On the Need for Rectification of Surface EMG

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TO THE EDITOR: The electromyogram (EMG) as an indirect measure of motor unit activity has proved invaluable in motor control studies. Increasingly, the application of frequency domain techniques to EMG signals has provided important insight into the structure and function of the human motor system. In a recent publication Neto and Christou (2010) claimed that rectification of the EMG impairs identification of oscillatory input to the muscle. This is a controversial claim since it is at odds with the preprocessing step of EMG rectification adopted in a number of significant studies examining oscillations in the motor system. If Neto and Christou (2010) are correct, then the findings of earlier studies are drawn into question. The contribution of Neto and Christou is important in making us think about what information is contained in an EMG signal and how best to extract it.

Oscillatory drive to human motoneurons during isometric contraction was first identified by Farmer et al. (1993). Using single motor unit recordings they demonstrated that the firing times of individual motor units are modulated in two distinct frequency bands, one of which (16–32 Hz) was hypothesized to reflect oscillatory activity in descending corticospinal pathways.

The analysis used by Farmer et al. (1993) was based on a framework in which individual motor units are treated as distinct events or pulses. The finite Fourier transform is used to generate a statistical description that provides a measure of the correlation between paired motor unit firing times. This type of treatment is part of a broader approach, in which the Fourier transform is viewed as a statistical quantity (Brillinger 1983) and the focus is on providing a description of stochastic data; in the case of motor unit activity, the focus is on rhythmic modulation of firing times. An alternative use for the Fourier transform is accurate reconstruction of a signal using Fourier synthesis. This deterministic approach is used, for example, in Fourier synthesis of audio signals using a sum of sines model (their Eq. 1). Such an approach does not take into account individual motor unit firing times and is thus concerned primarily with determining the frequency components in motor unit action potential shape. In contrast, Myers et al. (2003) generated simulated surface EMG signals from a sequence of firing times (see their Fig. 1). In a pioneering study of the contribution from motor unit firing to physiological tremor, Elble and Randall (1976) demodulated the surface EMG through rectification to better represent the effects of spike timing. As these and many others have subsequently shown, if the primary interest is a description of motor unit timing within surface EMG then the preprocessing step of rectification is an important one that should readily be adopted. The first is to threshold the surface EMG, generating a sequence of multiunit firing times (Gibbs et al. 1997); the second is to apply rectification to the EMG signal, which will then more closely approximate a sequence of pulses. The first approach will create sequences of pulses of unit height, but may miss firing times of motor units that have small amplitude in the surface EMG. The second will capture more firing times, but will generate pulses of uneven height. A component of the Fourier representation in this latter case will inevitably reflect pulse shape. Information from a Fourier decomposition of the raw EMG will be primarily concerned with reconstructing motor unit action potential shape as opposed to motor unit firing times.

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DISCLOSURES

No conflicts of interest are declared by the authors.

REFERENCES


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