

Lung volumes

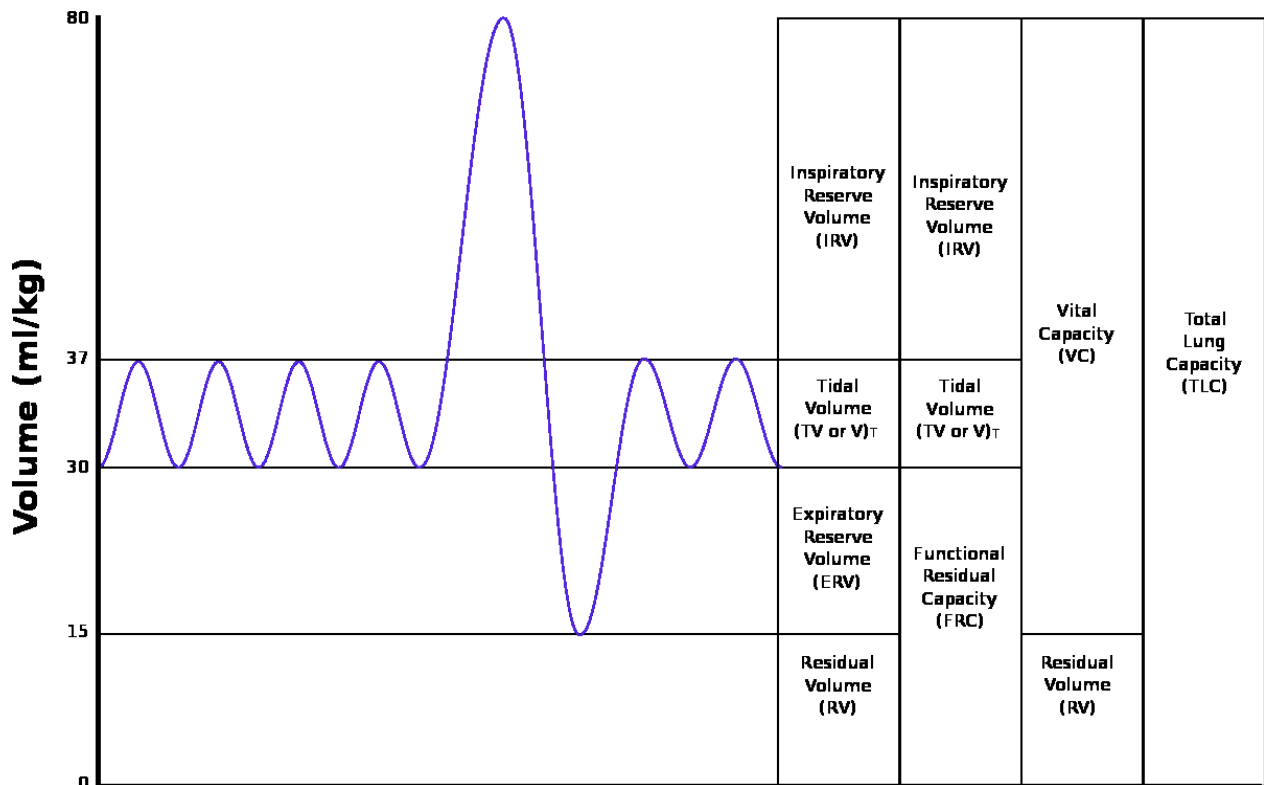


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Lung Volumes

Lung volumes and **lung capacities** refer to the volume of air associated with different phases of the respiratory cycle. Lung volumes are directly measured. Lung capacities are inferred from lung volumes.

The average total lung capacity of an adult human male is about 6 litres of air, but only a small amount of this capacity is used during normal breathing.

Tidal breathing is normal, resting breathing; the tidal volume is the volume of air that is inhaled or exhaled in a single such breath.

An average human breathes some 12-20 times per minute.

Factors affecting volumes

Several factors affect lung volumes; some can be controlled and some cannot. Lung volumes can be measured using the following terms:

Larger volumes	Smaller volumes
taller people	shorter people
non-smokers	smokers
people who live at higher altitudes	people who live at lower altitudes

A person who is born and lives at sea level will develop a slightly smaller lung capacity than a person who spends their life at a high altitude. This is because the partial pressure of oxygen is lower at higher altitude which, as a result means that oxygen less readily diffuses into the bloodstream. In response to higher altitude, the body's diffusing capacity increases in order to process more air.

When someone living at or near sea level travels to locations at high altitudes (e.g., the Andes, Denver, Colorado, Tibet, the Himalayas, etc.) that person can develop a condition called altitude sickness because their lungs remove adequate amounts of carbon dioxide but they do not take in enough oxygen. (In normal individuals, carbon dioxide is the primary determinant of respiratory drive.)

Specific changes in lung volumes occur also during pregnancy. Decreased functional residual capacity is seen, typically falling from 1.7 to 1.35 litres, due to the compression of the diaphragm by the uterus. The compression also causes a decreased total lung capacity (TLC) by 5% and decreased expiratory reserve volume. Tidal volume increases with 30-40%, from 0.45 to 0.65 litres, and minute ventilation by 30-40%^[2] giving an increase in pulmonary ventilation. This is necessary to meet the increased oxygen requirement of the body, which reaches 50 mL/min, 20 mL of which goes to reproductive tissues. Overall, the net change in maximum breathing capacity is zero.^[3]

Values

Average lung volumes in healthy adults^[4]

Volume	Value (litres)	
	In men	In women
Inspiratory reserve volume	3.3	1.9
Tidal volume	0.5	0.5
Expiratory reserve volume	1.0	0.7
Residual volume	1.2	1.1

Lung capacities in healthy adults^[4]

Volume	Average value (litres)		Derivation
	In men	In women	
Vital capacity	4.8	3.1	IRV plus TV plus ERV
Inspiratory capacity	3.8	2.4	IRV plus TV
Functional residual capacity	2.2	1.8	ERV plus RV
Total lung capacity	6.0	4.2	IRV plus TV plus ERV plus RV

The *tidal volume*, *vital capacity*, *inspiratory capacity* and *expiratory reserve volume* can be measured directly with a spirometer. These are the basic elements of a ventilatory *pulmonary function test*. Determination of the *residual volume* can be done by radiographic planimetry, body plethysmography, closed circuit dilution and nitrogen washout.

In absence of such , estimates of *residual volume* have been prepared as a proportion of body mass for infants (18.1ml/kg),^[5] or as a proportion of *vital capacity* (0.24 for men and 0.28 for women)^[6] or in relation to height and age ($(0.0275 * \text{AgeInYears} + 0.0189 * \text{HeightInCentimetres} - 2.6139)$ litres for normal-weight individuals and $(0.0277 * \text{AgeInYears} + 0.0138 * \text{HeightInCentimeters} - 2.3967)$ litres for overweight individuals).^[7] Standard errors in prediction equations for residual volume have been measured at 579ml for men and 355ml for women, while the use of $0.24 * \text{FVC}$ gave a standard error of 318ml.^[8]

Restrictive and obstructive

The results (in particular FEV1/FVC and FRC) can be used to distinguish between restrictive and obstructive pulmonary diseases:

Type	Examples	Description	FEV1/FVC
<i>restrictive diseases</i>	pulmonary fibrosis, Infant Respiratory Distress Syndrome, weak respiratory muscles, pneumothorax	volumes are decreased	often in a normal range (0.8 - 1.0)
<i>obstructive diseases</i>	asthma or COPD	volumes are essentially normal but flow rates are impeded	often low (Asthma can reduce the ratio to 0.6, Emphysema can reduce the ratio to 0.78 - 0.45)

References

- [1] <http://en.wikipedia.org/wiki/Lung>
- [2] Guyton and hall (2005) (in en). *Textbook of Medical Physiology* (11 ed.). Philadelphia: Saunders. pp. 103g. ISBN 81-8147-920-3.
- [3] Simpson, Kathleen Rice; Patricia A Creehan (2007). *Perinatal Nursing* (http://books.google.com/books?id=oz_4cTmVFD4C&pg=PA66) (3rd ed.). Lippincott Williams & Wilkins. pp. 65–66. ISBN 9780781767590. .
- [4] Ganong, William. "Fig. 34-7". *Review of Medical Physiology* (21st ed.).
- [5] Morris, Mohy G. (2010). "Comprehensive integrated spirometry using raised volume passive and forced expirations and multiple-breath nitrogen washout in infants.". *Respiratory Physiology & Neurobiology* **170** (2): 123–140. doi:10.1016/j.resp.2009.10.010. ISSN 15699048. PMC 2858579. PMID 19897058.
- [6] Wilmore, J. H. (1969). "The use of actual predicted and constant residual volumes in the assessment of body composition by underwater weighing.". *Med Sci Sports* **1**: 87–90.
- [7] MILLER, WAYNE C.; SWENSEN, THOMAS; WALLACE, JANET P. (February 1998). "Derivation of prediction equations for RV in overweight men and women". *Medicine & Science in Sports & Exercise* **30** (2): 322–327. PMID 9502364.
- [8] Morrow JR Jr, Jackson AS, Bradley PW, Hartung GH. (Dec 1986). "Accuracy of measured and predicted residual lung volume on body density measurement.". *Med Sci Sports Exerc* **18** (6): 647–52. PMID 3784877.

External links

- "Lung Function Fundamentals" at anaesthetist.com (<http://www.anaesthetist.com/icu/organs/lung/lungfx.htm>)
 - RT Corner (Educational Site for RT's and Nurses) (<http://www.rtcornet.net>) at rtcornet.net
 - Volume of Human Lungs (<http://hypertextbook.com/facts/2001/LaurenCalabrese.shtml>)
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