EFFECT OF REPEATED MUSCULAR WORK ON PULSE RATE AND BLOOD PRESSURE

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The results of many years of experience and a mass of experimental results lead us to conclude that frequently repeated muscular work is necessary in order to establish a condition of being in training, and that after the muscle work, a trace (aftereffect) remains, on which the functional changes produced by subsequent exercise are superimposed.

In a more detailed study of the aftereffect some authors have investigated the functional changes associated with repeated muscular work, in the case when the interval between the repetitions is small.

The group directed by G. E. Vladimirov [1, 2, 3] showed in animal experiments, that on repetition of a standard exercise at short intervals the increase in the lactic acid content of the blood was less at each repetition. With repeated exercise in men they failed to find a regular reduction in the "working shifts" of lactic acid. There were however certain changes associated with the repeated work: in many cases there was a reduction in the respiratory quotient (R.Q.) and a more rapid return of the oxygen consumption to normal after each successive period of work.

The work of M. E. Marshak [4, 5] showed that a second spell of work, undertaken before complete recovery from the first, does not result in either a further expenditure of energy of an increase in the blood lactic acid, and that in the next spell of work the period of "working in" is shortened.

The effect of repeated muscular work on the pulse rate has been described in the papers of I. N. Popov and G. G. Saruchanov [6].

Our aim was to find, through study of respiration and heart rates in repeated muscular work: a) the relation between the initial work, and changes in subsequent performance, carried out at short time intervals in the same experiment, b) the effect of frequent repetition of a standard set of exercises.

METHOD

The investigations were carried out on subjects aged 18-25 years. Records were made of the pulmonary ventilation (every thiry seconds), the respiration rate, the pulse frequency (using a photoelectric counter), the blood pressure, and the degree of oxygen saturation of the arterial blood (oxyhemometer).

The dynamic work was done on a bicycle ergometer, and the static work was performed on an apparatus in which a constant tention had to be maintained.

After a certain level of training had been reached in one task, another was introduced, and after 10-15 training sessions, a third was added. In certain cases four separate exercises were used in one experiment.

The average interval between dynamic work sessions was 5 minutes, so that they occurred at the end of a period of recovery from the work of the preceding session. In one series the interval was increased to 20 minutes. Repetition of the static work was carried out after complete recovery, as shown by the return of all the measured quantities to their initial values (2-8 minutes according to the subject).

RESULTS

On repetition of two or three spells of dynamic work, each successive working session caused a smaller increase in pulmonary ventilation, pulse frequency and respiration rate; in addition there was a more rapid increase of these quantities at the beginning of the session and the recovery period was shorter than in the preceding session (Fig. 1).

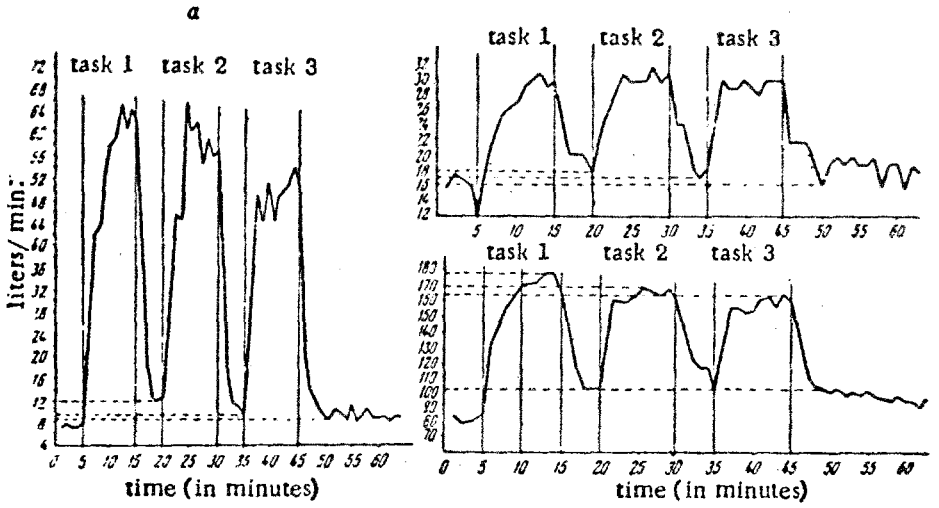

Fig. 1. Effect of one task on the pulmonary ventilation (a), respiration rate (b), and pulse frequency (c), during the performance of the next task.

During the first working period, the arterial oxygen saturation was reduced in some subjects by 3-6%, and in each subsequent session the reduction became progressively smaller.

Although the pulmonary ventilation was less in the first than in the second and third sessions, the oxygen saturation was increased. This may indicate that the oxygen saturation does not depend on the pulmonary ventilation rate, but on the relative values of the pulmonary circulation and gaseous exchange rates.

The respiratory and circulatory changes occurring during the 2nd and 3rd working sessions of one experiment, were analogous to the changes observed after many days of training to a single task.

During the process of training to a repeated set of tasks, it was noticed that the pulmonary ventilation, the respiration rate, and the pulse rate during the first task, all increased gradually in each successive experiment (Fig. 2, a and b). The shape of the recovery phase after the first session also showed a change in all of the quantities measured: during the first and second minutes after the end of the first working session there was a considerable reduction in pulmonary ventilation, respiration rate, and pulse frequency; however, subsequent recovery was greatly slowed or even arrested. In some experiments, even 1-2 minutes before the start of the next task, an increase in pulmonary ventilation and pulse frequency was observed.

This phenomenon is observed only on repeatedly working through a group of exercises, and is explained in terms of the emergence of a dynamic stereotype, in which all the tasks which make up the group, and the intervals between them become fixed as a unit in the higher nervous centers, and from the onset the work is performed as one single complex.

This conclusion receives support from the second set of experiments, in which the severity of each separate task in the group was periodically changed according to a single accurately followed plan. In the early experiments the task of altered severity caused fluctuation of the pulmonary ventilation, respiration rate, pulse rate,

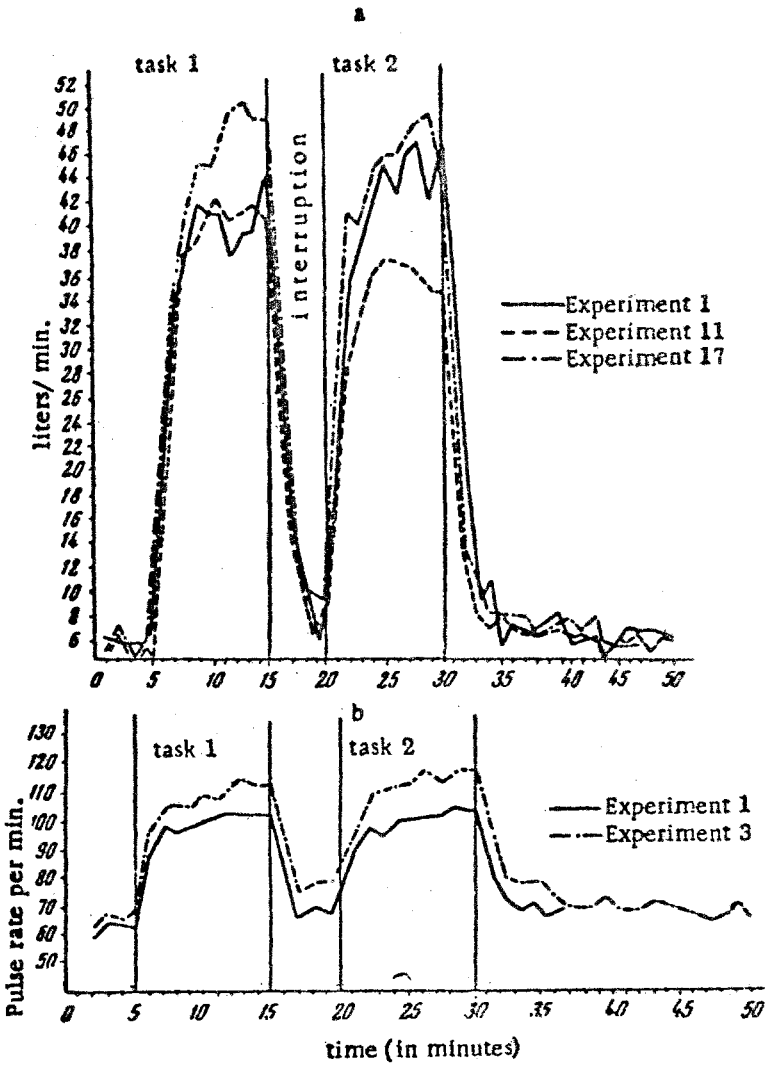

Fig. 2. Effect of training on a group of repeated standard tasks on pulmonary ventilation (a) and pulse frequency (b).

and arterial oxygen saturation of varying extent, according to the degree of alteration. The fluctuation of these quantities increased in proportion to the extent of the training.

The following experiments offer good evidence that the changes in the observed parameters occurring on repeated execution of a group of tasks, are due to the development of a dynamic stereotype: if, after long training to a group of tasks whose severity changed during the experiment, the severity was made not to change, there then occurred just such fluctuations in pulmonary ventilation as are normally observed to occur with work tasks of varied severity. Typically the fluctuations of pulmonary ventilation coincided in time and intensity with the periods of greater or less work (Fig. 3).

Repetition for several days of certain static exercises with short rests, also led to the development of a dynamic stereotype.

The breakup of the habitual complex of static tasks by an extra task, or by the change of one of the intervals, caused respiratory and circulatory changes to occur while working on these standard tasks; the pulmonary ventilation, the respiration rate and the pulse frequency increased in all tasks, and in spite of the increased pulmonary ventilation, the standard static load caused an increased fall in the arterial oxygen saturation. This indicates a breakdown of the correlation between aeration and the pulmonary blood supply of separate parts of the lungs, and a reduced effectiveness of the respiration.

The results of these investigations afford convincing evidence of the highly important function of the higher nervous centers in effecting the respiratory and circulatory changes induced by both repeated muscular work during the course of a single experiment, and by repeatedly working through a set of muscular exercises.

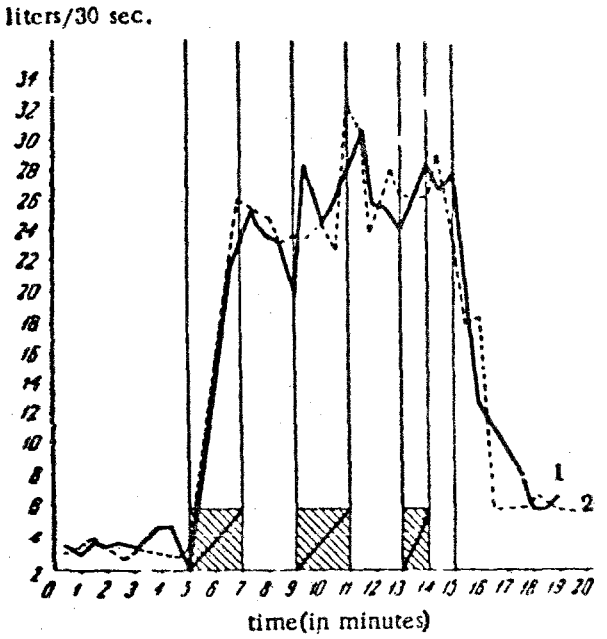

Fig. 3. Changes in pulmonary ventilation while performing work at a constant rate after lengthy training on work at a variable rate.
1) Task No. 1; Task No. 2.

SUMMARY

Changes in lung ventilation, frequency of respiratory movements, pulse rate, blood pressure and oxygen saturation of arterial blood have been studied during dynamic and static work.

With each new performance lung ventilation, pulse and respiratory rate increased less and less.

The rate of these functions was increased with the start of each new performance, while the duration of the restoration period diminished.

As training in each complex of work was prolonged, lung ventilation, pulse and respiratory rate, increased with each experiment: the character of their restoration changed as well.

Changes of external respiration and blood circulation occurring during work resulted in the development of a reinforced dynamic stereotype.

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