MECHANISM OF WORK REFUSAL THROUGH FATIGUE REFLECTED IN ELECTROMYOGRAPHIC CHANGES UNDER HYPNOSIS

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Changes in muscle electrical activity were studied during local static work until "refusal" under ordinary conditions and during inhibition of the program monitoring functions of the cortex (in the somnambulic stage of hypnosis). The experimental results show that the duration of maintenance of static effort in hypnosis was twice that in the control, and electrical activity of the muscles was increased on the average by 1.5-2 times or, in some experiments, by 3-4 times. In the light of these results the mechanism of formation of "refusal" to work may assume the form of active cessation of activity of the central structures responsible for the program monitoring function.

KEY WORDS: *muscle fatigue; myography; hypnosis; change in fatiguability of skeletal muscles in a state of hypnotic sleep.*

Analysis of changes in the electromyogram (EMG) during fatigue of working muscles shows that "refusal" to work (stopping work because of inability to perform it on the same scale as before) takes place long before the electrical activity (EA) reaches its maximum [1, 2, 4, 6].

Since the EMG directly reflects the flow of supraspinal central impulses, i.e., the processes of regulation of activity of the muscles and the segmental apparatus by higher levels of the movement control system, the cause of refusal to work before exhaustion of the reserves of the neuromotor system can be considered to be active cessation of activity of the central formations responsible for program monitoring functions (what P. K. Anokhin calls the "action acceptor"). If this suggestion is correct, in the deepest (somnambulic) stage of hypnosis, when the program monitoring functions of the cortex are inhibited, besides an increase in the quantity of work performable before refusal, as some investigators have previously observed [5, 7-9], a much greater increase in EA of the working muscles compared with ordinary conditions should be expected.

To study this problem a comparative study was made of changes in the character of EA of human muscles during work until refusal in the somnambulic stage of hypnosis and in the ordinary state (control experiments).

EXPERIMENTAL METHOD

The investigation was carried out in the laboratory on somnambulic subjects who

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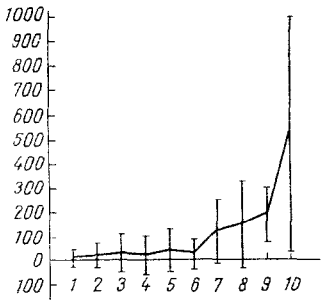

Fig. 1. Difference between mean amplitude of EMG of biceps brachii muscle during work until refusal in control and under hypnosis. Abscissa, periods of work until refusal; ordinate, difference between mean amplitude of EMG of biceps brachii muscle in control and under hypnosis (in μV).

were clinically healthy persons aged 23-25 years.* Altogether ten experiments were carried out. The static work consisted of supporting a certain weight by the horizontally outstretched hand until complete fatigue. Muscle potentials were recorded by bipolar skin electrodes from three areas of the deltoid muscle (scapular, acromial, clavicular) and the biceps brachii muscle simultaneously, i.e., from the principal working muscles with the upper limb in this position.

After the control experiments and the necessary rest, the subject carried out similar work under hypnosis. During the work the EMG was recorded photographically every 15 sec and the record was subsequently analyzed quantitatively in order to determine the mean amplitude of the oscillations and their frequency per second. Since the duration of work until refusal differed in individual experiments of each series, the basis for analysis of the results was taken as the commonest duration of the experiments. For the control series this duration included six recordings of the EMG, compared with ten for the experiments with hypnosis. All the results were subjected to statistical analysis.

EXPERIMENTAL RESULTS

Comparison of the results of the two series of experiments showed that the duration of static endurance under hypnosis was doubled on the average compared with the control experiments (from 66 to 133 sec). The increase in working capacity under hypnosis was accompanied by a more marked increase in EA of the working muscles than in the control experiments and by a decrease in the frequency of the oscillations, i.e., by more marked electromyographic signs of fatigue.

The more marked changes in EA under hypnosis did not appear on the EMG of most of the muscles tested immediately after work began: in comparable periods of time of work in the control and under hypnosis (the first 6 periods of recording) as a rule there was no difference in the changes in EA. An increase in EA under hypnosis compared with the control began in the 7th and subsequent periods of work, to reach a maximum at its end.

The results of quantitative analysis of the amplitude of oscillations on the EMG of the biceps brachii muscle by the direct difference method [3] are shown in Fig. 1. Comparison of the mean amplitudes of the EMG waves in the control and under hypnosis was carried out for corresponding periods of work until the 6th inclusive. All subsequent changes during work under hypnosis were included in the 6th period, i.e., the last period of work in the control experiments before refusal. It will be clear from Fig. 1 that the difference between the amplitudes of the waves in the 9th and 10th periods of the EMG recorded under hypnosis and the 6th period in the control is statistically significant ($P = 0.03$-0.05). Great scatter of the difference in amplitudes observed at refusal to work was connected with the sharp increase in EA under hypnosis at the last moment of work (on the average by 526 μV).

The frequency of waves on the EMG of the biceps muscle differed significantly from that in the control after the 6th period of recording; the difference later in-

*Dr. V. L. Raikov, an experienced hypnotist, assisted with the experiments.

creased still more and amounted to 21 waves/sec at the time of refusal ($P < 0.001$).

The dynamics of changes in the amplitude and frequency of the EMG waves from the scapular, acromial, and clavicular parts of the deltoid muscle was similar. The time of appearance and of increase in the changes in electromyographic parameters could vary somewhat: on the EMG of the scapular part of the deltoid muscle significant changes in EA under hypnosis compared with the end of work in the control appeared in the 8th period of recording and later ($P = 0.02$-0.05), in the EMG of the acromial part of the deltoid muscle in the 7th period, and on the EMG of the clavicular part of the muscle in the 6th period ($P = 0.05$-0.002). Absolute values of the increase in amplitude on the EMG of all parts of the deltoid muscle were slightly below those obtained on the EMG of the biceps muscle, evidently because of a redistribution of activity between the various parts of this muscle during fatiguing static work.

Before refusal to work under hypnosis the mean amplitude of the oscillations was 1.5-2 times higher than the corresponding amplitude in the control, or in some experiments as much as 3-4 times greater. The difference in the values of the amplitude and frequency of the waves before refusal to work under hypnosis and in the control was always statistically significant (for amplitude $P = 0.03$-0.05, for frequency $P = 0.04$-0.001).

The results of these experiments thus confirmed the view that the higher levels of movement control play a leading role in the mechanism of refusal, for they interrupt motor activity in man if it threatens to exceed the limits essential for ordinary vital activity.

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