SHOULD THE SOURCE OF ELECTROMECHANICAL DELAY BE RECONSIDERED?

Peter F. Vint\textsuperscript{1}, Scott P. McLean\textsuperscript{2} and Gregory M. Harron\textsuperscript{3}

\textsuperscript{1}Research Integrations, Inc., Tempe, AZ
\textsuperscript{2}Iowa State University, Ames, IA
\textsuperscript{3}University of North Carolina at Greensboro, Greensboro, NC
E-mail: Peter.Vint@ResearchIntegrations.com

INTRODUCTION

Electromechanical delay (EMD) has been defined as a temporal delay (26-131 ms) between the detected onset of muscular activity and the realization of force. It has been suggested that EMD is primarily attributable to “taking up slack” in the series elastic component (SEC) of the musculo-tendon (MT) actuator (e.g., Cavanagh & Komi, 1979; Viitasalo & Komi, 1981). However, if EMD were primarily attributable to an uptake of slack in the SEC, it could be argued that EMD should be manifest only at the beginning of an exertion initiated from rest. Once steady-state tension is developed by the MT, it would be expected that EMD be restricted to the short delays associated with depolarization of the muscle fiber and propagation of the action potential.

From the available literature, it is not possible to understand whether EMD exists beyond the initial stage of tension development because previous investigations involving EMD have been limited to the initiation of tension development from a resting state. Yet, some investigators have applied constant EMD values in an effort to temporally align EMG and force- or moment-time profiles during dynamic activities (e.g., Ingen Schenau et al., 1992). Inherent to this practice, however, is the assumption that EMD is manifest during pre-loaded MT states. This assumption appears to contradict the aforementioned association between EMD and the uptake of MT SEC slack.

Temporal shifts between changes in EMG and force initiated from a non-resting condition (i.e., a state of pre-tension) would suggest that EMD is not exclusively associated with SEC slack. Furthermore, varying the initial conditions would permit examination of whether EMD remains constant and thus test the validity of using a constant temporal offset. Therefore, the purposes of this study were 1) to test whether EMD is associated exclusively with the onset of tension from a resting state or if it is manifest continuously throughout a sustained submaximal isometric exertion; and 2) to test whether the duration of EMD remained constant regardless of initial tension.

METHODS

Twenty-four subjects (mean age 23.9 ± 5.4 years, mean height 171.7 ± 7.3 cm, and mean mass 72.9 ± 12.8 kg) performed isometric elbow flexion trials during which force data were obtained using a strain gauge device attached at one end to the subject’s wrist using a padded leather cuff and at the other end to an immovable structure. Pre-amplified, bipolar electrodes were used to measure surface EMG activity from \textit{m. biceps brachii}. All force and EMG data were obtained from the dominant arm.

Subjects completed three maximum effort isometric elbow flexion tasks in the transverse plane during which isometric force data were collected for 5 s at 1000 Hz. Subjects then completed a series of trials in which submaximal pulse forces of 25\%, 50\%, and 75\% (expressed relative to maximal effort) were produced from a constant baseline force level of 0\%, 25\%, and 50\%, respectively. Subjects produced baseline and pulse forces by matching a real-
time display. After the baseline force was achieved, subjects received an audible cue at 1 s intervals during a 10 s period to produce the appropriate pulse force. Pulse forces were initiated and released as quickly as possible and were performed so that baseline intensity forces were maintained immediately prior to and following every intermittent pulse exertion. Subjects performed three trials for each condition that were presented in randomized across subjects. EMG and force data were collected for 10 s during these sustained baseline/intermittent pulse exertion trials.

Force and rectified EMG records were low-pass filtered at 5 Hz using a 4th-order, zero-lag Butterworth digital filter. Filtered force and EMG data were normalized by their respective instantaneous maximum values. For each trial, EMD was defined as the temporal shift, \( \tau \), that maximized a normalized cross-correlation function (Oda & Moritani, 1996).

**RESULTS AND DISCUSSION**

EMD between the activity of *m. biceps brachii* and isometric elbow flexion force ranged from 60.6 \( \pm \) 16.6 ms (50% baseline-75% pulse) to 83.5 \( \pm \) 12.9 ms (0% baseline-25% pulse). A 3×3 (condition×trial) repeated measures ANOVA revealed a significant condition effect (p < .01). Neither the trial effect (p = .04) nor the condition×trial interaction (p = .30) was significant (Figure 1). Post-hoc pairwise comparisons of mean condition values demonstrated that EMD values from the 0% baseline intensity were significantly longer than those from the 25% and 50% baseline intensities. Despite the trend, EMD values were not statistically different between the 25% and 50% baseline intensity conditions.

These data suggest that explanation of the EMD as a period used to remove slack from the SEC should be reconsidered. When muscle sustains a sub-maximal load a limited number of motor units are activated. It is possible that non-activated motor units retain slack associated with the SEC. This would help explain the existence of an EMD when tension was increased from a state of pre-tension. However, because the tendon represents the largest component of the SEC and would presumably have any slack removed prior to the initiation of any force, the magnitude of EMD when force was raised above a pre-tension state should be dramatically less. This is contrary to the appreciable EMD (60 ms) found when force was developed from 25% and 50% pre-tension. These data also suggest that the use of a constant temporal offset for correction of the EMD be reconsidered because the magnitude of EMD decreased as the level of pre-tension increased.

**REFERENCES**


