Proceedings of the Iowa Academy of Science

Volume 74 | Annual Issue Article 34

1967

The Effects of Exercise on Lung Ventilation and Breathing Rate

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Abstract. Breathing rates and ventilatory data obtained from young subjects of college age during exercise conditions imposed by riding a bicycle ergometer and using standard physiological laboratory equipment and a polygraph indicate that this type of study is feasible during standard laboratory experiences.

The average breathing rate of an untrained adult at rest is about fifteen times a minute. Schmidt and Kohlrausch (1931) found that with exercise, respiratory rates increase as much as 100% but the factor of exhaustion limits the rapid rates to short periods. According to Morehouse and Miller (1963) there is a regular sequence of events in regard to exercise and increase in breathing rate. Due to anticipation and emotion, a subject's rate increases slightly just prior to and for the first few seconds of exercise. The rate then slows a bit and then increases as the subject continues to exercise. After a certain length of time, depending upon the type of exercise and the subject, the rate reaches a plateau and remains steady for a time if the exercise is not too strenuous. If the subject undergoes light exercise, the climb to the steady state appears quite gradual; but if the exercise is more strenuous, the steady state is reached in three to five minutes.

Ventilation is about nine or ten liters per minute at rest (Schmidt and Kohlrausch, 1931) and may increase with exercise as much as ten times (Morehouse and Miller, 1963). The research of Morehouse and Miller led them to believe that the minute volume of breathing in exercise is influenced by the physical condition of the individual. If a person is in good physical condition his minute volume decreases with time for the performance of a given work load. Also a person in good physical condition shows a greater maximal respiratory minute volume for strenuous exercise than people who are not in good condition.

The purpose of this study was to determine the effects of exercise imposed at different work loads on breathing rates and lung ventilation in young college students by means of equipment commonly used in a physiology laboratory and a polygraph recently obtained by the department.

Materials

A bicycle ergometer fitted with a speedometer and a tension adjustment device was used for exercise conditions. Exhaled air

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was collected by means of Douglas bags and valves and ventilatory volumes determined by use of a gas meter and a knowledge of the time of the test periods. Test periods were all three minutes in duration and since it was impossible to change collection bags every minute the exhaled air was determined for the three minute period. The breathing rates were determined by means of a bellows pneumograph transducer [2] placed at the level of the xiphoid process and connected to a polygraph [1].

Eight male and seven female subjects were used in the study. The ergometer was pedaled at 20 miles per hour. To determine the amount of work per revolution done in any test situation, the amount of force applied was multiplied by the distance it was applied. The total work done was determined by the number of revolutions.

Thus

$W = (F)\ (2\pi r)\ (N)$

where W is total work
F is force applied
$2\pi r$ is circumference of circle made by pedals
N is number of revolutions

The calculated values of the work loads imposed were 54.6, 215.2, 103,856, and 139, 319.0 ft. lbs.

Prior to exercise tests, resting tests in which subjects just sat on the bicycle were run.

Results

It was thought that as the work load was increased, perhaps the average breathing rate for three minutes would also increase stepwise. This occurred in only five of the fifteen subjects and four of these were girls. (See Table I.) Perhaps the increase in work load was not sufficient to have an effect on males. However, since in the majority of cases where there was not a stepwise increase in breaths per three minutes with increase in work load there was an increase in the average ventilation for three minutes (see Table II), it is more likely that subjects adjusted by increasing depth of breathing rather than rate. In any event there is not enough evidence to substantiate either suggestion.

Four of the eight males participated in an intercollegiate sport during the course of the study. These four are marked with asterisks in the tables.

When breathing rates were considered within any one work load condition a trend was evident. As Table III indicates, in the majority of cases there was an increase in rate with time during the three minutes of the test.

[2] E & M Company, Houston, Texas.

Table 1. Three Minute Breathing Rates at rest and during exercise conditions

		Males			
		Work Loads (ft/lbs)			
Subject	Resting	54.6	215.2	103,856.0	139,319.0
1*	49	52	62	64	66
2*	22	25	51	34	37
3	36	48	42	51	45
4	37	66	39	73	74
5	28	31	32	32	47
6*	39	21	29	36	35
7	22	30	36	34	60
8*	36	35	32	45	40
		Females			
Subject					
1	32	41	51	62	81
2	27	40	34	43	36
3	40	94	77	73	84
4	31	24	36	37	67
5	28	52	55	41	49
6	41	57	65	68	80
7	22	59	68	70	78

* Participated in intercollegiate athletics during study

Table 2. Three minute ventilation volumes in liters at rest and during exercise conditions

		Males			
		Work Loads (ft/lbs)			
Subject	Resting	54.6	215.2	103,856.0	139,319.0
1*	32.0	65.1	82.0	88.6	107.0
2*	23.2	33.6	74.8	84.6	96.5
3	27.7	59.2	64.8	74.0	86.0
4	34.1	60.8	55.6	79.0	99.5
5	35.6	40.3	55.9	68.9	70.3
6*	40.8	54.0	61.4	60.0	91.0
7	21.6	69.5	77.6	84.0	112.0
8*	34.0	39.4	71.2	88.2	112.0
		Females			
Subject					
1	26.1	44.9	52.4	66.3	83.8
2	16.2	37.5	41.2	50.8	65.0
3	21.2	87.9	85.2	83.5	135.0
4	21.7	39.8	59.5	61.0	64.1
5	16.2	56.4	40.0	61.5	86.1
6	21.6	54.7	59.6	74.0	87.0
7	25.5	57.2	86.7	125.0	136.0

* Participated in intercollegiate athletics during study

Insofar as the three minute ventilation figure is concerned (Table II), twelve of the fifteen subjects showed a steady increase with increase in work load. One female, a vocalist, actually showed a decline, until she performed work at the highest level.

Table 3. Minute breathing rates during rest and exercise conditions.

Males

Subject	Resting	Work Loads (ft/lbs) 54.6	215.2	103,856.0	139,319.0
1*	17,16,16	17,18,17	20,21,21	23,20,21	19,23,24
2*	7, 8, 7	9, 8, 8	18,18,15	12,11,11	10,12,15
3	12,12,12	16,14,18	12,16,14	11,13,17	12,16,17
4	14,13,10	21,20,25	10,10,19	19,26,28	16,28,30
5	7, 6, 8	10, 9, 9	9,12,11	10,11,11	12,16,19
6*	12,12,13	13,13, 9	11, 9, 9	10,13,13	10,15,15
7	8, 7, 7	8,11,11	7,13,16	9,13,12	15,22,23
8*	12,12,12	11,12,12	10,11,11	11,16,18	10,13,17

Females

Subject					
1	9,12,11	14,15,12	16,18,17	13,24,25	16,31,34
2	9, 9, 9	13,12,15	11,12,11	15,13,15	11,12,13
3	11,13,16	30,33,31	22,25,30	22,25,26	24,30,32
4	10,11,10	9, 7, 8	10,11,15	9,14,14	13,23,31
5	12, 7, 9	17,18,17	15,19,21	12,13,16	14,16,19
6	13,14,14	21,19,17	22,21,22	22,24,24	22,26,32
7	7, 7, 8	21,19,19	20,23,25	14,24,30	22,27,29

* Participated in intercollegiate athletics during study

Discussion

The main purpose of the study was to determine if physiological equipment such as a polygraph could be incorporated easily into ordinary laboratory experiences. It was determined that this could be done successfully. Expected results were obtained quite readily.

In the course of the study the following was noted. Whereas it was thought that perhaps both three minute breathing rates and three minute volumes of ventilation would increase with increase in work load this was true only for the lung ventilation. However, when by means of the polygraph record minute by minute breathing records were analyzed, it was found that breathing rate did increase minute by minute in tests where the work load was greatest.

Literature Cited

Morehouse, L. E., and Miller, A. T. (1963), *Physiology of Exercise* (4th ed.; St. Louis: C. V. Mosby Co.), p. 144-151.

Schmidt, F. A., and Kohlrausch, W. (1931), *Physiology of Exercise,* Philadelphia: F. A. Davis Co., p. 36, 137.