Muscular activation pattern during step recovery from a forward fall in the older women with a fall risk


Abstract—The muscle activation pattern of the step leg during step recovery from a forward fall was compared between older women with and without fall risk. The faller had larger co-activities in thigh muscles, and the delay in muscular deactivation and activation timing while stepping.

I. INTRODUCTION

The ability to quickly step forward is important in order to prevent a fall after tripping. No studies were found that compared muscle activation pattern during unexpected stepping tasks in old adults with and without a fall risk. The purpose of this study was to clarify the difference in muscle activation pattern when stepping to regain balance during a forward fall between faller and non-faller and to identify the cause of functional deficit in stepping.

II. METHODS

Female old adults with (faller, n=12; mean age ± SD, 82.8 ±4.5y) and without (non-faller, n=17; 81.4 ± 3.4y) a history of falls participated in this study. All subjects were able to walk independently. Written informed consent approved by the Ethical Review Board of Kyoto University Graduate School of Medicine was obtained prior to participation.

Tether-release method [1] was used to evaluate the fall avoidance step in both groups. In this method, subjects are released from a forward-leaning position at a lean control cable load of 15% of body weight and instructed to regain their standing balance by taking a single step forward. Foot-floor reactions and myoelectric signals of the swing leg were measured during the step response. The EMG data were obtained from rectus femoris (RF), biceps femoris (BF), and other three leg muscles. The step movement were divided into three phase; 1) Lift-off phase: from subject’s release until heel off, 2) Stepping phase: from heel off until foot contact, 3) Stance phase: from foot contact until 0.5 second later. An index of co-activation (%CI)[2] between agonist and antagonist muscles was calculated for each muscle pair (e.g. RF-BF) during each phase. The iEMG was calculated and normalized by its MVC. %CI value was calculated as follows: [2 × (iEMG\textsubscript{antagon}) / (iEMG\textsubscript{agon} + iEMG\textsubscript{antagon})] × 100. The pattern of muscle activities for the stepping movement were also evaluated. The duration of each phase were normalized to obtain an average EMG data of five points over the each phase. EMG signals were again normalized by the maximum EMG amplitude recorded for that muscle during the stepping.

III. RESULTS

The faller achieved a step velocity that was 18% slower, on average, than the non-faller. The faller had significantly higher %CI values between RF and BF than the non-faller during stepping phase (faller 65.0 ± 8.9%, non-faller 57.0 ± 7.7%, p< 0.05). When recovering from a leaning position, there were significant differences in the muscle activity timing of RF and BF muscles while the overall muscle activation patterns observed were similar for both the faller and non-faller. BF activation, used for knee flexion before swing leg, was delayed in the faller. After liftoff, the faller maintained activity levels in the RF and BF muscles compared to non-faller. (Figure 1).

![Figure 1. Thigh muscle activities when stepping to recover balance following release from a leaning position. (Shown are ensemble averages normalized to maximum EMG activities during stepping, and regions of significant differences between faller and non-faller are denoted by the shaded areas.)](image)

IV. DISCUSSION AND CONCLUSION

The higher %CI value in the thigh muscle pair during the stepping phase observed in the faller may inhibit generating a rapid step. The delay in muscular deactivation and activation during the movement could be a compensation for differences in muscular capabilities. The muscle activation pattern during step response reflect a disability of rapid step which is required to regain balance in old adults with fall risk.

REFERENCES
