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Studies on lung volume. VI. The absolute and relative size of the different lung volumes.

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In 27 normal adults, 19 men, 8 women, age 19 to 36 years, total capacity, vital capacity, residual, complementary and reserve air were determined. Vital capacity was determined by expiration into a Krogh spirometer. The highest value of five determinations was chosen. Reserve and complementary air and middle capacity were determined by rebreathing air plus oxygen from a Krogh spirometer. Total capacity was determined by the dilution method (rebreathing oxygen). That complete mixture took place was proved by construction of mixture curves. Residual air was determined directly by the dilution method and indirectly as the difference between the total capacity and the vital capacity. The highest and lowest values are recorded in Table I. The values in this and the following 3 papers are given at observed tension and room temperature.

If the total lung volume is given a value of 100, we obtain an average value for the other volumes as shown in Table II, where we have included the corresponding values calculated from previous investigator's publications. We have determined the mean error of each determination by means of the usual formula $f = \sqrt{\frac{\Sigma \zeta^2}{(n-1)}}$. The values for the mean, for the mean error and for the mean error in percentage of the mean are given in Table III.

In order to find out whether or not any systematic error was responsible for the deviations from the mean, we compared the observed and calculated number of errors in the different groups. The agreement was satisfactory. In Table IV are given the relative size of the lung volumes. If we know the normal value of one of the lung volumes, the normal values for the other may be calculated by means of the figures in Table IV. We do not

put much stress on the middle capacity, the reserve and the complementary air, on account of the uncertainty in the determination of these figures.

The other figures are more important, and the relation of 4 — 3 — 1 of the total capacity, vital capacity, and residual air may prove of value in future work.

TABLE I

Highest and lowest absolute values for lung volumes in 27 normal adults arranged according to total capacity.

		Total capacity.	Middle capacity.	Residual air.	Vital capacity.
		liter	*liter*	*liter*	*liter*
18 men	maximum	7.82	4.89	1.97	5.85
	minimum	4.84	3.09	1.34	3.50
9 women	maximum	4.83	2.91	1.06	3.77
	minimum	3.08	1.88	0.88[1]	2.20

[1] In two other women the residual air was 0.75 liter and 1.38 liter.

TABLE II.

Relative values of different lung volumes.

Authors.	Material	Total capacity. T	Middle capacity. $\frac{M}{T} \times 100$	Residual air. $\frac{R}{T} \times 100$	Vital capacity. $\frac{V}{T} \times 100$
Bohr (1906)	9 men 1 woman	100	58.2	23.2	76.8
Rubow (1908)	8 women	100	56.0	26.3	73.7
Lundsgaard and Van Slyke (1918)	10 men 5 women	100	58.8	24.8	75.2
Present paper	19 men 8 women	100	62.0	24.7	75.3

TABLE III

Mean error and mean error in per cent. of mean value of relative lung volumes.

	Number of determinations.	Mean value.	Mean error on each determination.	Mean error in per cent. of mean value.
$\frac{M}{T} \times 100$	25	62.0	3.5	5.6
$\frac{R}{T} \times 100$	27	24.7	4.0	16.2

TABLE IV.
Normal relative values for the different lung volumes based on 27 observations.

Total capacity	100	T
Middle capacity	62	$T \times \frac{62}{100}$
Residual air	24.7	$T \times \frac{24.7}{100}$
Vital capacity	75.3	$T \times \frac{75.3}{100}$
Reserve air	37.3	$T \times \frac{37.3}{100}$
Complementary air	38.01	$T \times \frac{38.0}{100}$

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Studies on lung volume. VII. Relation of size of chest to lung volume.

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In 1918 Lundsgaard and Van Slyke[1] worked out the quantitative relationship between the different lung volumes and the size of the chest (so-called chest volume) in 18 normal individuals. The size of the chest was determined as the product ("chest volume") of three dimensions, the height, depth, and width of the thorax. The ratio between the chest volume and the lung volume in the corresponding position was found to be 55 for maximum expiration, 37 for middle capacity, and 19 for maximum inspiration. We thought it would be of value to increase the number of observations. We used the technique described by Lundsgaard and Van Slyke in measuring the chest dimensions and the total capacity. Complete mixture has always

[1] Lundsgaard, C., and Van Slyke, D. D., *J. Exp. Med.*, 1918, xxvii, 65.