THE EFFECT OF STATIC EXERCISE ON THE RATE OF CONTRACTION OF THE HEART

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Studies of the effect of static work on the rhythm of the heart have shown that this is accelerated [1, 2, 3, 6, 7]. Data on the rate of the blood flow [1, 8] and on the minute volume [4], however, indirectly show that there is depression of cardiac activity during static exercises.

The conflicting nature of these findings may possibly be explained by the fact that the static exercises studied in the research cited above differed in their character and difficulty.

In the present investigation we studied the effect of static exercises on the activity of the heart by means of static poses used in sport.

EXPERIMENTAL METHOD

The research was carried out with the aid of 17 weight lifters and gymnasts who performed various exercises. We confined our choice to static exercises used in sport because they permitted the activity of the heart to be studied in the same persons carrying out exercises of varying degrees of difficulty. Some of these (horizontal handstand, lifting weights twice as heavy as the athletes themselves, and so on) could only be done by highly qualified athletes.

Static exercises in such forms of sport as gymnastics and weight lifting are widely practiced and their study is of great interest.

The recording of the contractions of the heart during the performance of the static exercises was carried out by means of a photocell fixed to the pinna of the subjects. The EMF of the cell was fed into the input of an amplifier and recorded on a paper tape.

The following static exercises were performed: standing on the shoulders and hands, balancing (resting on the outstretched hands, and supported on the elbows, "swallow" and sideways, on one foot), resting (lying, lying on the thighs and lying on the hands), "bridge", hanging from a crossbar, lunging, lifting weights of different sizes while sitting, standing and with outstretched hands.

During the course of one experiment each subject carried out 10-15 exercises lasting 5-30 seconds, with intervals of rest of 5-10 minutes.

EXPERIMENTAL RESULTS

The course of the changes in the heart rate before, during, and after performing static exercises of a gymnastic character showed certain variations.

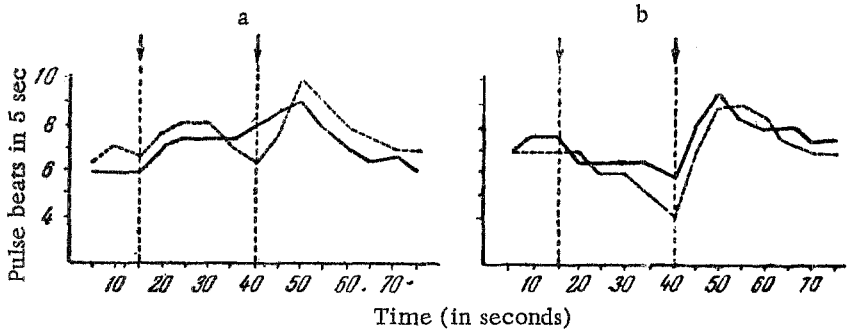

Fig. 1. Frequency of contraction of the heart before, during, and after the performance of static exercises (the times are indicated by arrows). a) ——— During performance of "angle at rest." Subject A, Grade 2 athlete; – – – – During performance of "balancing with elbow support." Subject T, Grade 1 athlete. b) ——— During the "bridge" exercise with forced breathing; – – – – the same, but while holding the breath. Subject Sh. Master of Sport.

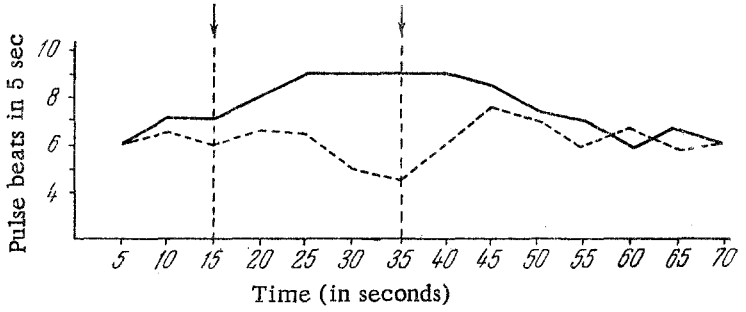

Fig. 2. Rate of the heart before, during, and after performance of static exercises (the times are indicated by arrows). ——— During lifting a weight of 100 kg, sitting, by the "scissors" method; – – – – During the exercise of "handstand." Subject P, Grade 2 weight lifter, welterweight.

In the performance of the simpler exercises the pulse quickened, and after they were finished it slowed. When more complicated exercises were carried out the pulse quickened both during the exercise and during the first 7-10 seconds after their completion, followed by a fall in the pulse rate (Fig. 1, a, angle at rest). This effect was similar to Lindhard's phenomenon [5]. Sometimes during the performance of the exercise, in the first 10-15 seconds the pulse quickened and then slowed (Fig. 1, a, balancing with elbow support). In some cases at the end of the exercise the pulse rate was below the original value, and after completion of the exercise a sharp rise took place in the pulse rate, followed by a fall. Finally, during the performance of some exercises the heart rate was diminished from start to finish (Fig. 1, b).

The effect of static exercise was greatest in the last two variants. Such reactions were found in the performance of the most complicated exercises.

The effect of static exercise was observed in gymnasts, whatever their qualifications, and no difference was found during the performance of the same exercises by trained and untrained gymnasts. In gymnastics, training in static exercises did not, therefore, completely remove this phenomenon, and probably did not even reduce its degree of expression.

In static poses in which the athlete held his head down ("bridge", handstand), the effect of static exercise

was more pronounced than when the head was held upright (angle, lunging) or in the horizontal position (balancing).

During the performance of the same exercises the effect of static exercise was more pronounced in women than in men.

Thus in the performance of simple gymnastic exercises no effect was found from static exercise on the rate of the heart.

The performance of complicated exercises was accompanied by a reaction similar to Lindhard's phenomenon, and its intensity depended on the difficulty of the exercise and the character of the pose.

From the results which we obtained we considered that the effect of static exercise on the rate of the heart would be more marked in weight lifting. Experiments showed, however, that the changes in the rate of the heart during lifting of weights of different sizes were no different from those taking place during dynamic exercise. During the performance of gymnastic exercises by these weight lifters, an effect of static exercise was found (Fig. 2).

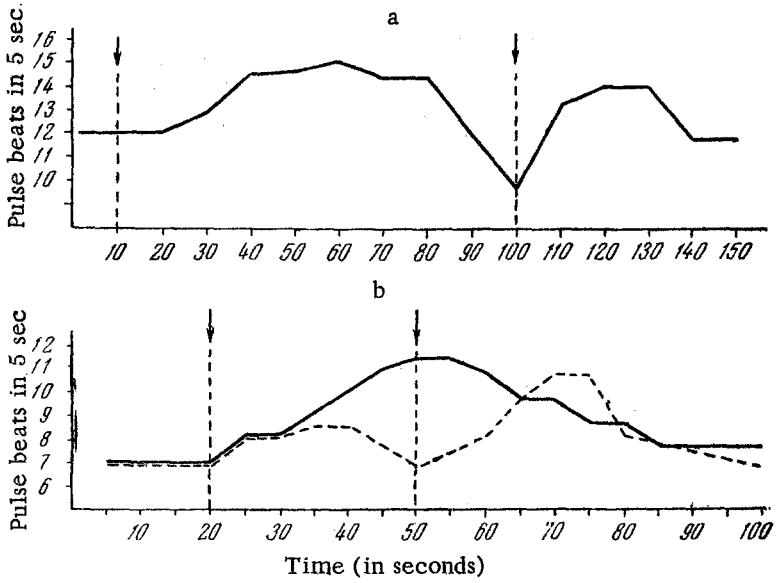

Fig. 3. The effect of holding the breath on the rate of the heart.
a) Heart rate while holding the breath at inspiration of 80% of the vital capacity of the lungs while sitting at rest.
b)—— during work on the bicycle ergometer; – – – – the same, but while holding the breath at inspiration of 80% of the vital capacity of the lungs. Uniform rate of work, 642 kgm in 30 seconds, rate 80 per minute; amount of work the same in both cases (times of working are indicated by arrows).

The effect of static exercise on the rate of the heart consequently depended on the character of the static pose.

The performance of static exercises is often accompanied by holding the breath and by straining. In special experiments during the study of the variation in the rate of the heart during and after holding the breath a phenomenon was found which was equivalent to that during static exercise (Fig. 3, a). It appeared only during great voluntary effort. In these cases a fall in the heart rate was sometimes observed to half the original value. If the subject was unable to hold his breath for a "limiting" period, this phenomenon did not arise.

We considered that the effect of static exercise on the activity of the heart was due to holding the breath. However, when the same exercises were carried out by the same persons during forced respiration or holding the

breath, it was found that an effect of static exercise was observed in both cases (Fig. 1, b).

Furthermore, in weight lifting with the breath held, and also during dynamic work with the breath held, a phenomenon was observed which was similar to that seen in static exercise (Fig. 3, b).

Thus while holding the breath (we are speaking here of holding it for a relatively long time), a phenomenon similar to that of Lindhard affecting the activity of the heart was observed both at rest and during static and dynamic exercise. Forced breathing during static exercise may minmize this phenomenon to some extent but it does not remove it completely.

In a study of the minute volume of the heart and the oxygen demand during static exercise, some workers observed Lindhard's phenomenon, others did not. We also observed that this phenomenon was sometimes present, sometimes absent. This fact, and also the undoubted resemblance of the changes in the heart rate, along with the characteristic changes in the minute volume and oxygen demand during static exercise, suggest that these phenomena have a common central mechanism.

It may also be postulated that the reflex which inhibits the cardiac activity during a static pose is one of the central links of the physiological mechanism of Lindhard's phenomenon.

The operation of this reflex causes corresponding changes in the minute volume and oxygen demand, and so possibly explains why in some cases Lindhard's phenomenon is observed during static poses and sometimes it is not. This hypothesis, however, requires special experimental verification.

SUMMARY

Cardiac contractions registered in 17 qualified gymnasts and weight lifters by means of a photoindicator and a phenomenon similar to that of "Lindhard" revealed that after cessation of the exercises, especially difficult ones, the rate of cardiac contractions increased sharply. This phenomenon was more pronounced in women than in men. There was no significant difference between qualified and nonqualified sportsmen.

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