INITIAL ELECTROMECHANICAL REACTION TO REARWARD PERTURBATION

Nitin Moholkar, Venkata Gade, Jerome Allen, and W. Thomas Edwards

Kessler Medical Rehabilitation Research & Education Center, West Orange, NJ, USA
E-mail: nmoholkar@kmrrec.org, Web: www.kmrrec.org

INTRODUCTION

Falls are a major health concern due to the increased morbidity, mortality, and healthcare costs, as well as the decreased quality of life. A sudden rearward perturbation to balance will lead to a fall without a proper response. The nervous system needs to send the proper signal to the muscles, and the musculo-tendon units (MTU) need to respond in an appropriate and timely manner. This mechanical response can be broken down into three components: preset properties of the MTU due to current activation, reflex changes to the MTU, and active changes to the MTU. Prior studies examining the EMG response of muscles crossing the ankle joint in similar situations have observed short, medium, and long latency responses (Schieppati and Nardone 95), usually linked to reflexes of agonists (short and medium) and reflexes of antagonists (long). But the mechanical effect of the EMG responses has not been adequately investigated.

In our study, we examined the combined EMG and mechanical response to a rearward perturbation and categorized the responses into the three categories (preset, reflex, & active) described earlier. We hypothesized that it is the active response that provides the bulk of balance recovery.

METHODS AND PROCEDURES

Seven healthy adult subjects gave informed consent and were screened to exclude internal pathologies or medications affecting balance. Subjects stood on a NeuroCom Research Platform. The platform oscillated 12 cm in the anterior-posterior direction at three different frequencies (0.75, 1.0, and 1.25 Hz), with the initial movement in the rearward direction. Each condition was repeated three times with eyes open, for a total of 9 trials per subject. Motion data was collected at 100 Hz using a Vicon motion capture system and reflective markers placed on anatomical landmarks. Subjects wore a safety harness attached to a metal frame to prevent a fall. Ground Reaction Force (GRF) data was collected through the NeuroCom Research Platform at 200Hz. Motion and GRF data were combined through inverse dynamics to calculate ankle joint moments in the sagittal plane. EMG data from ankle extensor muscles was collected at 1000 Hz. All data was synchronized through the Vicon motion capture system.

To determine initial reaction to the platform movement, the initial movement cycles were compared to later cycles, by which point subjects had fully adjusted to the platform motion. Both timing and magnitude of EMG and force and moment data were examined to separate observed changes into preset mechanical properties of the joint, reflex response, and active response to the perturbation. All results presented are group averages plus/minus standard error of the mean.

RESULTS

EMG response: There was a burst starting at 75±4 ms, 60±4 ms, and 60±4 ms after the
onset of movement, lasting for 216±16 ms, 210±10 ms, and 203±7 ms for the 0.75, 1.0, and 1.25 Hz trials (figure 1, first peak in EMG curve). In all trials, there was a second burst starting approximately 70±10 ms later. After two to three cycles, the EMG activity became more consistent and coincided with the movement of the platform.

Figure 1: Ankle EMG (top, dotted green), ankle moment (bottom, dashed red) and platform position (both, solid blue) vs time.

Ankle Moment Response: The ankle moment increased immediately as the movement started (figure 2). This was followed by a cycle where the timing of the moment is synchronizing with the platform movement. After two to three cycles, the ankle moment becomes more consistent and timed with the platform movement.

DISCUSSION

The timing of the first two ankle extensor EMG bursts in response to the initial movement of the platform matched well with values in the literature for reflex activity. Furthermore, they matched well with the timing of small deviations in the ankle moment response, with small time delays, explained by electromechanical delay. By the third cycle of movement, the EMG and extensor moment had settled into their patterns.

If preset conditions and reflex activity were sufficient to respond to perturbations, there would not have been a two cycle settling time before reaching a consistent pattern. An active response was necessary to prevent a fall. This study further demonstrates that reflexes alone are insufficient to balance recovery after a perturbation.

SUMMARY

Initial preset condition of the ankle extensor muscles combined with reflex activity is not sufficient to maintain balance on a moving platform. Following an initial reflex reaction, further active control is required to match the timing (phase) of the ankle moment and the platform motion and avoid a loss of balance. This study provides new insight for the diagnosis of postural deficits.

REFERENCES


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