EFFECT OF DENERVATION OF THE WORKING CAPACITY OF MUSCLES

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In acute experiments on cats, the working capacity of the leg muscles during stimulation of the sciatic nerve was increased after division of the sciatic and femoral nerves. This effect was not due to changes in the circulation, for it persisted if the blood flow was stabilized. Increased working capacity was also manifested after partial deafferentation of the limb by division of the dorsal roots of the spinal cord or extirpation of the tibial bone marrow.

KEY WORDS: striated muscles; denervation; working capacity.

The central nervous system (CNS) plays an important role in the regulation of the working capacity of muscles. However, the mechanisms responsible for this role have not yet been identified. It has been suggested that an increase in the flow of afferent impulses from working muscles contributes to the onset of fatigue [4, 8], but only isolated experimental data can be found to support this view [3]. The opposite hypothesis has also been put forward, according to which fatigue arises as a result of a weakening of the spontaneous afferent impulse flow from working muscles [5].

The object of this investigation was to study changes in the working capacity of muscles after interruption of their connections with the CNS.

EXPERIMENTAL METHOD

In acute experiments on 29 cats (4 series, 7-8 cats in each series) under urethane-chloralose anesthesia, contraction of the flexor muscles of the foot was evoked by stimulation of the sciatic nerve or the ventral roots of the spinal cord at level L_7 with square pulses of supramaximal strength and 0.1 msec (sciatic nerve) or 1.0 msec (ventral roots) in duration, 4 times a second. The muscles contracted under isotonic conditions for 10 or 5 min with intervals of not less than 30 min and a load of 200 g. The quantity of work done was calculated in kilogram-meters. Changes in working capacity were assessed relative to the quantity of work done at the beginning of the experiment, taken as 100%. One limb acted as the control; in the other limb the sciatic and femoral nerves were divided or partial deafferentation of the limb was carried out by dividing the dorsal roots of the spinal cord at the level L_6-S_1, or the bone marrow was extirpated from the tibia. The central ends of the divided nerves and the bone cavity were treated with procaine.

EXPERIMENTAL RESULTS

After division of the sciatic and femoral nerves the working capacity of the leg muscles in response to sciatic nerve stimulation showed a statistically significant ($P < 0.05$) increase compared both with the control limb (by 33.9%) and in absolute figures – by 11.7% (Fig. 1a). This effect could be presumed to be due to division of the sympathetic vasoconstrictor fibers, as a result of which the muscles of the denervated limb received more blood than in the control. To rule out this possibility in the experiments of series II the flow of blood to the limb was stabilized by means of a resistograph. To abolish the unfavorable redistribution of blood between muscles and skin, at the expense of the muscles of the denervated limb, the

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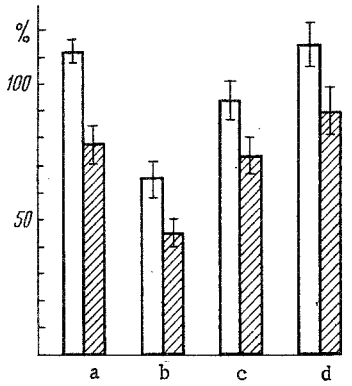

Fig. 1. Mean relative quantity of work done by limb muscles after denervation (a), after denervation with the blood flow stabilized (b), after deafferentation (c), and after extirpation of the bone marrow (d). Unshaded columns, experiment; shaded columns, control.

cutaneous blood flow was excluded by separating the skin from the muscles and then reattaching it in its former position (to prevent cooling and drying of the muscles, and also by application of a tourniquet above the malleolus. The blood flow was maintained at the resting state level during the experiment, which led to a deficiency of the blood supply to the muscle during contraction, with the relatively rapid onset of fatigue. Stimulation therefore continued for only 5 min. Under those conditions, just as when the blood flow was unrestricted, the working capacity in the denervated limb was 21.3% higher than in the control (Fig. 1b).

To study the role of afferent impulses in the regulation of the working capacity of the muscles the dorsal roots of the spinal cord were divided at the level L_6-S_1 in 7 cats. After this partial deafferentation, the leg muscles performed 20.5% more work than the muscles of the control limb in response to stimulation of ventral root L_7 (Fig. 1c).

To study whether afferent impulses from the specific muscle receptors (proprioceptors) play the leading role in the development of this phenomenon or whether activation of receptors of other tissues also is concerned, in one series of experiments (8 cats) the reflexogenic zone of the tibial bone marrow was blocked by extirpation of the marrow.

This zone was chosen because stimulation of bone and bone marrow (the osteoreceptive zone) induces powerful responses in the circulatory and respiratory systems [2, 7, 9]. Blocking the osteoreceptive zone, like deafferentation of the limb, increase the working capacity of the muscles by 25.5% (Fig. 1d).

Not only degenerating muscles [10], but acutely denervated and deafferented muscles thus have increased working capacity.

The results are in agreement with observations showing that stimulation of the interoceptors induces a decrease in the amplitude of muscular contraction [6] and that the working capacity of the muscles of the hind limbs is significantly increased after division of the spinal cord and sympathetic chain [1].

The results of the present experiments show that the CNS may have a reflex inhibitory effect on the working capacity of muscles. Since this inhibition is not determined by changes in the blood flow and since, with the frequency of stimulation chosen, changes in synaptic function are unlikely, it must be assumed that the CNS can inhibit the contractile power of muscles.

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