

THE EFFECT OF DIFFERENT INTENSITIES OF STIMULATION  
OF THE MECHANORECEPTORS OF THE URINARY BLADDER  
ON THE STRIPED MUSCULATURE

COMMUNICATION 2. RELATIONSHIP BETWEEN THE CHARACTER OF THE  
REACTION OF VARIOUS MUSCLES AND THEIR PROXIMITY TO THE  
SITE OF STIMULATION

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In a previous communication [8] we described reflexes from the mechanoreceptors of the urinary bladder on the striped muscle of the external sphincter of the urethra and on the oblique muscle of the abdomen, which takes part in the act of micturition. Several workers [1, 2, 3, 9, 10, 11, 13, 16, 18, 20] have described the effect of stimulation of the mechanoreceptors of the urinary bladder on different groups of skeletal muscles, not directly connected with micturition. There are indications [9, 10, 21] that differences in the degree of functional and anatomical proximity to the receptive zone affects the threshold of development of interoceptive reflexes on skeletal muscle. Miller and Waud [21] stimulated the central end of the superior mesenteric nerve and observed not only the contraction of the abdominal muscles but also the contraction of the muscles of the hindlimbs, and noted that the threshold of development of the reflex to the abdominal muscles was lower than that to the limb muscles. Only in individual experiments did these writers observe contraction of the muscles of the forelimbs and neck.

Merkulova [9] showed that during stimulation of the mechanoreceptors of the urinary bladder or rectum reactions developed in the abdominal muscles more readily and at a lower threshold of stimulation than in the muscles of the hindlimbs. As Merkulova's numerous investigations showed, the reaction of skeletal muscles to interoceptive stimulation were largely brought about by the condition of the nervous centers. Changes in the strength, frequency and duration of stimulation of the afferent somatic nerve, and also changes in the state of the central nervous system caused by the administration of various drugs, had an important influence on the visceromotor reflexes.

Nearly all writers have noted also that stimulation of the mechanoreceptors of the urinary bladder may cause both stimulation and inhibition of skeletal muscles; only a few, however, have attempted to ascertain what conditions may determine the particular character of the effect. Several workers [4, 5, 9, 12, 17] point out that it is dependent on the strength of interoceptive stimulation. As a rule weak stimulation caused inhibition of the contractions, a decrease in the tone and a shortening of the chronaxie of the muscles. With an

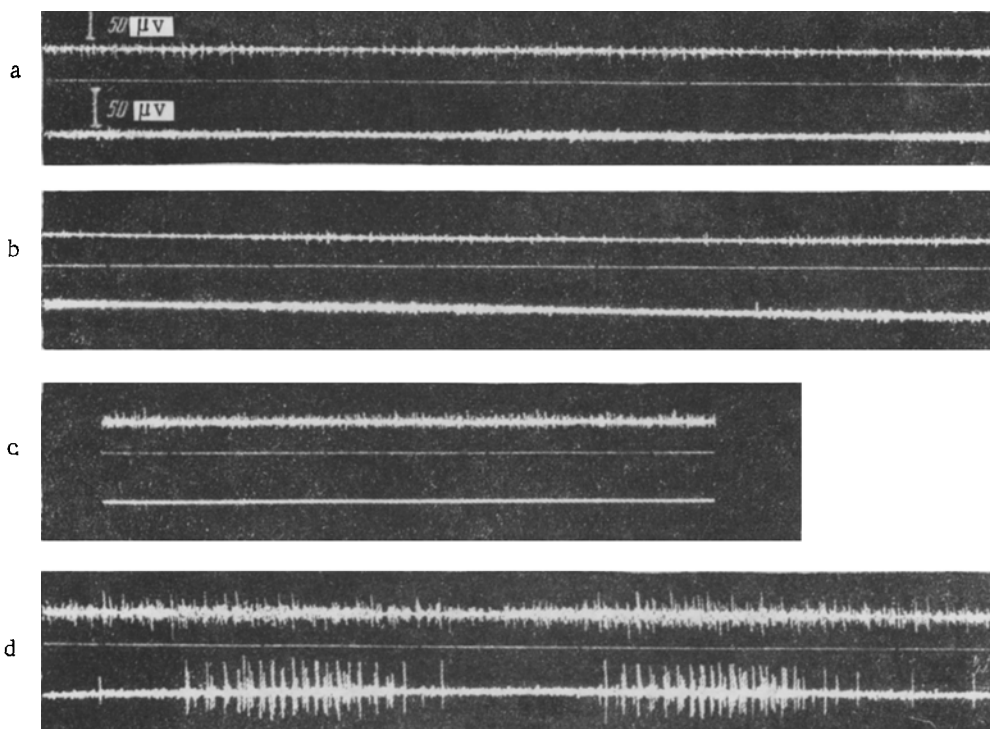


Fig. 1. Change in the activity of the oblique abdominal and semitendinosus muscles with different strengths of stimulation of the mechanoreceptors of the urinary bladder. a) Background activity of the oblique abdominal and semitendinosus muscles with an empty urinary bladder; b) pressure in the bladder 10 mm Hg, activity of the oblique muscle of the abdomen inhibited, that of the semitendinosus unchanged; c) pressure in the bladder 30 mm Hg, strengthening of the activity of the oblique abdominal muscle and inhibition of the activity of the semitendinosus muscle; d) pressure in the bladder 80 mm Hg, strengthening of the activity of the oblique muscle of the abdomen and semitendinosus muscle. Significance of the curves (from above down): action potentials of the oblique muscle of the abdomen; time marker (1 second); action potentials of the semitendinosus muscle.

increase in the strength of stimulation all the effects became opposite in character, i.e., strengthening of the contractions, an increase in the tone and a lengthening of the chronaxie of the muscles developed.

Evans and McPherson [19] recorded the effect of gradual increase of pressure in the urinary bladder on the monosynaptic reflexes (they stimulated the dorsal root and tapped the action potentials from the corresponding anterior root of the spinal cord), and observed that the potentials decreased in magnitude with slight filling of the bladder, but increased in magnitude when the pressure became higher.

When investigating, by another method, the influence of stretching of the urinary bladder on the flexor and extensor reflexes of the muscles of the hindlimbs (in response to electrical stimulation of the corresponding afferent nerve), these workers found that stretching of the urinary bladder at low pressure (10-20 mm Hg) increased the reflexes. When a high pressure (20-50 mm Hg) was created the reflex contractions of the corresponding muscle were increased in amplitude.

The object of the present investigation was to compare reflex influences on various groups of skeletal muscles in response to different intensities of stimulation of the mechanoreceptors of the urinary bladder.

#### EXPERIMENTAL METHOD

The muscles which were chosen as differing in their proximity to the place of stimulation were the oblique muscle of the abdomen, the semitendinosus muscle and the sternohyoid muscle in the neck. In view of discrepancies between the findings of different workers, which were largely due to differences in the methods which

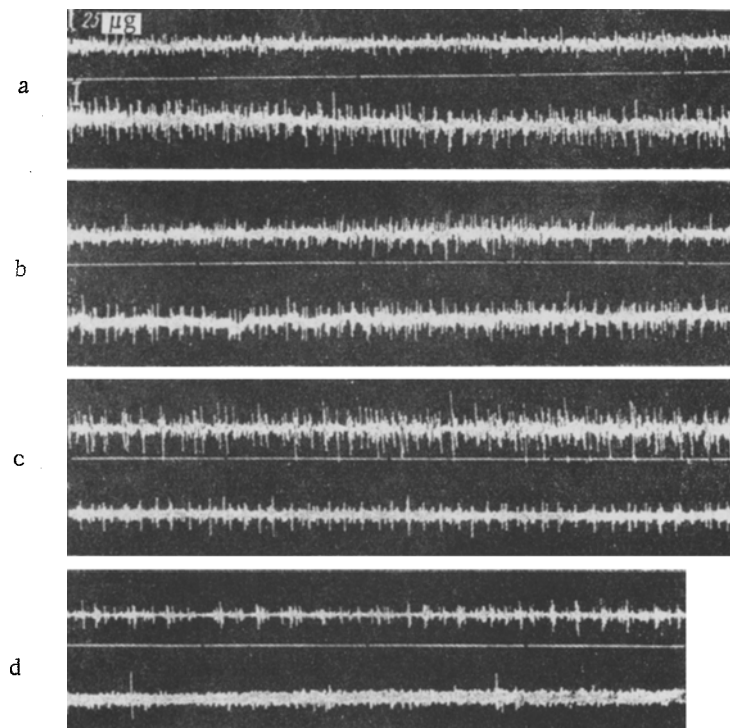


Fig. 2. Change in the activity of the oblique abdominal and sternohyoid muscles in response to different strengths of stimulation of the mechanoreceptors of the urinary bladder. a) Background activity of the oblique abdominal and sternohyoid muscles with an empty urinary bladder; b) pressure in the bladder 20 mm Hg, activity of the oblique muscle of the abdomen strengthened, that of the sternohyoid unchanged; c) pressure in the bladder 34 mm Hg, strengthening of the activity of the abdominal muscle and inhibition of the activity of the sternohyoid muscle; d) pressure in the bladder 150 mm Hg, strengthening of the activity of the oblique muscle of the abdomen and deep inhibition of the activity of the sternohyoid muscle. Significance of the curves (from above down): action potentials of the oblique abdominal muscle; time marker (1 second); action potentials of the sternohyoid muscle.

they used, we gave no additional stimulation and we studied the changes in the existing bioelectrical tone of the muscles under the influence of stimulation of the bladder receptors of different strength. Altogether 28 experiments were carried out.

The method is described in detail in our previous communication [8].

#### EXPERIMENTAL RESULTS

When the electrical activity of the semitendinosus muscle and oblique muscle of the abdomen was recorded simultaneously, the presence of background activity was noted in both muscles (Fig. 1,a). This activity could be associated with the respiratory rhythm, as in the figure cited, or not (Fig. 2,a). With weak stimulation of the mechanoreceptors of the urinary bladder there was a decrease in the activity of the abdominal muscles, although the action potentials of the semitendinosus muscle were unchanged (Fig. 1,b). With a somewhat greater strength of stimulation of the mechanoreceptors of the urinary bladder, depression of the activity of the semitendinosus muscle developed, whereas that of the abdominal muscles increased (Fig. 1,c). Stimulation of still greater strength caused an increase in the electrical activity of both muscles (Fig. 1,d). With extremely strong stimulation (140-150 mm Hg) the increase in the activity of the two muscles became less marked than with moderate stimulation, and in certain cases it was replaced by depression.

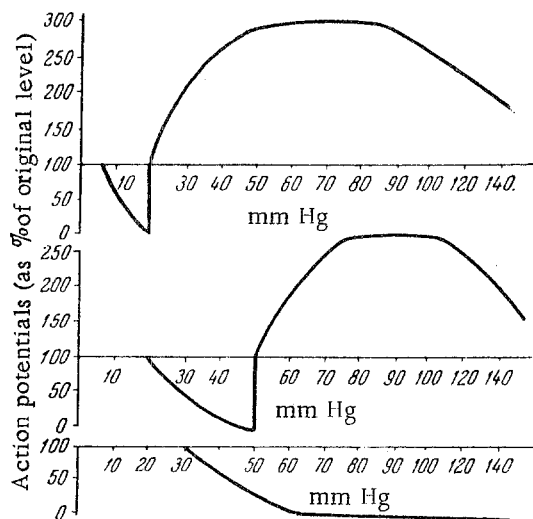


Fig. 3. Relationship between the reflex change in the activity of the oblique muscle of the abdomen, the semitendinosus and the sternohyoid muscles and the intensity of stimulation of the mechanoreceptors of the urinary bladder (schematic). Along the axis of abscissas — strength of stimulation of the urinary bladder (in mm Hg); along the axis of ordinates — action potentials of the muscles (from above down: oblique abdominal, semitendinosus, sternohyoid) as percentages of the original level.

on the skeletal musculature. With minimal strengths of stimulation these influences concern the muscles most closely connected functionally with the stimulated organ, but as the strength of stimulation increases they spread to other groups of skeletal muscles. Under these circumstances the intensity of the influences on the more closely situated muscles is adequate for depression to be transformed into intensification, whereas the activity of the remaining muscles is subjected only to a weaker, depressing influence.

The fact that Evans and McPherson [19] observed an increase in the reflex contractions of the muscles with weaker forms of stimulation and depression of the contractions in response to stronger stimulation of the ipsilateral somatic nerve. In such conditions the afferent flow of impulses from the urinary bladder evidently merely redoubled this "intrinsic" (to the recording muscles) reflex, exhibiting a succession of alternations of strengthening and depressing influences, which we found in the case of the external sphincter of the urethra. The "conjoined" reflexes are characterized by the opposite relationship between the nature of the reflex influences and the strength of stimulation, which we constantly observed in the absence of stimulation of somatic nerves, both in the skeletal muscles and in the vessels of closely situated organs.

The flow of impulses to the vessels of regions remote from the site of stimulation, like the tone of the more distant muscles, was also depressed during the strongest forms of stimulation [6, 7].

#### SUMMARY

The reflex changes of the electric activity in the oblique abdominal, semitendinosus and sternohyoid muscles were studied in acute experiments on cats. With the rise in the strength of the mechanoreceptor stimulation in the urinary bladder the first to appear is the reaction of abdominal muscles, with low strength stimulation — relaxation, with strong stimulation — contraction; with excessively strong stimulation the contraction is somewhat decreased or changes into relaxation. The muscles of posterior extremities are the second to react —

The change in the bioelectrical activity of the abdominal muscles thus developed at lower strengths of stimulation of the mechanoreceptors of the urinary bladder than the change in the activity of the muscles of the hindlimbs.

The recording of the action potentials of the cervical muscle showed that it also possessed background activity (see Fig. 2,a). The threshold of development of reflex changes in the activity of the cervical muscles during stimulation of the mechanoreceptors of the urinary bladder was higher than the threshold of development of changes in activity of both the abdominal muscles and the muscles of the hindlimbs. With strengths of stimulation of the urinary bladder sufficient to cause strengthening of the activity of the abdominal muscles, no changes were yet observed in the activity of the cervical muscles (Fig. 2,b). A further increase in the strength of stimulation, however, caused an increase in the activity of the abdominal muscles but also inhibition of the activity of the cervical muscles (Fig. 2,c), which became deeper as the strength of stimulation was increased up to excessive degrees, and did not change to strengthening of the activity (Fig. 2,d). The results of all these experiments have been combined in schematic form as graphs which are shown in Fig. 3.

It may be seen in Fig. 3 that the character of the reaction of the striped muscles to interoceptive stimulation is dependent on the degree of functional connection between the particular muscle and the region stimulated.

From this investigation certain conclusions may be drawn regarding the influence of interoceptive impulses

at first by relaxation, and then by contraction. With still greater strength of stimulation there appears a reaction of the cervical muscles — they relax and remain in this state with further increase in the intensity of the stimulation. Thus, the threshold and the character of the striped muscles reaction to the interoceptive stimulation depend on the degree of the functional connection of the given muscle with the area stimulated.

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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.

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