ADDITIONAL DATA ON THE CHANGES IN THE EFFICIENCY OF MUSCLES UNDER THE INFLUENCE OF THE ACTIVITY OF OTHER GROUPS OF MUSCLES

V. V. Rozenblat

From the Department of Normal Physiology (Prof. N. K. Vereshchagin, Chairman) of the State Medical Institute and from the City Medical and Physical Culture Dispensary (M. B. Kazakov, Head Physician), Sverdlovsk

(Received June 26, 1956. Presented by V. N. Chernigovsky, Active Member of the Academy of Medical Sciences of the USSR

As we showed earlier [9], Sechenov's phenomenon (an increase in the efficiency of muscles under the influence of the prior activity of other groups of muscles) is distinctly expressed on a mercury dynamometer during static tension of the wrist, which was the object of our study. Moreover, in full agreement with the data of M. E. Marshak [4], S. P. Narikashvili and Sh. A. Chakhnashvili [6] as well as the recent data of S. I. Krapivintseva [1, 2], it was shown that the greatest effect is produced by work of other muscles which is characterized by a known moderate intensity and a moderate degree of fatigue; light or, on the other hand, excessively fatiguing work is scarcely effective. These facts support the idea that, in the intercentral influences which determine the effect of active rest, a leading role is played by the induction relationships which prevail, according to I. P. Pavlov [7], under just such conditions, i. e., not during weak, nor during excessively strong, but during moderately strong excitation of the cortical cells. The centers of the muscles being studied as other muscles are working show up in virtue of the simultaneous negative induction by the inhibited ones. If they were fatigued, a protective process of inhibition restores their strength more rapidly. The competence of the centers which were not working and were not fatigued also increases, but to a lesser extent.

The final question – that of the changes in the efficiency of the muscles which were not fatigued and were not working, under the influence of the activity of other groups of muscles – became the theme of our further research.

In the first series of examinations (76 observations of three subjects), performed under our direction in 1952 by a student, G. A. Dedyurkina, a study was made of the influence on the static endurance of the wrist (the duration of static tension on a mercury dynamometer under a load amounting to half the strength of the muscles being tested) of simultaneous, less intensive work by the other hand – static tension under a load amounting to one third of the strength. The given form of work by the other hand, used earlier by us as one of the types of active rest, afforded the greatest effect, i. e., with it, if it was used during rest, the induction relationships were most clearly evident. It was therefore of interest to explain what influence will be exerted by its use simultaneously with the work of the hand being examined.

Both in the fundamental and in the control observations, after the work of the hand being examined ceased, the subject was given 1½ minutes of rest, and then the static tension was repeated with the same load (but this time without including the other hand). This permitted one to judge indirectly the degree of fatigue in the first period of work, because the greater it is, the smaller will be the duration, other conditions being equal, of the repeated work after a short interval of time.

In handling the data obtained, as in our preceding work, we made use of the "individual relative values": for each hand of the individual subjects the average data of the control experiments were taken as 100%, and all

the results of the experiments with a given hand were expressed in percentages of this value. This provided a proportional handling of the data according to statistical variation. The averages of the relative individual values are cited in the third column of Table 1.

The data obtained (Table 1) show that worked performed simultaneously by the other hand increases the capacity for work of the muscles under investigation. This agrees with the data of E. A. Mukhamedova [5] and some other authors.

The increase in capacity for work is caused in our opinion by a mechanism of dominance. Proprioceptive impulses from the moderately taut muscles of the other hand are "attracted" to the dominant focus and stimulate it.

What is interesting in our data is that as an "accompanying" load that form of work was performed by the other hand which, during its performance before and after the work of the symmetrical muscles, produced inhibition in their centers in virtue of marked negative induction. Performed simultaneously with the work of the centers under investigation, it exerted the opposite influence on them: if the induction relationships were preserved in this instance, we would have obtained, not stimulation, but depression of the capacity for work (G. V. Popov [8] obtained just such a result during a corresponding set of experiments).

TABLE 1

Subjects	Hand	Simultaneous tension other hand (A)		Ordinary conditions (B)		A/B, in %	Duration of second work period (after 1.5 min. rest) in sec.	
		no. of measurements	average endurance in sec.	no. of measurements	avg. endurance (sec.)		A	B
D.	Right	7	67.1	7	63.1	106.3	45.0	50.0
	Left	7	66.7	5	59.8	110.0	45.3	47.0
Zh.	Right	7	55.4	7	55.4	100.2	39.4	40.8
	Left	7	51.8	6	43.5	119.2	37.5	37.7
U.	Right	6	50.2	6	45.8	109.5	40.0	32.5
	Left	6	54.2	5	45.0	123.1	34.2	35.0
Average			57.7		52.5	111.1 ±2.4	40.4	40.8

Notation. The probability integral (the reliability of the difference between the average measurements during the simultaneous work of the other hand and under ordinary conditions) amounts to 0.9996.

A comparison of the data of the 4th and 5th columns of Table 1 shows that the repeated (after $1^1/_2$ minutes) work of the hand under investigation was of the same duration in the fundamental and control experiments. Consequently the simultaneous work of the other hand postpones the development of exhaustion, not through disturbing the functions of the protective protective inhibition which later asserts itself (this would lead to a more marked exhaustion and to shortening the repeated work), but as a result of a real increase in competence under the influence of the stimulation of the dominant focus.

The data obtained show that a more careful look is required at the "superfluous" movements in athletics. At times supplementary movement (that, for example of the free hand of a thrower etc.) may even heighten the effect of the work.

In the second series of our examinations (70 observations of six subjects) a study was made of the influence of prior static tension of the other hand on the strength of the wrist which was not working (earlier in all our other examinations we studied the influence of this factor on another characteristic – endurance).

The strength of the hand under investigation (the right hand among 2 subjects and the left hand among 4) was measured with the use of a mercury dynamometer before and after static tension of the other hand continued

to the limit, i. e., until marked exhaustion, at which point continuation of the work was only possible with a reduction of the load. Control observations showed that with the time intervals selected repeated measurements by themselves do not provide substantial shifts in strength.

The data obtained (Table 2) show that the strength of the hand which was not working, measured immediately at the cessation of the work performed by the other hand, was in all 6 of the subjects greater than the initial level. Moreover, in two of the subjects the increase in strenght continued for yet a period of 30 seconds, and only during subsequent measurement – 2 minutes later – was there noted a reduction in strength and a return to the initial value. Among four subjects the maximal increase in strength was noted immediately after the cessation of the work of the other hand.

The fact of an increase in the strength of one hand under the influence of the work of the other corresponds to the data of A. N. Krestovnikov [3]. The special feature of our results was the fact that among a part of the subjects the increase in strength continued for a known period after the cessation of the work of the other hand.

This evidently indicates the duplex mechanism of that temporary increase in excitability of the corresponding cortical cells which is the basis of the observed short-term increase in the strength of the wrist.

If during the work of the other muscles the centers under investigation are in state of induced inhibition, then at the cessation of the work of the other hand the state of inhibition, in virtue of successive positive induction, gives place to a state of increased excitability. The given mechanism emerges distinctly in those two subjects (Ch. and V., see Table 2) in which was noted a gradual increase in strength. The induction relationships which prevailed during the work of the symmetrical muscles may, toward the end of their work, (when the development of fatigue and the corresponding increase in volitional tension considerably augments the excitation of the working centers) give place to irradiation of excitation (the neighboring muscles do not accidentally contract involuntarily during fatigue). This increases the excitability of the symmetrical centers, and this means the strength of the muscles as well. The given mechanism stands out distinctly among those four subjects in which the maximal increase in strength was noted immediately after the cessation of the work of the other hand (see Table 2.

TABLE 2

Subjects	No. of measurements	Average strength value (cm of mercury)			
		before work of other hand	right after work of other hand	after 30 sec.	after 2 mins.
M.	13	116.7	123.2	120.7	120.2
Ch.	7	114.0	115.7	116.8	114.0
Kp.	14	113.9	116.0	112.8	114.0
K.	12	118.5	121.2	118.6	116.5
Sh.	12	115.8	119.0	116.9	116.6
V.	12	117.8	118.8	119.1	118.9

Thus the facts obtained in comparison with the results of preceding research enable one to approach a precise statement of certain mechanisms of these intercentral relationships which produce a change in the working capacity of muscles under the influence of the work of other groups of muscles.

One and the same form of work by definite muscles (i. e., one and the same degree of proprioceptive impulsation into the corresponding centers) may exert a different influence on the other centers depending on their state: during relative rest it produces and strengthens inhibition in them (according to the principle of induction); during excitation it increases their activity (according to A. A. Ukhtomsky's principle of dominance).

The increase in the strength of certain muscles after the work of others is linked both with irradiation of excitation and with successive positive induction (following the induced inhibition during the work of the other muscles).

SUMMARY

A mercury dynamometer was used to study changes in the working capacity of muscles of the hand as influenced by the work of symmetrical muscles of the other hand. The first series (76 observations of 3 subjects) showed that endurance toward static tension (measured under a load equaling one half of the strength of the tested muscles) increases during simultaneous moderate tension in the other hand equaling one third of its strength. The second series (70 observations of 6 subjects) showed that the grasping power of the hand grows when static tension in the other hand is continued to the point of fatigue; sometimes this growth went on for several seconds after work had ceased. The central nervous mechanisms of the observed changes were analyzed.

LITERATURE CITED

[1] S. I. Krapivintseva, Byull. Eksptl. Biol. i Med., XXXII, 2, p. 105 (1951).

[2] Ibid., XXXII, 5, p. 334 (1951).

[3] A. N. Krestovnikov, Essays on the Physiology of Physical Exercises,* Moscow (1951).

[4] M. E. Marshak, Physical Culture and Socialist Construction,* 10-11, p. 52 (1932).

[5] E. A. Mukhamedova, Abstracts of Papers Presented at the Scientific Conference on the Problems of the Physiological Basis of Physical Education and Sports,* Moscow, p. 25 (1954).

[6] S. P. Narikashvili and Sh. A. Chakhnashvili, The Theory and Practice of Physical Culture,* X, 7, p. 317, (1947).

[7] I. P. Pavlov, Complete Works,* Vol. 3, Chap. LXI (1949).

[8] G. V. Popov, Scientific Reports of Leningrad State University,* 23, Biology Series, No. 6, p. 106, (1938).

[9] V. V. Rozenblat, Byull. Eksptl. Biol. i Med., XXXII, 5, p. 339 (1951).

* In Russian.