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Experimental Detection of the Average Motor Unit Action Potential Frequency by Means of Surface Electromyogramm

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Abstract

We present here experimental records of surface electromyogramms (sEMG) and it's average power spectra. We demonstrate that the detailed analysis of all sEMG power spectra reveals significant peaks at the characteristic position. This position can be associated with the average repetition rate of a single motor unit action potential. Also, we prove here the possibility to measure the dependence of the myo-pulse repetition rate on the muscle mechanical load.

Keywords: SEMG pulse simulations; Spectral analysis of electromyographical signals

Introduction

The analysis of simulated and analytically modeled electromyogramms shows the characteristic line in the mean power spectrum, located in the low frequency domain [1-4]. In these papers it was shown that the position of this spectral line corresponds to the myo-pulses repetition rate, if the sequence of myo-pulses is periodic enough, through the ratio of the standard deviation of the repetition rate to the rate mean value is around 0.2. We detected the predicted spectral line with the stable position in all electromyogramms, recorded from real probationers. The relevancy of electro myogram spectra models was demonstrated in [1-4].

In order to reconstruct the myo-pulse repetition rate from the surface electromyogram, we performed the detailed spectral analysis of such myogramms, recorded from the biceps of patients of various age and gender. The constant muscle mechanical load was provided by the weight, fixed by the patient's wrist. The angle between the shoulder and the elbow was about 90 °C. In total, we recorded 15 mean electromyogramms with duration of 1s each by exploiting the electromyograph [5] with the 10 kHz sampling rate. The three flat rectangular copper electrodes with dimensions of 5x40mm were serving as potential probes. These electrodes were placed parallel to each other with the 10mm pitch at the 6cm distance from the elbow.

The final results were obtained after following analysis steps: every electromyogramm was centered and any baseline trend was subtracted, the simple data quality cuts were performed by removing electro myograms with non recostructable trends and mean power spectra were calculated. A typical power spectrum of the single myo-pulses sequence with the duration of 1 s is shown on Figure 1a-1d, and the typical mean power spectrum is presented on Figure 1. As can be seen from these figures, power spectra have pronounced lines and the first line in the low frequency region is clearly visible for almost all records and located at the characteristic position, corresponding to the mean repetition rate of a single motor unit action potential. Assuming that the structure of the low frequency domain of the mean power spectrum is not stochastic, we expect the significant correlation between the mean repetition rate of a single motor unit action potential and the muscle mechanical load, as it was discussed in [6].

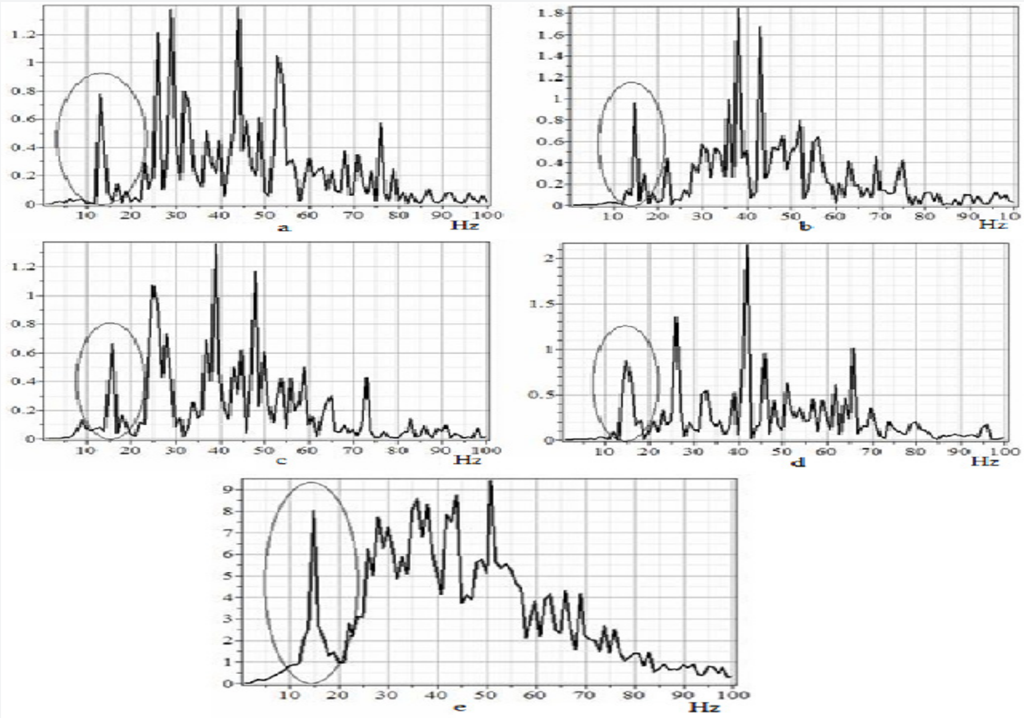

Figure 1A-1E: Realization of power spectra of electromyograms Svetlana L. (age 32 years), duration 1s, weight of cargo 1kg; e ¬– is the average power spectrum of the electromyograms.

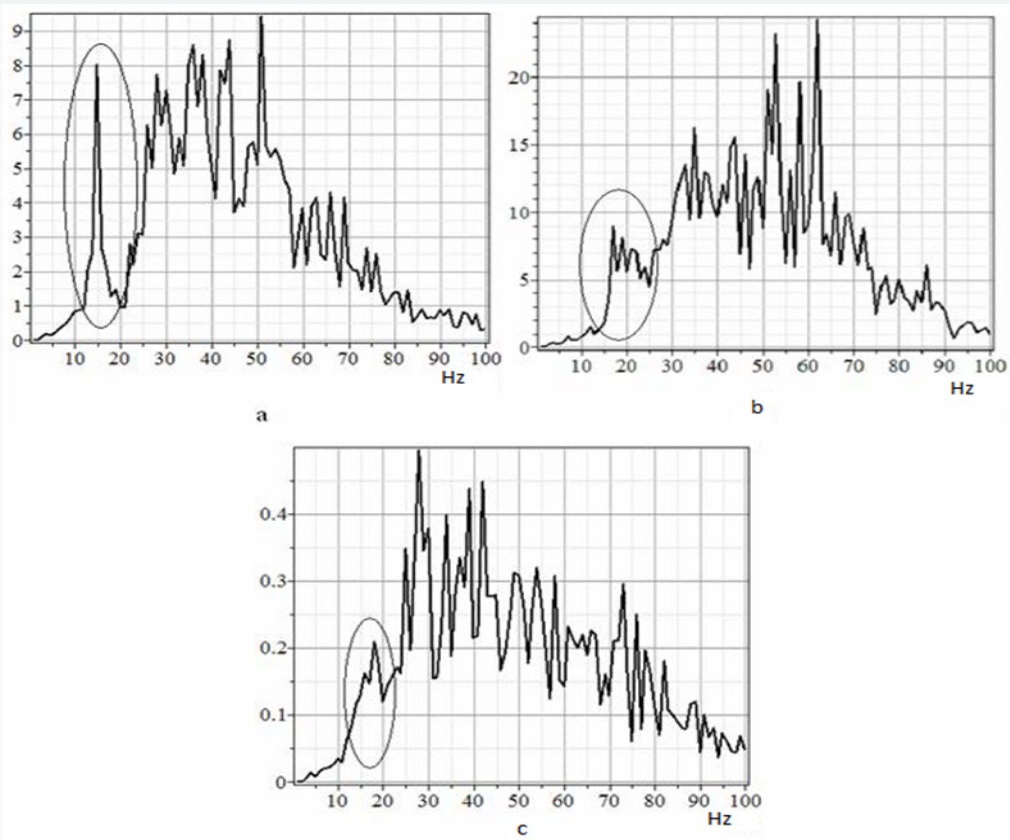

Figure 2: Average power spectra of electromyograms Svetlana L. (age 32 years) with different weight of the retained cargo. a – mass of cargo 1 kg; b – weight of cargo 2 kg; c – weight of cargo 3 kg.

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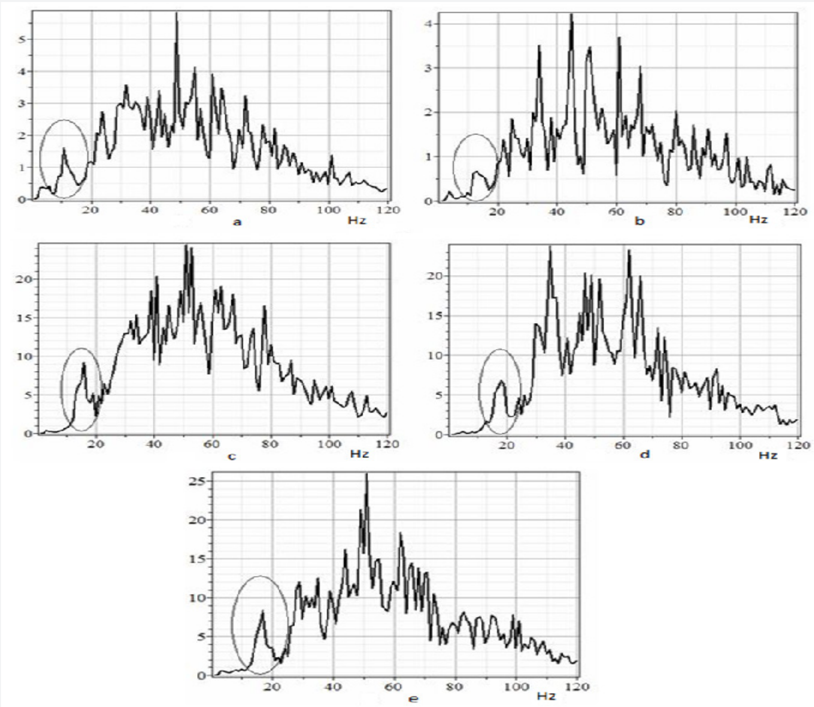

Figure 3: Average power spectra of electromyograms of Alexander Sh. (Age 54 years) with different weight of the retained cargo. a – mass of cargo 1 kg; b – weight of cargo 2 kg; c – weight of cargo 3 kg; d – weight of cargo 4 kg; e – weight of 5 kg.

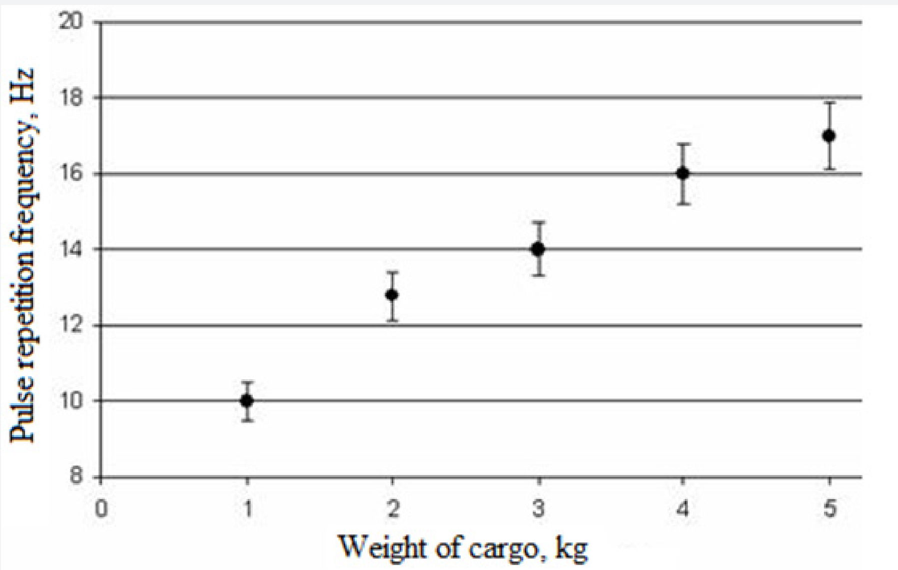

Figure 4: Dependence of the repetition rate of myo-impulses of one motor unit on the mechanical load (the value of the retained load) on the biceps of Alexander Sh. (Age 54 years).

Thus, the first line in the myogramm power spectrum will shift to higher frequencies with the increase of the muscle mechanical load. In order to demonstrate this relation, we measured the mean power spectra of the biceps electromyogramm under the static load and reconstructed the mean myo-pulse repetition rates. The load value was varied with 1kg steps. The results of the spectral analysis are shown on Figure 2 & 3. As it was described above, the motor unit action potential repetition rates for various load were reconstructed from mean power spectra of surface electro myogram. The dependence of the repetition rate on muscle mechanical load is shown on Figure 4. These results are in good agreement with the other data, presented in [7-8]. The assistance of E. A. Kalashnikov in the data analysis is greatly acknowledged.

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