The Nature of Periodic Input to the Muscles

Tjeerd W. Boonstra

School of Psychiatry, University of New South Wales, Sydney; and Black Dog Institute, Prince of Wales Hospital, Randwick, New South Wales, Australia

TO THE EDITOR: There is much interest in the synchronization of neural discharge and its potential role in information coding within the nervous system. To assess oscillatory input to the muscle by means of corticospinal (EEG–EMG) coherence and intermuscular (EMG–EMG) coherence, it is common practice to rectify electromyographic (EMG) signals, although the rationale for rectification remains incompletely understood. In a recent simulation study (Neto and Christou 2010), the authors concluded that rectification of EMG signals impairs the identification of oscillatory input. Some important issues need to be addressed before such a general conclusion can be reached.

To determine the effectiveness of EMG rectification, the authors manipulated recorded EMG signals to generate reconstructed EMG signals. In short, the amplitude within predefined frequency bands was doubled or zeroed to simulate the effect of oscillatory input. In addition, pairs of signals were generated to simulate common input in which the amplitude of the first signal was used to construct the second signal. Given these manipulations it comes as no surprise that the effects can best be identified in the unrectified EMG and were largely abolished after rectification. Their conclusion critically depends on the assumption that periodic input directly affects the amplitude of surface EMG at the input frequency. This assumption should have been motivated because it is not necessarily true.

A first issue is how periodic input to the motor unit pool is translated into surface EMG. It can be expected that periodic input will increase the amplitude at the input frequency, but this may not be the primary effect. Periodic input may also result in amplitude modulations of high-frequency content at the input frequency, akin to amplitude-modulated radio signals. In this case, the periodicity in the input signal can be obtained through the envelope of the signal, i.e., by rectifying the EMG signal (Myers et al. 2003). Another issue is the nature of periodicity of the input signal. Although it is convenient to consider periodic input to be purely sinusoidal, biologically realistic input more likely resembles a spike train. Periodicity may then be introduced by periodic rate modulation, such as a periodically modulated Poisson process (Zeitler et al. 2006), or by the relative timing of spikes. Thus the effects of periodic input on surface EMG may be more wide-ranging than amplitude changes at the input frequency.

It is very well likely that periodic input can be identified in both the unrectified and rectified EMG. Which method is most accurate and precise may depend on various parameters, such as input strength, the form of motor unit action potentials, and the presence of artifacts. These issues can be addressed using biophysical models that translate input signals into surface EMG (Farina and Merletti 2001; Stegeman et al. 2000). Meanwhile we should bear in mind that rectification is most widely used and has thus proven to identify periodic input. In an empirical study, we used both rectified and unrectified EMG and found that rectification identified common 10 Hz input most clearly (Boonstra et al. 2008).

In sum, the simulation study (Neto and Christou 2010) is based on the assumption that periodic input to the muscle solely affects the amplitude of surface EMG at the input frequency. This assumption may be overly simplistic, rendering their conclusion on the use of rectification incomplete. More detailed computational studies are required to characterize the properties of periodic input and their effects on electrophysiological recordings. Conversely, empirically observed differences in spectral estimates obtained with unrectified and rectified EMG signals could be used to validate existing biophysical models.

REFERENCES


