# OPTIMUM AND PESSIMUM FREQUENCY OF STIMULATION FOR THE TETANIC AND TONIC REFLEX APPARATUS

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E. K. Zhukov and O. V. Tarushkin [2] have suggested that the nerve centers innervating tonic skeletal muscles show slight mobility (lability). If this is the case, then tonic motor apparatus should tend to transition to a state of pessimal inhibition more than centers which innervate phasically active systems. The present work presents investigations concerned with this problem.

## EXPERIMENTAL METHOD

Experiments were performed on 50 spinal frogs, one hour after the operation. The sciatic nerve was isolated on one side, with transection of the tibial and peroneal branches. The central ends of these nerves were subjected to simultaneous tetanizing stimulation, using condenser discharges interrupted by a neon breaker. The frequency of the discharges could be varied from 10 to 500 per second, without affecting the strength of stimulation. On the side contralateral to the nerve the tetanic sartorius muscle and the mixed ilio-tibial and gastrocnemius muscles were dissected and the tonic bundle of the iliofibular muscle was isolated. Muscular contractions were recorded on a kymograph. The experimental results were similar in the vast majority of experiments.

## EXPERIMENTAL RESULTS

In a freshly prepared sartorius muscle the reflex responses to optimal strength of stimulation are small in amplitude and duration when the frequency of stimulation is 50-100 per second. However, even under these optimal conditions of stimulation tetanus is not usually maintained for longer than 10-15 seconds; despite the continuing stimulation of the afferent nerve the muscle undergoes relaxation fairly rapidly (Fig. 1, a). In these cases "post-inhibition excitation" is observed as a rule. At higher frequencies of stimulation reflex tetanus becomes weaker and of less duration. At stimulation frequency of 150-200 per second reflex responses are often completely absent.

The reflex responses of the tonic bundle of the iliofibular muscle ate highest in amplitude and longest in duration at a stimulation rate of 25-50 per second. Under these optimal conditions tonic contraction may be maintained without slackening for several minutes (Fig. 1, b). On termination of stimulation the muscle does not relax immediately but does so gradually; no contraction of the "post-inhibition excitation" is observed. The amplitude of tonic contraction diminishes at stimulation frequencies of 60-70 per second and higher; the contraction loses its persistence and becomes a small slow wave which drops to zero during a few seconds of stimulation.

It is noteworthy that complete cessation of reflex response of the tonic bundle occurs, as a rule, at higher frequencies of stimulation (300-350 per second) than cessation of response of the tetanic sartorius muscle (150-200 per second). Figure 2 shows reflex contractions of the whole iliofibular muscle. In response to stimulation

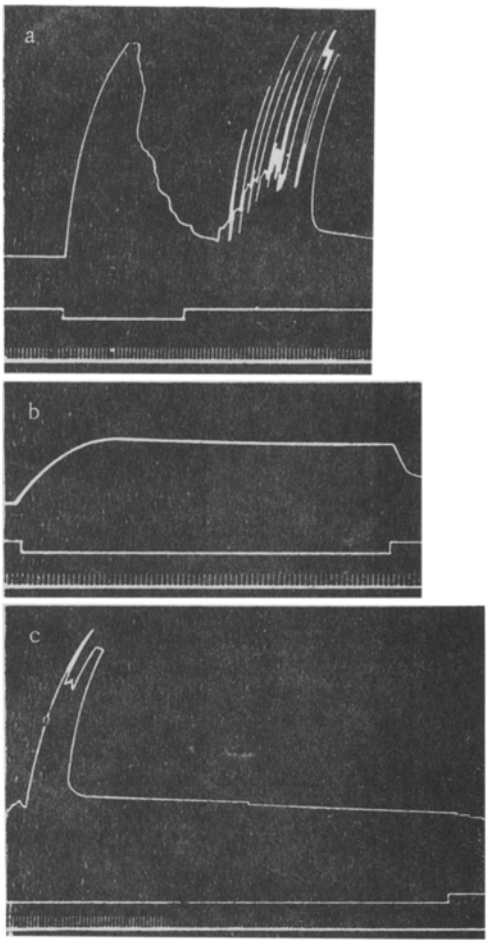


Fig. 1. Reflex contractions of frog skeletal muscles in response to optimal strength and frequency of stimulation of the sciatic nerve. a) Sartorius muscle, b) tonic bundle of iliofibular muscle, c) whole iliofibular muscle. Records from above down: myogram, time marker (1 second).

frequency of 50 per second there is first strong tetanic contraction, which, however, becomes weaker fairly quickly, revealing a more persistent tonic background (which can be seen more clearly in Fig. 1, c). At stimulation frequencies of 70, 80 and 100 per second the latent period of the tetanic response becomes longer; the amplitude and duration of the response show a decrease. There is simultaneous decrease in the tonic component of the contraction which becomes a small wave with the tetanic peak superimposed on it. Reflex tetanus disappears completely at 150 simulations per second, while the abortive tonic wave disappears only at 360 stimulations per second.

The more sluggish development of inhibition in the centers of the tonic apparatus is also shown by the following. When the afferent nerves are stimulated at frequencies at which complete inhibition develops in the centers of the fatigued sartorius muscle, no such inhibition develops in the centers of the fatigued tonic bundle; the latter responds to such stimulation by weak, slow waves of contraction.

The data presented above provide evidence confirming the hypothesis of lower functional mobility of nerve centers associated with tonic contractile musculature. In fact pessimal inhibition in these centers occurs at lower frequencies of stimulation than in centers associated with phasically active systems. The slower development of complete inhibition in tonic centers is not contradictory to this hypothesis. A. A. Ukhtomskii [3] indicated that "the more labile the tissues dealt with the more marked is the significance of intervals and urgency of performance of the component functions. Where the intervals are large, the individual moments of their interaction are of much less critical significance. That is why typical humoral influences in the body and tonic systems show relatively greater inertia than tetanic innervation of the musculature. That is also

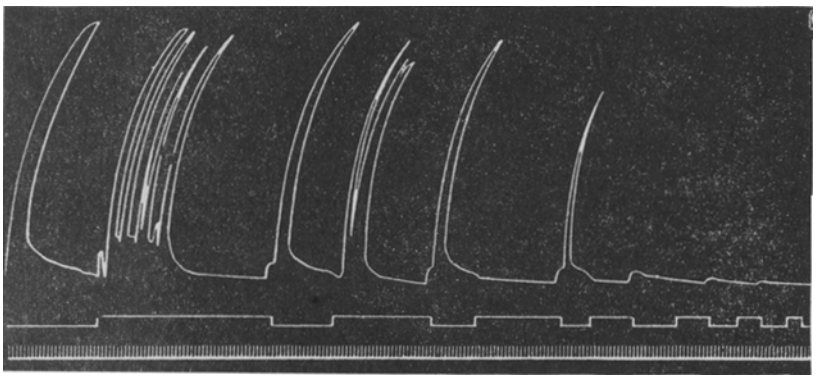

Fig. 2. Reflex contractions of iliofibular muscle. Stimulation of the central end of the sciatic nerve at the rates of 50, 70, 80, 100, 150, 220, 300 and 360 per second. Records the same as in Fig. 1.

why marked parabiotic stages presuppose a relatively high labile state of the experimental preparation." "Parabiotic inhibition" in the words of E. K. Zhukov [1], "is only possible in lively tissue with rapid metabolism and capacity for quick reaction."

## SUMMARY

Experiments were performed on spinal frogs. It was demonstrated that in excessive increase of the frequency of stimulation of the afferent paths a condition of pessimal inhibition is developed in the nerve centers innervating the tonic muscular apparatus. Pessimal phenomena begin at the frequency of 60-70 stimulations per second. Complete depression of the reflex response takes place at the frequencies of 300-350 stimulations per second. As to the centers innervating the tetanic muscle fibers the pessimal phenomena commence only at the frequency of 100-150 per second. Inhibition in "tetanic centers" develops much quicker. Complete depression of the reflex response usually takes place at the frequencies of 150-200. These facts point to the lower lability of the nerve centers innervating the tonic muscular apparatus.

## LITERATURE CITED

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