THE EFFECT OF STIMULATING THE MECHANORECEPTORS IN THE URINARY BLADDER ON THE STRIATED MUSCULATURE

REPORT III. THE EFFECT OF STIMULATING THE MECHANORECEPTORS IN THE URINARY BLADDER ON THE ELECTRICAL ACTIVITY OF THE MUSCLE ANTAGONISTS

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In previous reports [2, 3] we described the effect of stimulating the mechanoreceptors in the urinary bladder on the various groups of striated muscles. The reactions of the different muscles showed a definite graduation in involvement. The smaller the part that one or another muscle took in the act of micturition, the higher was the threshold of

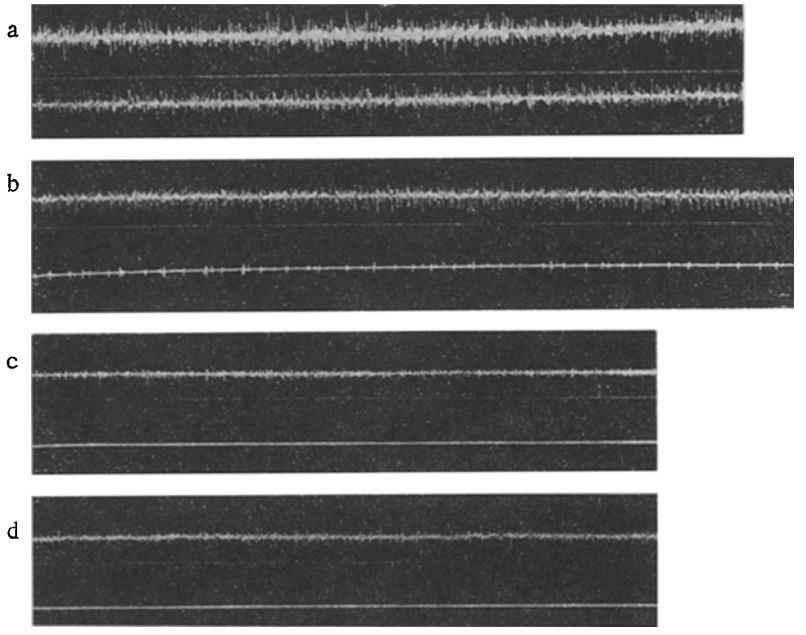

Fig. 1. Change in the activity of the sternoglossus and cleido-trapezoideus muscles of the neck associated with various strengths of stimulation delivered to the mechanoreceptors of the urinary bladder. a) Background activity of the cervical muscles with an empty urinary bladder; b) pressure in the urinary bladder of 48 mm Hg, activity of the sternoglossus muscle inhibited, the cleido-trapezoideus, unchanged; c) pressure in the urinary bladder 64 mm Hg; d) pressure in the urinary bladder 150 mm Hg, activity of both cervical muscles inhibited. Meaning of the curves (from above downward): activity of the cleido-trapezoideus muscle; time markings (1 second), activity of the sternoglossus muscle.

its reflex. The activity of the oblique abdominal and the semitendinosus muscles was inhibited in response to weak stimulation, but increased in response to a stronger stimulus. The activity of other (cervical) muscles was inhibited no matter how strong the stimulation to the mechanoreceptors of the urinary bladder. It was important to determine whether this relationship was true for the muscle antagonists as well.

There are several works in the literature in which authors recorded the reactions of the muscle antagonists during the stimulation of various interoceptor zones. Thus, O. S. Merkulova, in short term experiments on cats [4, 5], studied the actuating and correlating effects on the activity of the muscle antagonists of the posterior extremity caused by stimulation of the mechanoreceptors in the urinary bladder, rectum, small intestine, and even the chemoreceptors of the small intestine. She observed extremely diverse effects.

S. E. Ginzburg [1], in long term experiments on dogs, showed that weak mechanical stimulation of the receptors in the stomach most often caused a shortening in the chronaxis of the muscle antagonists in the rear extremity (m. tibialis and m. gastrocnemius), while strong stimulation caused its increase.

Evans and McPherson [6], in short term experiments on cats, observed an increase in the bio-electrical activity of both the flexors and extensors of the posterior extremities when they stimulated the mechanoreceptors of the urinary bladder. With stronger stimulation they noted inhibition of the bio-electrical activity in those and other muscles.

We recorded the electrical activity of the semitendinosus and quadriceps muscles of the posterior extremities, and the sternoglossus and cleido-trapezoideus muscles of the neck at various stages of filling of the urinary bladder. The experimental method was described in previous reports [2].

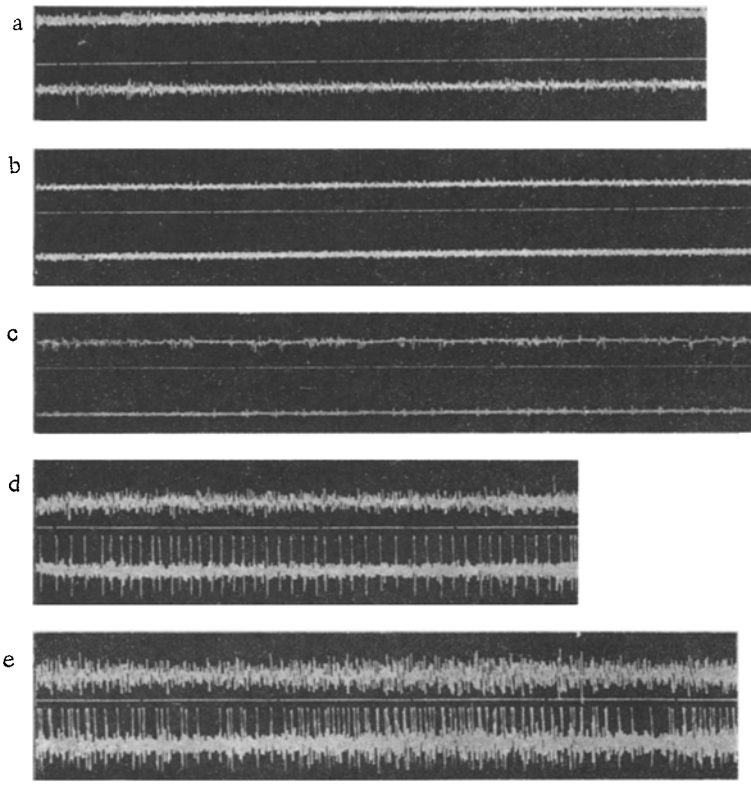

Fig. 2. Change in the activity of the semitendinosus and quadriceps muscles associated with various strengths of stimulation delivered to the mechanoreceptors of the urinary bladder. a) Background activity of the semitendinosus and quadriceps muscles with an empty urinary bladder; b) pressure in the urinary bladder of 43 mm Hg, activity of both muscles inhibited; c) pressure in the urinary bladder of 46 mm Hg, activity of the semitendinosus muscle somewhat increased, quadriceps– still inhibited; d pressure in the urinary bladder of 50 mm Hg; e) pressure in the urinary bladder of 51 mm Hg, activity of both muscles increased. Meaning of the curves (from above downward): activity of the semitendinosus muscle; time markings (1 second); activity of the quadriceps muscle.

EXPERIMENTAL

It was observed that the reactions of the muscle antagonists to stimulation of the mechanoreceptors in the urinary bladder conform to a general rule: muscle antagonists in regions of the body distant from the site of stimulation (for example, the flexors and extensors of the neck) uniformly decrease their activity in response to weak stimulation, and increase their activity in response to strong stimulation.

However, in individual experiments we observed a difference either in the thresholds at which the changes in electrical activity of the different muscle antagonists arose (Fig. 1) or in the thresholds of transition from one phase of changes in activity to another (from inhibition to increase in electrical activity; Fig. 2). The latter variation was demonstrated less frequently, and it was not as clearly manifested as the first.

The electrograms of the cervical muscle antagonists are presented in Fig. 1: sternoglossus (flexor) and cleido-trapezoideus (extensor). The activity of the sternoglossus muscle, observed with an empty urinary bladder (background activity, Fig. 1a), was not altered in response to distension of the urinary bladder with a pressure of 48 mm Hg, while the background activity of the cleido-trapezoideus muscle was inhibited (Fig. 1b). An increase in the stimulation strength to 64 mm Hg (Fig. 1c) and 150 mm Hg (Fig. 1d) causes inhibition of the activity of both muscles. Thus, both cervical muscles react in the same way to distension of the urinary bladder, i.e. by decreasing their activity, with the difference that for one of them the threshold for these activity changes is somewhat higher than for the other. The relative magnitude of the threshold does not depend on whether the muscle acts as a flexor or extensor: in different experiments the higher threshold could be observed in either of the muscles.

In Fig. 2 we present the simultaneous recording of the action potentials from the semitendinosus (flexor) and quadriceps (extensor) muscles of the posterior extremity. The background activity (Fig. 2a) of both muscles was in-

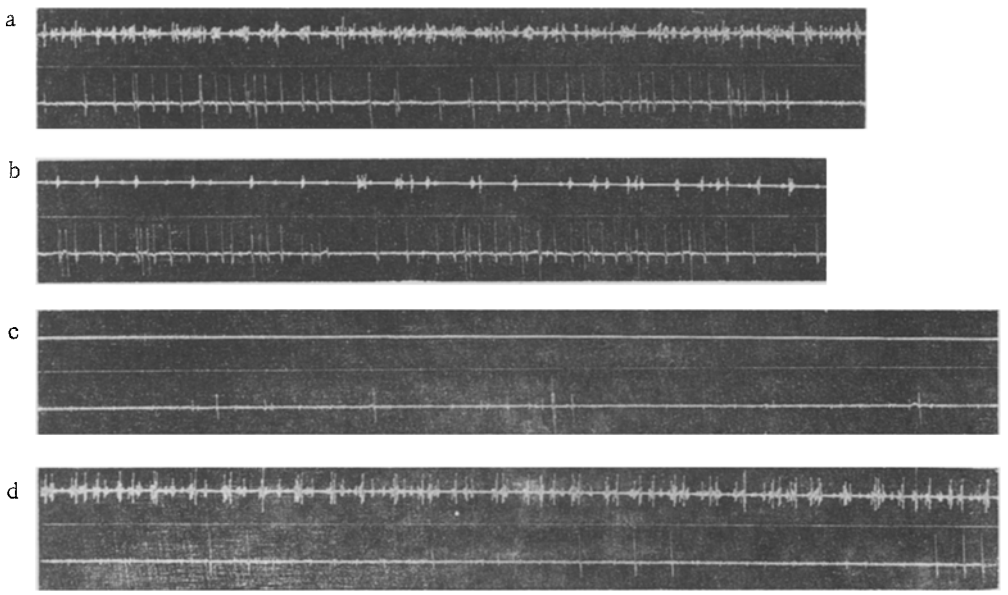

Fig. 3. Change in the activity of the quadriceps and cleido-trapezoideus muscles associated with various strengths of stimulation delivered to the mechanoreceptors of the urinary bladder. a) Background activity of the quadriceps and cleido-trapezoideus muscles; b) pressure in the urinary bladder of 22 mm Hg, inhibition of the activity of the quadriceps muscle, activity of the cleido-trapezoideus muscle unchanged; c) pressure in the urinary bladder of 36 mm Hg, inhibition of the activity of both muscles; d) pressure in the urinary bladder of 50 mm Hg, increase in the activity of the quadriceps muscle, inhibition of the activity of the cleido-trapezoideus. Meaning of the curves (from above downward): activity of the quadriceps muscle; time markings (1 second); activity of the cleido-trapezoideus muscle.

hibited in this experiment by the very same intensity of stimulation delivered to the mechanoreceptors of the urinary bladder (Fig. 2b). However, the transition from an inhibited to a hyperactive reaction arose at a somewhat lower level of stimulation intensity for one of the muscles than for the other. Just as in the case of the thresholds for the reactions of the cervical muscles, it did not matter whether the muscle was a flexor or extensor. In the trial demonstrated (see Fig. 2) the activity of the semitendinosus muscle increased at a somewhat lower stimulation level than the activity of the quadriceps (Fig. 2c). However, in the experimental series even this minimal difference in the thresholds for the transition from one reaction to another was not observed. Further increase in the stimulation intensity led to a still greater elevation in the activity of both muscles (Fig. 2d, e).

Thus, the muscle antagonists (flexors and extensors) in each segmental level react completely synergistically to stimulation of the mechanoreceptors of the urinary bladder. A difference may be observed either in the thresholds at which the transition from one reaction (inhibition) to another (strengthening) arises, or in the thresholds at which the changes in muscle activity occur. However, in a series of the experiments these differences cannot be observed.

The same situation is true for two muscle antagonists equidistant from the site of stimulation— flexors or extensors. For example, the right and left extensors of the neck diminish their activity in response to all intensities of stimulation; the right and left semitendinosus muscles weaken in response to weak stimulation, but increase their activity with strong stimulation. Changes in the activity of muscles removed to a various degree (functionally and anatomically) from the site of stimulation, are related to each other in a more complex fashion: at one strength of stimulation these muscles may react synergistically, at another— as antagonists.

In Fig. 3 we present the results of an experiment in which we simultaneously recorded the activity of two extensors— the quadriceps and cleido-trapezoideus muscles.

It can be seen that in response to weak stimulation of the urinary bladder mechanoreceptors the activity of the quadriceps muscle was inhibited, while the muscles of the neck did not alter their activity (Fig. 3b). An increase in the intensity of stimulation led to the activity of both muscles being inhibited (Fig. 3c). Further increase in the stimulus intensity again gave rise to divergent changes: in the quadriceps muscle the activity increased, while the activity of the cervical muscle was inhibited as before (Fig. 3d).

The results obtained completely coincide with the ideas expressed in the previous reports. The character of the reaction of the skeletal muscles from various regions of the body to stimulation of the internal organs is not determined by any kind of fixed connections of the afferent fibers with inhibitory or excitatory synapses, but by the degree of functional and anatomical proximity of one or another group of muscles to the site of stimulation. Indeed, symmetrical muscles, functionally related to the urinary bladder to an identical degree, react synergistically to an elevation in its pressure, although these muscles are antagonists in the act of locomotion. However, for this pair of muscles the functional relationships to the site of stimulation may not be entirely identical, resulting in a discrepancy in the thresholds at which they react, and in certain cases, at medium stimulation intensities, a reciprocal relationship may be observed between them while the synergistic relationship normal for these muscles is seen with weaker or stronger stimulation. Similar relationships were noted by S. E. Ginzburg in long term experiments on dogs.

In comparing the reactions of muscles removed to different degrees from the site of stimulation, which function synergistically in the act of locomotion, one may observe similar reactions at the medium level of stimulation intensity and an antagonistic relationship at weaker or stronger stimulation levels.

SUMMARY

In acute experiments on cats a study was made of the reflex changes occurring in the electric activity of muscle antagonists (semitendinosus and quadriceps, sternoglossus and cleido-trapezoid). As demonstrated, the muscle antagonists react in the same way in response to the stimulation of mechanoreceptors of the urinary bladder: the activity of muscles located far from the stimulation sites (flexors and extensors of the neck) decreases at the same rate in response to all adequate stimuli. In the antagonists of the adjacent areas (flexors and extensors of the posterior extremity) it diminishes to an equal degree in response to weak stimulation; but increases in response to stong stimuli. However, in individual experiments there may appear variations either at the threshold marking origination of the electric activity changes in various muscle antagonists, or at those incidents to the phase transition of the changes.

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All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. *Some or all of this periodical literature may well be available in English translation.* A complete list of the cover-to-cover English translations appears at the back of this issue.
