Research of muscle adaptive biotronic system frequency and amplitude relation

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Introduction

Scientific works [2–9] have shown that in longer muscle loading duration and at higher load, amplitudes of most biosignals are increasing and similarly the value of summary biosignal amplitude is growing [10]. However in the sources [8, 11–13] decrease of muscle biosignal frequency at longer or steady loading was found. Analyzing muscle as adaptive BS was studied the assumption that it works at resonance frequency [1] and this assumption was proved practically, i.e. has been shown that with minimal impact of external energy adaptive system output generate higher amount of energy. However, there were the scientific works those didn't analyze the relation between muscle BS excitation frequency and the oscillation amplitude of biosignal size. Therefore, the aim of this work is to determine the relationship between muscle adaptive BS excitation frequency of the vibration amplitude level, muscle size and distance traveled, or load-term relationship, and experimentally confirm the existence of resonant work conditions.

Methods

Analyzing specific examples the relation between adaptive BS excitation frequency ω_{imp} and amplitude size A_{imp} as well as distance of lifting load h was estimated. Observing the rise in the weight of the athlete was noticed that to the lifted weight was given sudden impulse at the moment of its uplift of the base point. However, if the weight is raised above his head violently – fatigue would be significantly lower. Thus, the assessment of performed work size in one or another case, the inequality can be written: $D_{slow} > D_{imp}$, where D_{slow} is the slow work, D_{imp} is the impulsive work. In the way of impulsive work D_{imp} and by underestimating energy dissipation the equality exists:

$$D_{imp} = Q \cdot h = \frac{mv_{imp}^2}{2} - \frac{mv_0^2}{2}, \tag{1}$$

where Q is the loading weight kg, h stands for lifting height, m is the mass of lifting load, v_{imp} is the velocity of lifting impulse and v_0 stands for initial velocity (at estimating case it would be equal to zero).

After transforming the equality (1) the expression of muscle generated impulse angular velocity has been given: $\omega_{imp} : \omega_{imp} = \sqrt[3]{g\frac{v_h}{A_{imp}}}$, where v_h is average velocity of lifting load Q, A_{imp} is the size of impulse amplitude generated by muscle. As evaluating energy dissipation in the system inequalities (2) should exist. Values of parameters such as loading size F, height h and mass m for appropriate person are constant and only A_{imp} are varying. Therefore, by decreasing muscle generated impulse angular velocity and for satisfy the condition of resonance work in the system,

$$v_h > \frac{1}{g}\omega_{imp}^3 A_{imp}^2, \quad \omega_{imp} \geq \sqrt{\frac{2Fh}{m}} = \sqrt{2gh} = const, \tag{2}$$

oscillation amplitudes should nonlinearly increase. Furthermore, for every *F*, *m h* value is necessary different muscle BS generated impulse frequency and the excitation amplitude. It is seen from the expressions (2) that the value of initial impulse frequency ω_{imp} provided to a load nonlinearly depend on a height and free-fall acceleration g, but is independent of the mass and the weight of athletes. Thus, biosignal excitation frequency must also be varied by the same law, that the condition $E_{imp} > E_{in}$ is met. When a person performs a work carrying the load, the variable "*h*" in the previous equation by changing the variable "*s*" or its derivative, we can assess the adaptive BS settings.

Experimental research

By the harmonic analysis made on biosignals of the thumbs short abductor muscle (*m. abductor pollicis brevis*), then the spectrum changes in loading duration and as F = 18 N was noticed that values of spectral low frequencies are diminishing at longer loading duration.

Analyzing changes of the frequency range from 520 to 175 Hz in the loading duration according its upper surrounding line, the reflection at the 7th loading minute is clearly seen. After this time the generation and stimulation frequencies are decreasing. Such situation when biosignal amplitude is increasing at frequency fall is showing approximate resonance conditions in adaptive BS.

Conclusions

After observing analytical and experimental research results there were formulated the following conclusions:

1. Optimal initial impulse values of adaptive BS are estimated in the moment when the weight is raising and the relation with the loading size and a lifting distance is explained.
2. The frequency of the initial impulse and the angular velocity nonlinearly depend on the load lifting distance and free-fall acceleration, but are independent of the person's weight. These parameters should be clearly specified.
3. Experimental research has shown decreasing frequencies in longer loading and their amplitudes vary nonlinearly. The multiplication of these parameter's sizes is approximately constant.
4. Resonance work conditions of adaptive muscle BS were determined.

References

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