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Recovery from the hyperpnea of moderate exercise. The recovery ratio.

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After muscular exercise, the excessive pulmonary ventilation lessens rapidly at first and then more slowly. The promptness of recovery is obviously one of the factors which indicate the individual's reaction to the exercise. It is difficult to measure the total duration of hyperpnea because the final approach to the resting level is very gradual and there is no sharp end point. We have therefore sought a numerical expression for the earlier and more rapid stages of recovery.

The test exercise here reported consisted of 200 hops at a rate of 120 hops per minute, or of climbing 200 steps on a treadmill at a rate of about 80 per minute. The rate of pulmonary ventilation was recorded just before and for several minutes just after the exercise, using the recorder described by Slonaker.[1] We found that in these experiments, the rate of pulmonary ventilation, at any moment, t, after the exercise stopped, roughly approximated a logarithmic curve of the form

$$h.\ r^t + c$$

According to such a formula the ventilation for successive minutes after the exercise stopped may be expressed as follows:

For the first minute	$M + c$
For the second minute	$M\ r + c$
For the third minute	$M\ r^2 + c$
For the fourth minute	$M\ r^3 + c$

and so on. In our calculations, c equalled the rate of ventilation before the exercise started, M was determined by subtracting c from the ventilation of the first minute and r was so chosen as best to fit the ventilation of subsequent minutes. Since r is a fraction the value of the expression diminishes with each succeeding minute and the ventilation ultimately approaches c, the resting ventilation. The rapidity of the approach depends upon

[1] Slonaker, J. R., *Sci.*, 1923, lvii, 180.

the value of r. For this reason r may we called the recovery ratio.

In the accompanying tables a comparison is made between the observed ventilations and those calculated by this formula. In each case, averages of a number of experiments were used so as to lessen the accidental fluctuations in ventilation, which are sometimes rather marked. It will be noted that observed ventilations roughly correspond to the postulated type of curve. Differences in the speeds of recovery are indicated by the volumes of r.

TABLE I.

Comparison of observed and caluculated values of recovery from the hyperpnea induced by muscular exercise. In each case the averages of observed values are first given, next the calculated values and finally the differences between the two.

Subject	Exercise	No. of observations	Minute volumes before exercise	Minute volumes on successive minutes after exercise.				M	R
				First	Second	Third	Fourth		
M. G.	200 hops	6	6.5	22.8	16.2	12.0	8.7	16.3	.565
				22.8	15.7	11.7	9.4		
					—.5	—.3	+.7		
M. G.	200 hops	6	7.1	26.0	18.8	13.5	11.0	18.9	.594
				26.0	18.3	13.8	11.1		
					—.5	+.3	+.1		
A. W. H.	200 steps	20	7.4	26.7	14.6	10.2	9.2	19.3	.394
				26.7	15.0	10.4	8.6		
					+.4	+.2	—.6		
J. S.	200 steps	7	9.7	27.5	17.6	13.6	12.7	17.8	.489
				27.5	18.4	13.9	11.7		
					+.8	+.3	—1.0		