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16. Abstract
There is no data on the comparative effect of tenotomy on the function of the muscle spindles of fast and slow muscles. This study covers this question.
The experiments were conducted on cats. The musuculus extensor digitorum longus (m. EDL) was selected as the fast muscle, and the musculus soleus (m. Sol.) as the slow.
In a comparison of the spontaneous activity of primary and secondary endings of the fast and slow muscle spindles (i.e., the activity with complete relaxation of the muscles) normally no difference between them was successfully found.
The Authors recorded the integrative, and not the individual activity, and secondly, under conditions of such recording technique, those slight changes that are observed in the fast muscle receptors could remain unnoticed.

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EFFECT OF INACTION ON FUNCTION OF FAST AND SLOW MUSCLE SPINDLES

R. S. Arutyunyan*

It is known that during inaction of muscles caused by cutting /1833** of the tendon, morphological and histochemical changes are expressed unequally in the fast and slow muscles. The slow muscles are exposed to faster and more considerable atrophy [5, 16, 18]. Histochemical changes in the fast and slow muscles also are not expressed the same [6]. As for the functional changes, here there is no single opinion. According to some data, after tenotomy there is a decrease in the ratio of the maximum tetanic contraction to the single, and the rate of muscle contraction also diminishes [3, 19]. According to other data [1, 17], there are no changes in the contractile properties and the EMG after tenotomy. There is also no unified opinion in relation to the functional changes in the receptor apparatus of the muscles during tenotomy. According to some data, an increase occurs in the activity of the muscle spindles [10, 14], according to other--such changes are not observed [7]. At the same time, there is no data on the comparative effect of tenotomy on the function of the muscle spindles of fast and slow muscles. This study covers this question.

The experiments were conducted on cats. The musuculus extensor digitorum longus (m. EDL)was selected as the fast muscle, and the musculus soleus (m. Sol.) as the slow. The selection of the

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indicated muscles was governed by their approximately similar weight, which is extremely important in a comparative study. Tenotomy was done under sterile conditions. The experiment began two-five weeks after surgery. The afferent activity of the muscle spindle was recorded from an isolated posterior root bundle that contained a fiber from the studied spindle. The muscle receptors were identified based on their reactions to the muscle contraction. If on the background of muscle contraction the pulse activity stopped, then the given receptor belonged to the muscle receptor [15]. Based on the rate of conducting the stimulation, the sensitive endings of the muscle spindles were divided into primary and secondary [11]. A recording was made: 1) spontaneous pulse activity that was recorded no earlier than in 3 min. after relaxing of the muscle; 2) background activity that can be induced by passive stretching of the muscle with a 100 g load, and 3) induced activity, when the muscle is additionally stretched by 3,6,9 and 12 mm with a rate of 20 and 40 mm/s. The muscle is in the stretched state for 3 s. Contraction of the muscle and its stretching are recorded tensometrically with the help of a universal tensometric unit type UTS-VT-12. A total of 30 primary and 10 secondary endings were isolated on each muscle normally, and the same number after tenotomy. The reliability of the experimental data was determined according to Student's t-criterion. A difference between /183
the arithmetic means with $P<0.05$ was considered to be reliable. During the entire experiment, the animal was warmed so that the body temperature and the temperature of the wound that was operated on fluctuated in limits of 36-38°.

In a comparison of the spontaneous activity of primary and secondary endings of the fast and slow muscle spindles (i.e., the activity with complete relaxation of the muscles) normally no difference between then was successfully found. The average frequency of spontaneous activity in the primary endings of the m. Sol. normally equalled 15 imp/s, and in the m. EDL--14 imp/s. After tenotomy, no reliable change was observed in the frequency of spontaneous impulse activity. The frequency of spontaneous activity of the primary

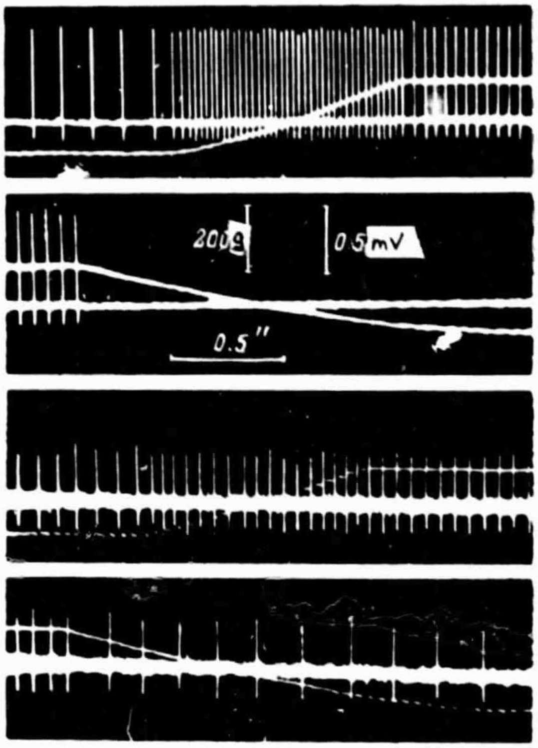

Figure 1. Responses of Primary and Secondary Endings of Muscle Spindle during Stretching of m. Sol by 9 mm at Rate of 20 mm/s.
The oscillograms present the background activity, dynamic phase, beginning and end of the static phase, moment of relaxing and return of the muscle to the initial level. Continuous recording. Two second gap between the frames.

endings of the m. Sol. is 19 imp/s, and in the m. EDL--15 imp/s, in the secondary endings of the m. Sol.--15 imp/s, and in the m. EDL 13 imp/s. Other authors [10] have indicated the absence of changes on the part of spontaneous impulse activity after tenotomy. As experiments have shown, there is no reliable difference in the background activity of the fast and slow muscle receptors induced by stretching the muscles with a 100 g load (see table, A and B). At the same time, it is necessary to note that according to other data, the background activity of the muscle receptors of loaded fast muscles as compared to the activity of slow muscles is higher [8]. After tenotomy an increase is observed in the background activity of the primary and secondary endings of the loaded

slow muscle spindles, while no changes are observed in the background activity of the loaded fast muscle spindles (see table, A and B). Figure 1 presents typical responses of the primary (A) and secondary (B) endings during muscle stretching. It is apparent from the data of the cited figure that at the moment of stretching the frequency of discharges in the primary endings rises sharply, while this increase is less pronounced in the secondary endings. During the transition from the dynamic phase to the static, the /1835
frequency of discharges is sharply reduced, but remains considerably higher as compared to the original level. As in the dynamic phase of stretching, the frequency of spindle responses in the static phase is higher in the primary endings. The responses of the primary and secondary endings are also distinguished in the process of muscle relaxation. At the moment of relaxation and before complete return of the muscle to the original condition, the frequency of responses in the primary endings drops sharply, while in the secondary endings only a certain decrease in impulse activity is observed. The indicated properties of the primary and secondary endings have been previously described [1,2,4,9].

In a comparison of the responses of the primary and secondary endings of the fast and slow muscle spindles it was found that with additional passive stretching no reliable difference in the responses of the primary and secondary endings was successfully found in the dynamic and static phases of stretching (see table, A and B).

One should note one interesting feature--the interrelationships between the dynamic and static phases with an increase in the stretching amplitude. It is apparent from figure 2 that with an increase in the stretching amplitude the frequency of responses in both the primary and secondary endings of the fast and slow muscles in the dynamic phase is not altered or has a tendency to drop, while the responses in the static phase with an increase in stretching become greater. It is also apparent from the figure that while

CHANGE IN ACTIVITY OF PRIMARY (A) AND SECONDARY (B) ENDINGS OF MUSCLE SPINDLES OF FAST AND SLOW MUSCLES NORMALLY AND AFTER TENOTOMY

Endings	Muscle	frequency of back-ground activity (imp/s)	frequency of pulses in dynamic phase of stretching		frequency of pulses in static phase of stretching					
					1 s		2s		3 s	
			rate of stretching 20 mm/s	rate of stretching 40 mm/s	rate of stretching 20 mm/s	rate of stretch. 40 mm/s	rate of stretch. 20 mm/s	rate of stretch. 40 mm/s	rate of stretch. 20 mm/s	rate of stretching 40 mm/s
A	Normal	23 ±1.0*	75 ±4.1	115 ±5.6	34 ±2.0	34 ±1.8	30 ±2.0	30 ±1.2	29 ±2.1	28 ±1.1
		26 ±1.1**	77 ±2.5	114 ±3.1	33 ±1.7	34 ±1.5	32 ±1.6	31 ±2.0	31 ±1.5	30 ±1.4
	Operated on	30 ±1.2*	109 ±3.0	157 ±2.6	53 ±2.4	50 ±1.8	49 ±2.1	45 ±1.7	47 ±1.9	42 ±2.6
		27 ±1.5**	85 ±3.2	128 ±5.6	40 ±1.9	37 ±1.8	37 ±1.7	35 ±1.7	36 ±1.7	34 ±1.6
B	Normal	24 ±1.2*	38 ±1.9	54 ±3.1	28 ±1.3	26 ±1.1	27 ±1.3	25 ±1.0	26 ±1.3	25 ±1.0
		28 ±2.4**	42 ±3.2	58 ±4.0	32 ±2.8	31 ±2.9	31 ±2.6	30 ±2.6	30 ±2.6	30 ±2.6
	Operated on	38 ±3.0*	62 ±4.9	82 ±5.2	47 ±3.7	47 ±3.5	45 ±3.3	45 ±3.3	44 ±3.2	45 ±3.4
		29 ±1.3**	56 ±2.5	69 ±3.0	37 ±1.7	36 ±1.5	36 ±1.5	34 ±1.3	35 ±1.5	34 ±1.3

Note: * Sol., ** EDL.

the frequency of rsponses in the dynamic phase depends on the rate of stretching, the frequency of responses in the static phase does not depend on the rate of stretching, and is determined entirely by the amplitude of stretching. Such a course of the impulse activity in the muscle spindle is governed by those local processes that occur in the sensitive endings of the receptor [12, 13].

During tenotomy, the indicated trend towards correlation /1836
of the dynamic and static phases of responses is preserved both in the responses of the sensitive endings of the fast and slow muscle spindles, but then become "steeper." After tenotomy, the sensitivity of the muscle spindles of both the fast and slow muscles is increased. This increase in sensitivitiy is expressed in the fact that the frequency of discharges of the muscle receptors is sharply increased during stretching of the muscles. However, this increase is expressed more strongly in the receptors of the slow muscles. In addition to an increase in responses of the primary endings in the dynamic phase, an increase is observed in the static phase of the responses. It is necessary to note that if a statistically reliable increase occurs in the static phase of stretching in the primary endings of the m. Sol. already during stretching of the muscle by 3 mm, then in the primary endings of the m. EDL it is observed during great stretching, namely, starting with 6 mm and more.

Changes in the activity of the secondary endings after tenotomy in principle are analogous to the changes in the primary endings. As in the case of primary endings, an increase in the background activity is observed only in the secondary endings of the m. Sol. As in the case with primary endings, the most noticeable changes after tenotomy are observed in the responses of the secondary endings of slow muscles (see table, A and B). As in the case with primary endings, the statistically reliable changes in the secondary endings of the m. EDL begin to be observed during stretching of the muscle by 6 mm and more (fig. 3). Thus,

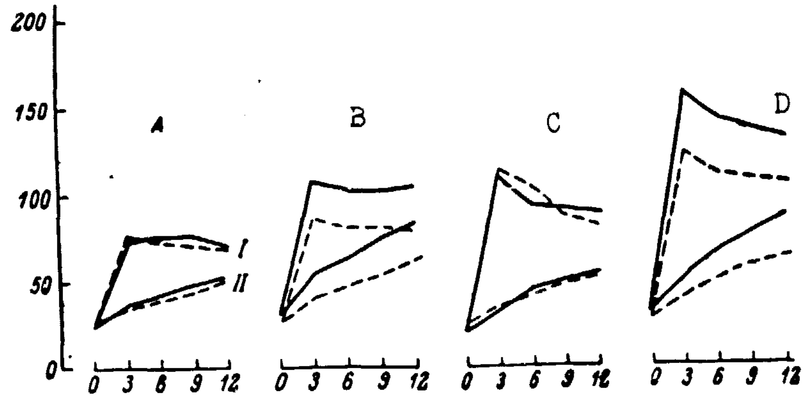

Figure 2. Dependence of Frequency of Responses by Primary Endings of Muscle Spindles on Amplitude and Rate of Stretching
On x-axis--amplitude of stretching, in mm; on y-axis--frequency of discharges, in imp./s; Solid line--responses of m. Sol., dotted--m. EDL; I--dynamic phase of response; II--static, A, C--normal, B and D--tenotomized. Rate of stretching--for A and B--20, C and D--40 mm/s.

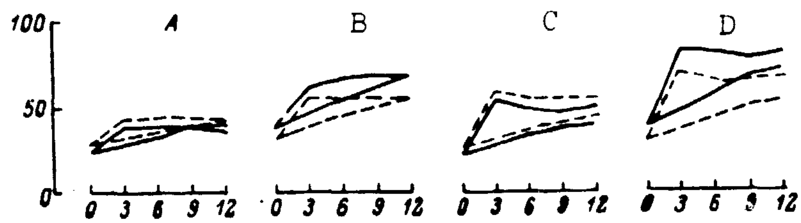

Figure 3. Dependence of Frequency of Responses of Secondary Endings of Muscle Spindle on Amplitude and Rate of Stretching.
Designations the same as in figure 2.

after tenotomy an increase is observed in the activity in the spindles of the fast and slow muscles, which is expressed more strongly in the slow muscle receptors. It is necessary, however, to note that Eldred et al. [7], in recording the integrative activity from the posterior roots of the tenotomized muscle, could not find an increase in the afferent activity from the operated-on muscle. The observed discrepancy could be explained by the following reasons. First of all, the indicated authors recorded the integrative, and not the individual activity, and secondly, under conditions of such recording technique, those slight changes that are observed in the fast muscle receptors could remain unnoticed.

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