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Conclusion

Automation of doctors' work in medical institutions with the use of information technology makes it possible to increase the efficiency of diagnosing diseases at early stages, thereby speeding up the treatment process.

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METHOD FOR DETERMINING OPTIMUM FREQUENCY OF STIMULES DURING ELECTRICAL STIMULATION OF SKELETAL MUSCLES

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Electrical stimulation consists in such an effect of a pulsed electric current with a certain set of parameters on the patient's body, in which the necessary positive therapeutic effects occur. Electrical stimulation of skeletal muscles is especially common. It is an effective method of rehabilitation for various injuries and disorders, as well as an auxiliary method in the preparation of athletes. Existing devices, as a rule, have a number of standard modes; the possibilities for fine tuning of stimulus parameters are limited. This does not allow to adequately take into account the individual characteristics of the patient. At the same time, a lot depends on the chosen muscle, its properties, age, sex of the patient, etc. Therefore, it is quite important to determine a priori some parameters of current stimuli, in particular, its frequency.

There are single and tetanic muscle contractions. A single contraction can be induced with a short rectangular voltage pulse (approximately 1 ms long). The contraction caused by this stimulus does not appear immediately, but with a certain time delay of the order of 10 ms. Then there is a contraction for 30-50 ms and relaxation for about 50-60 ms..

The duration of depolarization of the action potential of the muscle fiber is 3-5 ms, after which the membrane restores the ability to excite. Because the contraction time is about 50 ms, which means that even during the contraction, the fiber can respond to new stimuli. Such an overlay of contractions is called tetanic (tetanus). It takes place both in a separate muscle fiber and in the muscle as a whole. The amplitude of the tetanus is much greater than the amplitude of a single contraction, because periodic stimulation causes an additional contraction, which is added to the previous one [1-3].

The tetanus can be serrated or smooth. Serrated tetanus occurs when the frequency of stimuli is such that each subsequent stimulus is given after contraction (the shortening phase), but while relaxation has not yet ended. Smooth tetanus appears at higher stimulus rates, when the stimulus rate is such that each successive stimulus is delivered during the shortening phase before relaxation begins. So, for the one considered in Fig. 1 case, serrated tetanus is observed at frequencies of 10-20 Hz, smooth - at frequencies above 20 Hz.

With regard to the amplitude of contractions, the following can be said. It is minimal with a single contraction, increases with a serrated tetanus, and is maximal with a smooth one. However, the increase in the amplitude and force of contraction with a further increase in frequency stops and an increase in frequency leads to a decrease in the amplitude of contractions. This is called the feedback pessimum. Those. there is some optimal frequency of muscle stimulation. More optimal frequencies are pessimal.

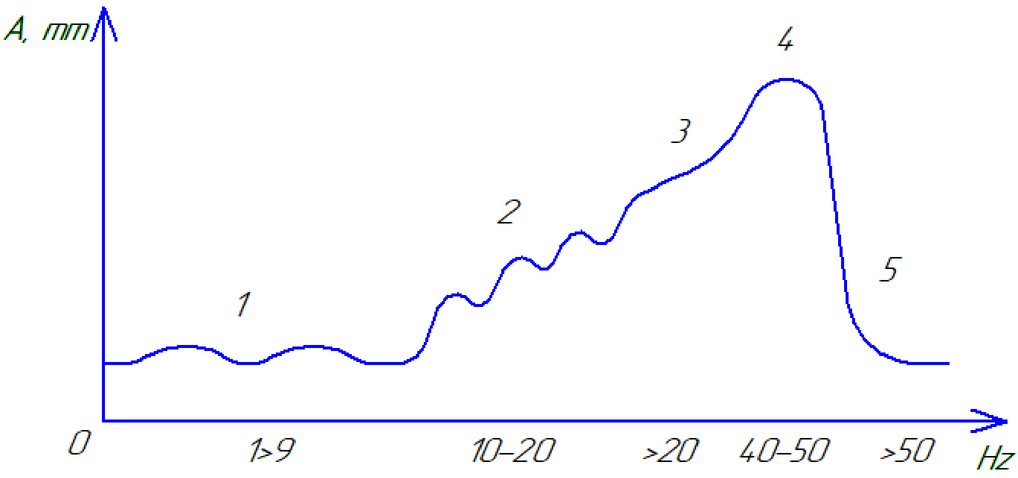

Fig. 1 Dependence of the amplitude of muscle contraction on the frequency of the stimulating signal

Thus, the optimum is a smooth tetanus with maximum amplitude at the optimal frequency of stimulation, when each impulse in the sequence acts on the muscle in the exaltation phase, when the conditions for excitation and summation of single contractions are the best. The pessimum is also a smooth tetanus, but with a minimum amplitude at a pessimal stimulation frequency, when each impulse in the series acts on the muscle in the phase of relative refractoriness, when the conditions for excitation and summation of single contractions are the worst.

In this regard, the problem of mathematical modeling of these processes in order to obtain an analytical expression, which will allow a priori finding the optimal stimulation frequency, turns out to be relevant. To do this, it is advisable to use a “black box” approach, according to which the relationship between input and output variables is subject to consideration, without going into the details of the physiological processes occurring in the motor units and the entire muscle as a whole..

It is necessary to obtain some analytical description that establishes a relationship between input and output variables.

For this, it is proposed to use polynomial functions of the form:

$$\varphi(\omega) = a_n \omega^n + a_{n-1}\omega^{n-1} + a_1\omega + a_0,$$

where a_i - some coefficients;

n-degree of the polynomial.

The problem then reduces to determining the necessary degree n and determining the values $a_i (i = \overline{1, n+1})$.

Given the smooth nature of the modeled dependence, polynomials of degree from 3 to 5 were tested. The final choice was made for a polynomial of degree n = 4, as the most accurately and simply reflecting the electrical stimulation curve and having a derivative of the third degree, which is important for further theoretical calculations.

For the found optimal value of the degree of the approximating polynomial n = 4, the coefficients of the polynomial are determined a = (1,915 -3,020 2,075 -0,510 0,040). Based on this, a model trajectory of the electrical stimulation object was constructed. The accuracy of the model was estimated using the maximum deviation modulus $\varepsilon = \max|y_i - y_{Mi}|,$ where y_{Mi}– response values calculated using the model, and y_i - experimental data. The error does not exceed 5%.

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