale, how much you exhale and how quickly you exhale.


Patient takes a deep breath and blows as hard as possible into tube
Clip on nose
Technician monitors and encourages patient during test
Machine records the results of the spirometry test


Monitor
Nose clip
Spirometer


Spirometry measures how fast and how much air you breathe out

Setting steps

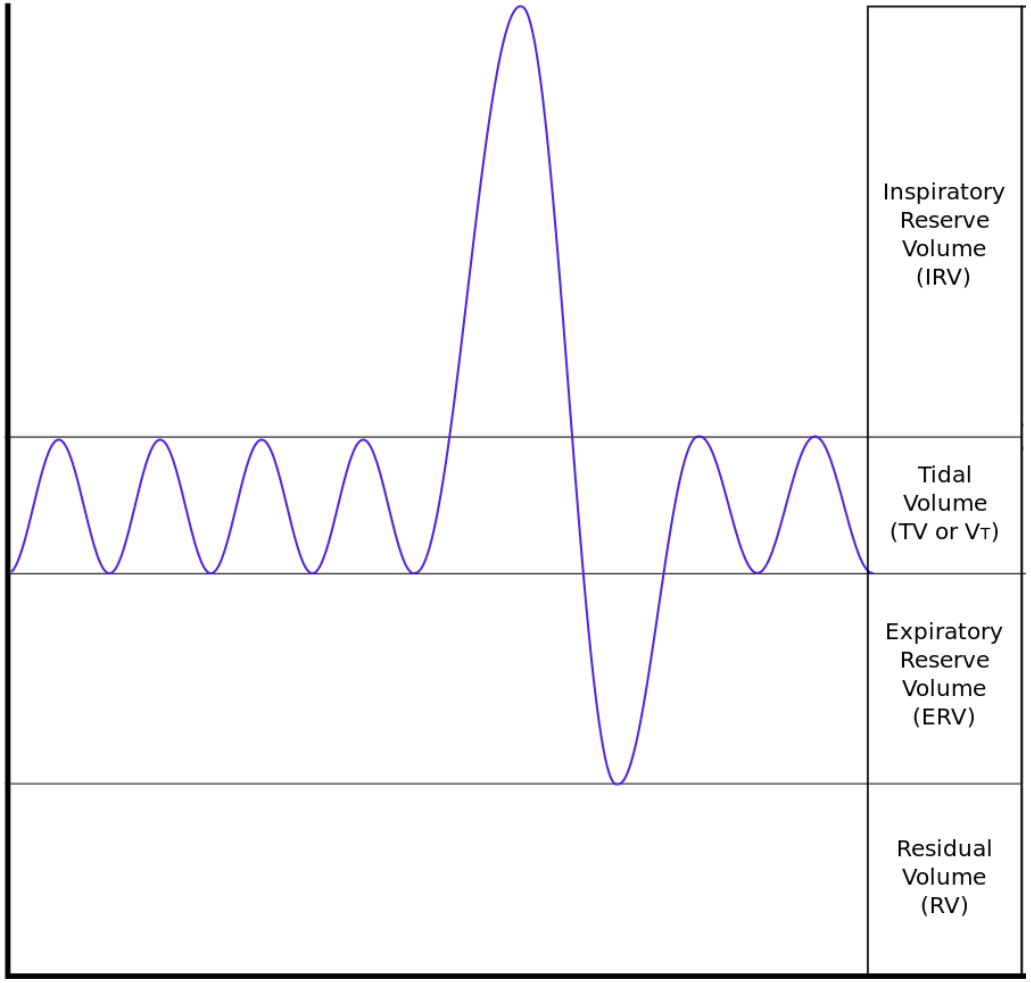
1- Put the nose clip on

2- Begin with normal breathing

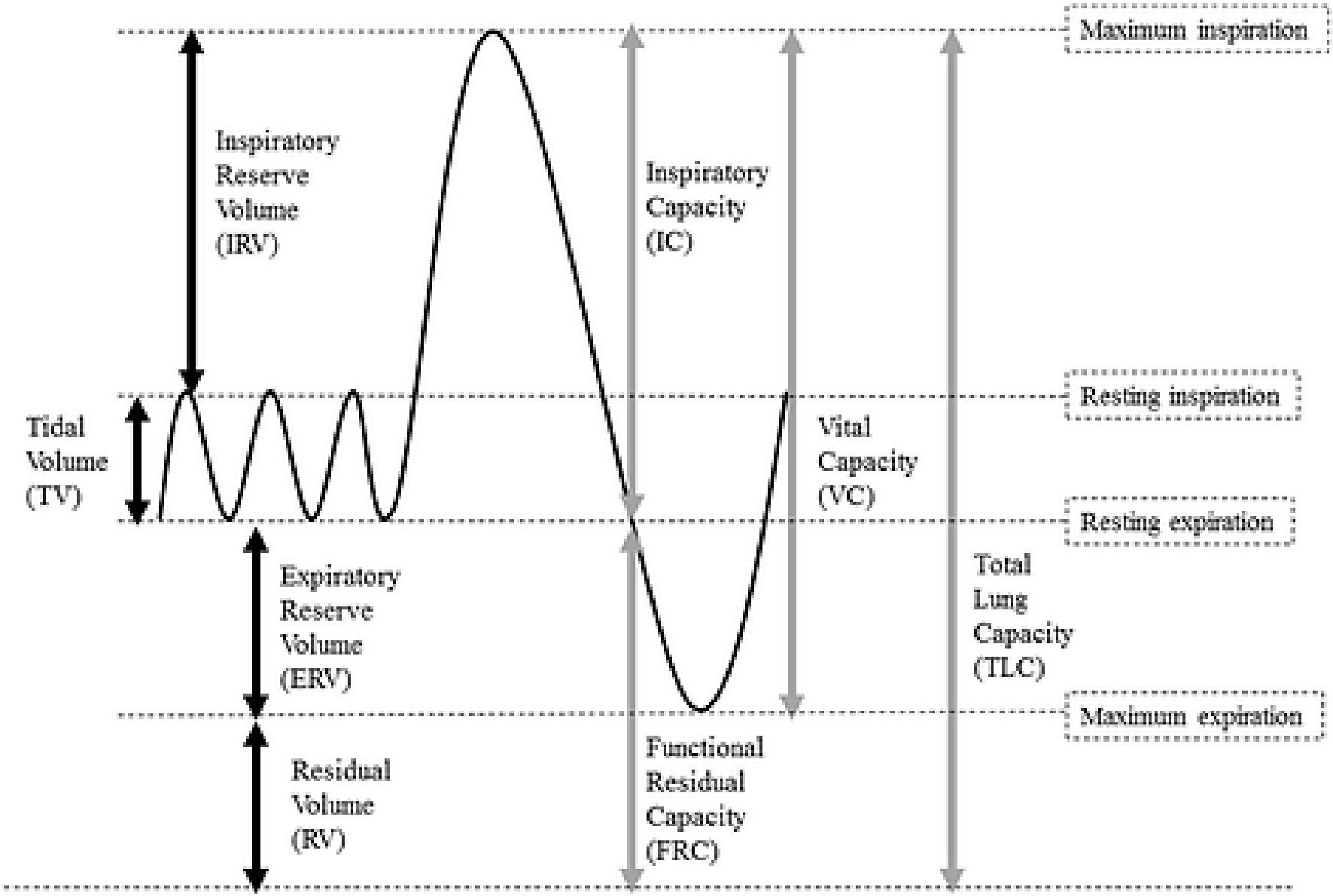
3- Take a fast deep breath in and blast it out

Lung volumes

- **Tidal volume (TV)** = 500 ml
  Vol. of air inspired or expired per each cycle of normal quiet breathing(**eupnea**)
- **Inspiratory reserve volume (IRV)** = 3000 ml
  Vol. of air which can be inspired by **maximum forced inspiration** ***AFTER*** normal inspiration.
- **Expiratory reserve volume (ERV)** = 1100 ml
  Vol. of air which can be expired by **maximum expiration** ***AFTER*** normal expiration.
- **Residual volume (RV)** = 1200 ml
  Vol. of air remaining in the lung after maximal expiration.
  Can't be tested by spirometry.



Lung capacities



1- Inspiratory capacity (IC):

- It is the volume of air that can be inspired by maximal inspiratory effort ***After*** the end of normal resting expiration
- IC = TV + IRV = 500 + 3000 = 3500 ml.

2- Expiratory capacity (EC):

- It is the volume of air that can be expired by maximal expiratory effort ***After*** the end of normal resting inspiration
- EC = TV+ERV =500+ 1100 =1600 ml.

3- Functional residual capacity (FRC):

- It is volume of air remaining in lungs after normal expiration.
- FRC = ERV + RV = 1100 + 1200 = 2300 ml.

Can't be tested by spirometry.

4- Vital capacity (VC):

- Volume of air expired maximally after maximal inspiration.
- VC= IRV + TV + ERV = 3000 + 500 + 1100 = 4600 ml.

5- Total lung capacity (TLC):

- Volume of air present in the lung at end of maximal inspiration.
- TLC = VC + RV = 4600 + 1200 = 5800 ml

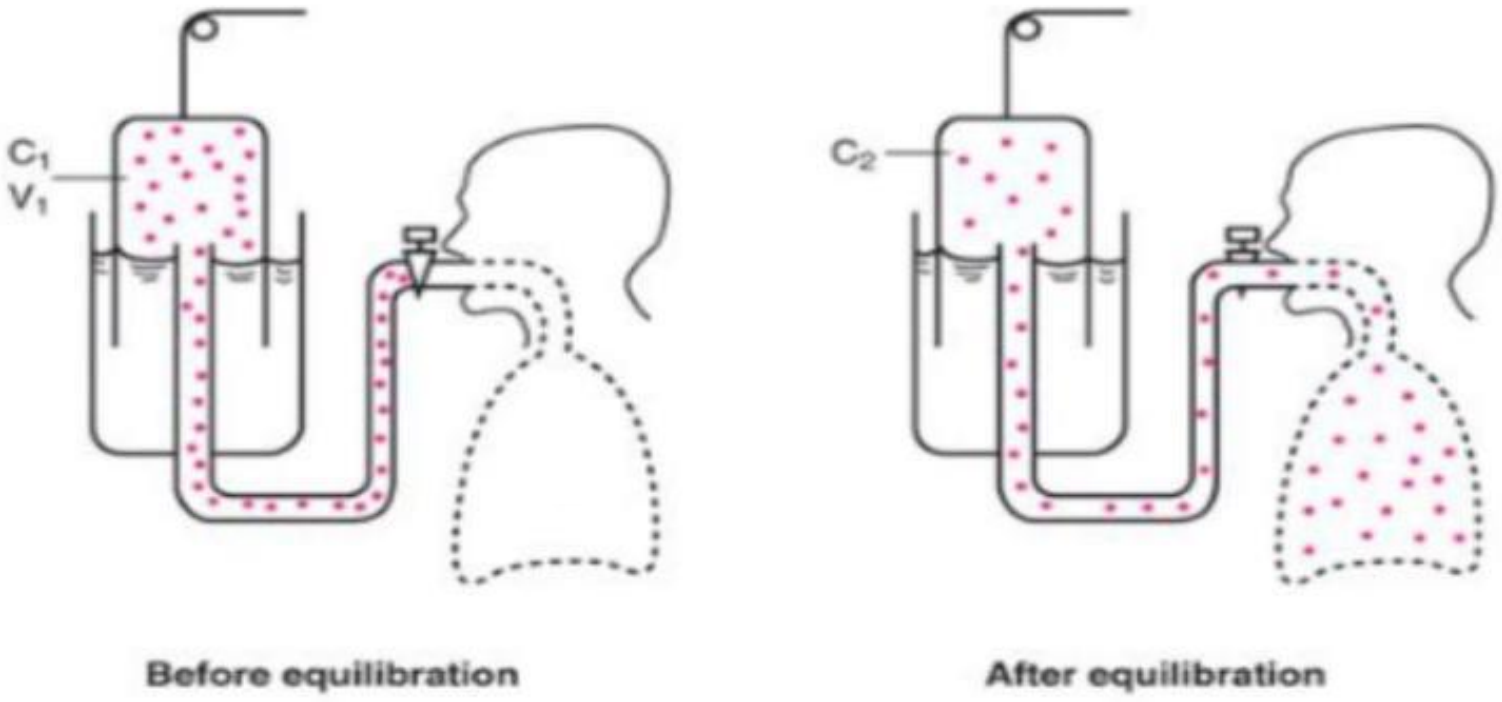
Can't be tested by spirometry.

Static pulmonary function tests

1. Residual volume:

Measured by Helium dilution method, using the dilution principle

C1 x V1 = C2 x V2



Importance of testing RV:

- RV/TLC ratio: Normally is less than 30%, ↑ in **disease with insufficient expiration (asthma & emphysema)**
- **Medicolegal**: determination of minimal air to differentiate stillbirth from death after delivery (Infanticide)

2. Total lung capacity (TLC):

- **Definition:** the volume of air present in the lung at the end of maximal inspiration.
- **Measurement:**

$$TLC = IRV + TV + ERV + RV.$$

- **Normal value:** 5800 ml.

3. Vital capacity (VC):

Definition: It is the amount of air expired maximally after maximal inspiration.

Measurement: by spirometer.

Value: VC = IRV + TV + ERV = 4600 ml

Significance:

1) It indicates the strength of respiratory muscles and lung elasticity.

Factors affecting Vital Capacity

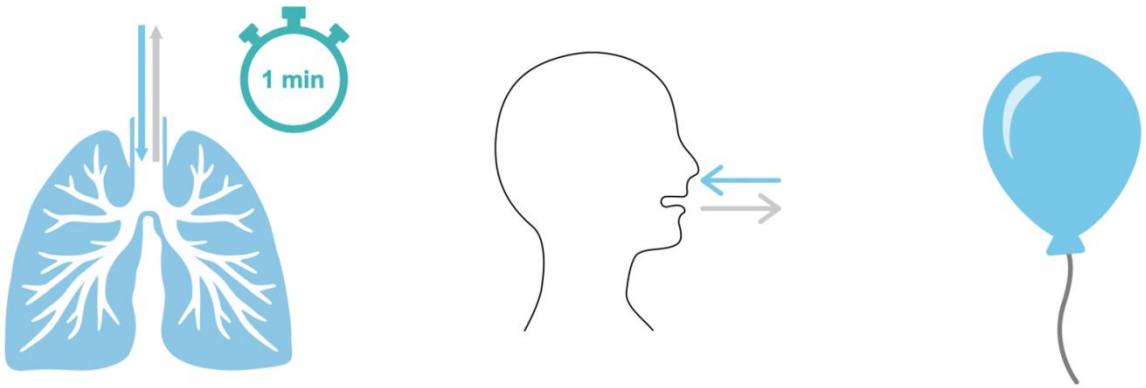
	Increase	Decrease
Physiological	Athletes	Females, old age, pregnancy and recumbent position due to return of more blood to the lung.
Pathological		a- **Chest wall diseases**: - Paralysis of respiratory muscles &myasthenia gravis - Fracture ribs or kyphosis(limit expansion of thorax) b- **Lung diseases**: -Decreased compliance (stretchability) **as(fibrosis, hydrothorax, pneumothorax**) -Decreased elasticity as (**emphysema**) - Obstructive conditions like **bronchial asthma** as resistance to air flow mainly during expiration c- **Increased blood volume in the lung**: as in pulmonary congestion by left side heart failure. d- **Presence of intra-abdominal masses**: as tumour and ascites. So, prevent free descent of diaphragm.

Dynamic pulmonary function tests

- **Respiratory minute volume (RMV) (Minute ventilation):**

  It is the volume of air respired/min.

  At rest = TV x respiratory rate = 0.5 x 12 = 6 L/min.



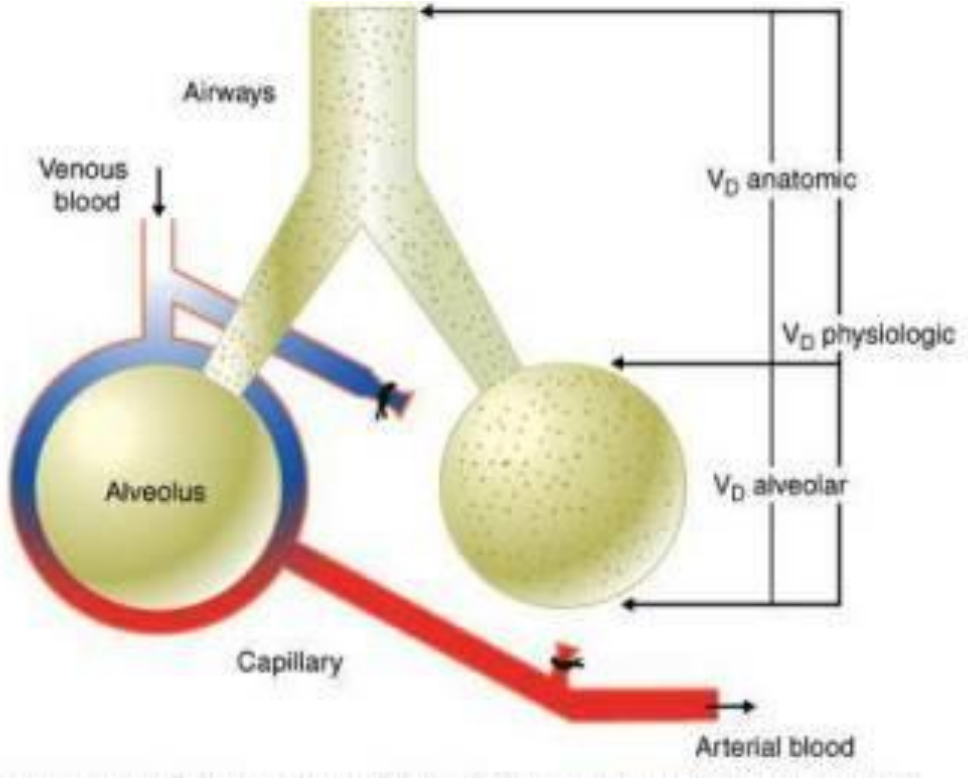
Minute ventilation = respiratory rate (RR) × tidal volume (V_T)

- **Effective ventilation volume (EVV):**

  It is the volume of air that enters in gas exchange/ min.

  At rest = (TV – DS) x respiratory rate = 0.35 x 12 = 4.2 L/min.

Dead space

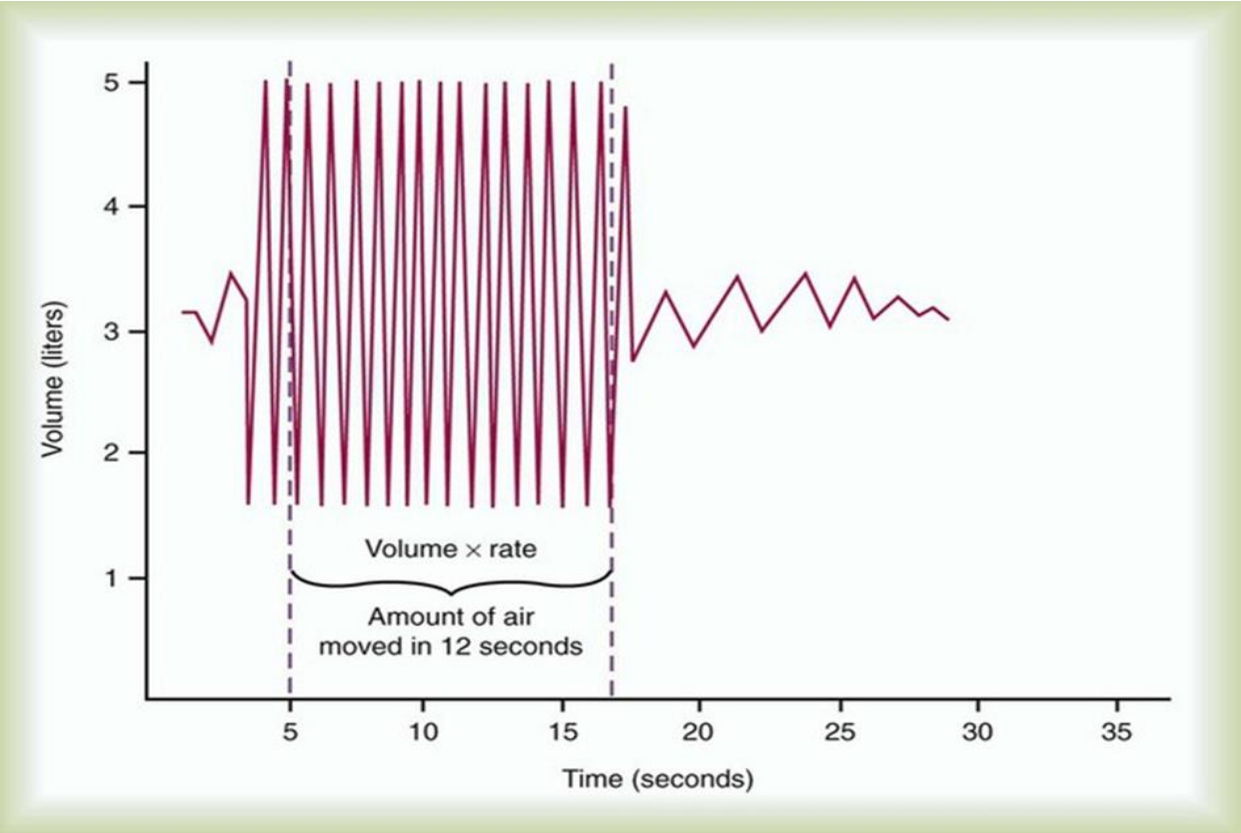


- **Maximum breathing capacity (MBC) or maximum voluntary ventilation:**

  Maximal volume of air that can be inspired or expired using the deepest and fastest respiratory movements.

  Measured in12 to 15 seconds then multiplied by 4.

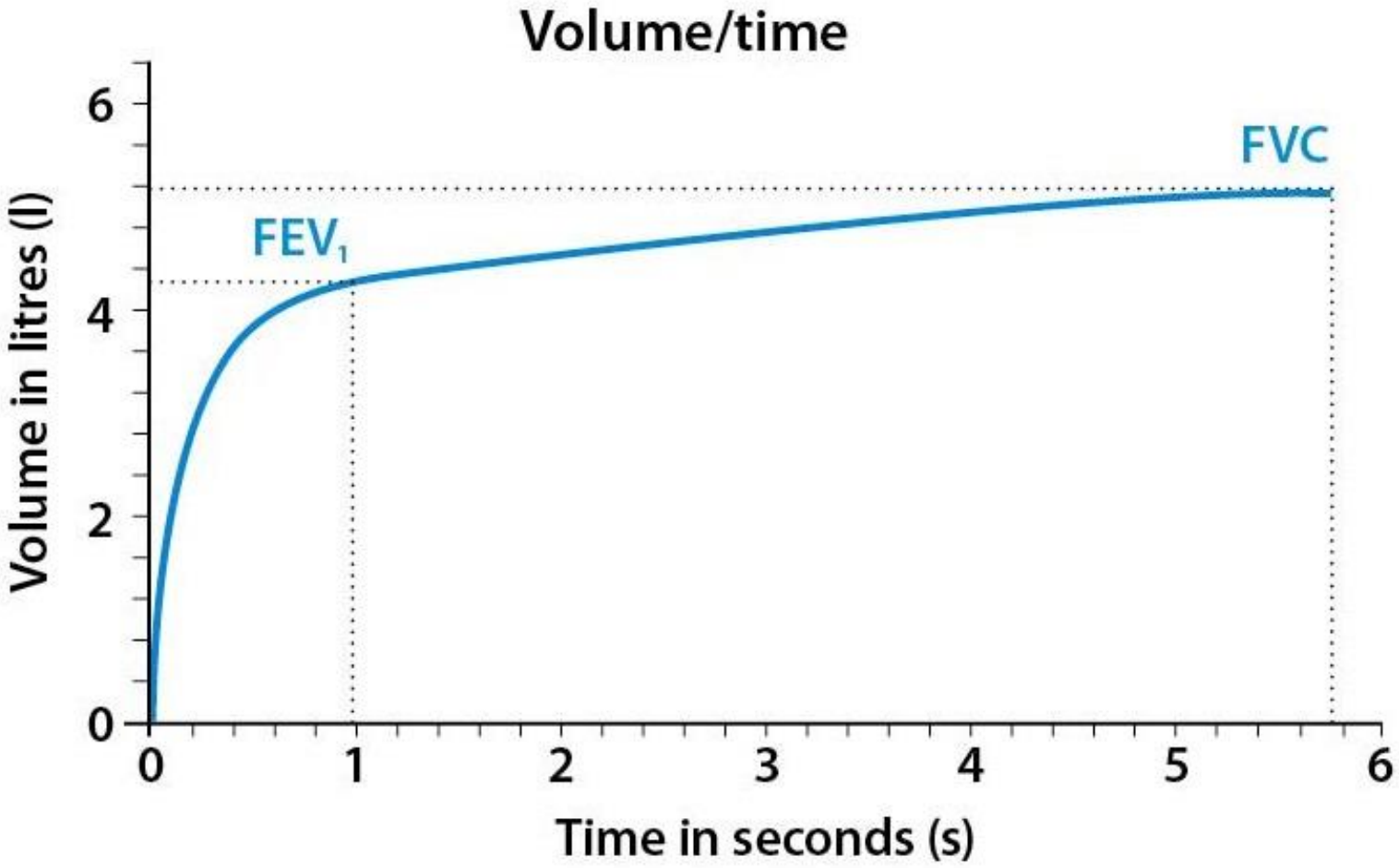
  MBC= 80 to160 L/min in **males**, 60 to120 L/min in **females.**



- **Breathing reserve:**
  - The ***difference*** between the MBC and RMV
  - BR = 100 – 6 = 94 L.

- **Dyspneic index (DI):**
  - The ***percentage*** between the **breathing reserve** and the **MBC**.
  - Normally: DI > 90%
  - If DI < 70% → Dyspnea.

- **Timed vital capacity:**
  - A test of **vital capacity** of the lungs expressed with respect to the volume of air that can be quickly and forcibly breathed out *in a certain amount of time*.
  - **FEV1:** The fraction of vital capacity expired maximally and rapidly in the first second. FEV1= 83% of VC, and reaches 97% in three seconds(good test for airway resistance so, it is helpful in obstructive lung diseases diagnosis & prognosis (e.g asthma & emphysema)
  - **FVC:** The total amount of air exhaled during the **FEV** test.


Volume/time
Volume in litres (l)
6
4
2
0
FVC
FEV1
0
1
2
3
4
5
6
Time in seconds (s)

Obstructive lung disease

- **E.g. Asthma & Emphysema**
- VC decreased
- FEV1 decreased markedly
- FEV1/ VC is reduced
- TLC is almost normal
- RV is increased

Restrictive lung diseases

- **E.g. Lung fibrosis**
- VC is decreased
- FEV1 is decreased
- FEV1/ VC *may be normal*

As both decreased equally

- TLC reduced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