

## THE ABILITY OF LOWER LIMB STRENGTH TO PREDICT THE STRATEGY USED BY OLDER ADULTS TO RECOVER BALANCE FROM A FORWARD FALL

<sup>1</sup>Christopher P Carty, <sup>1</sup>Rod Barrett, <sup>1</sup>Neil Cronin, <sup>1,2</sup>Glen Lichtwark and <sup>1</sup>Peter Mills

<sup>1</sup>Griffith Health Institute, Griffith University, Queensland, Australia &

School of Physiotherapy and Exercise Science, Griffith University, Queensland, Australia,

<sup>2</sup>School of Human Movement Studies, University of Queensland, Queensland, Australia

### SUMMARY

The purpose of this study was to investigate differences in strength between older adults that require multiple steps to recover from a range of forward lean magnitudes and older adults that recover with a single step, and to assess whether reduced strength predicted use of multiple steps. Ninety-five, older adults were released from forward lean magnitudes that corresponded to 15, 20 or 25% of body weight (BW) on a horizontal restraining cable. Participants were instructed to recover with a single step and were subsequently classified as using either a single, multiple or mixed stepping strategy. Isometric strength at the ankle, knee and hip were assessed using an isokinetic dynamometer. The balance recovery task resulted in an approximately equal number of single and multiple steppers at the 20%BW lean magnitude. Single steppers had stronger ankle, knee and hip flexors and extensors compared to multiple steppers. Odds ratios indicated that individuals in the lower strength tertile for ankle dorsiflexion, knee extension and hip flexion were respectively 14.6, 12.1 and 10.5 times more likely to require multiple steps compared to those in the upper tertile. Results suggest lower limb muscles that assist in foot placement following a forward fall are important for balance recovery.

### INTRODUCTION

Older adults have a decreased ability to recover their balance from an imbalance episode [1]. The factors governing the ability to recover balance in older adults are varied and complex, but include cognitive and information processing capacity as well as sensory, neuromuscular and biomechanical function [2]. An experimental paradigm used to assess biomechanical and neuromuscular responses to a forward loss of balance involves participants being suddenly released from a static forward leaning posture. A common finding in the literature from experiments using this paradigm is that some older adults are able to recover using a single step, whereas others require multiple steps to recover [3,4]. The purpose of this study was to investigate differences in lower limb strength between older adults that require multiple steps to recover from a range of forward lean magnitudes and older adults that are able to recover with a single step, and to assess whether reduced lower limb strength predicted the use of multiple steps.

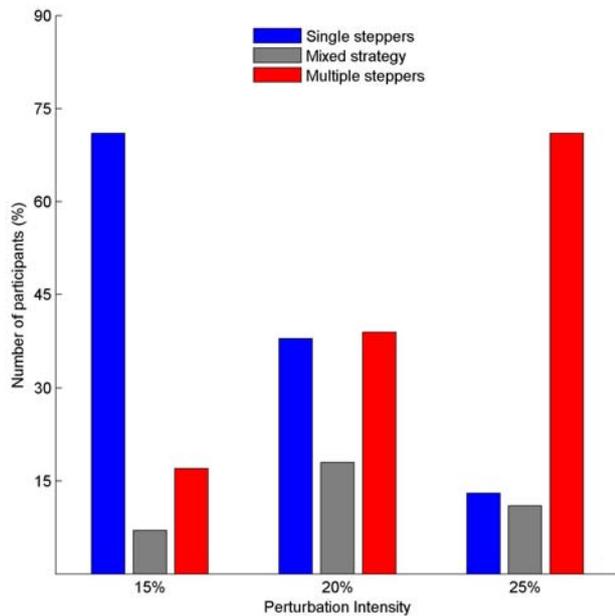
### METHODS

Ninety-five healthy, older adults (51 men, 44 women; mean  $\pm$  SD: age, 69 $\pm$ 4 years; height, 1.67 $\pm$ 0.09 m; mass, 75.9 $\pm$ 12.4 kg) that were randomly selected from the electoral roll participated in the study. The balance recovery task involved the release of participants from a range of initial static forward lean magnitudes that corresponded to 15, 20 or 25% of body weight (BW) on a force transducer placed in series with the horizontal restraint cable. As soon as participants perceived they were falling they were instructed to recover their balance by taking a single step. Four trials were performed in a random order at each lean magnitude and participants were classified as using either a single, multiple or mixed stepping strategy (i.e., a mixture of single and multiple steps across the four trials). Isometric strength of the ankle, knee and hip flexors and extensors in the stepping lower limb were assessed using an isokinetic dynamometer (Biodex System 4, Biodex Medical Systems, USA). Ankle strength measurements were taken at 0, 15 and 30 degrees of plantarflexion. Knee strength measurements were taken at 30, 60 and 90 degrees of knee flexion. Hip strength measurements were taken at 10, 40 and 70 degrees of hip flexion. For each trial participants were instructed flex or extend the joint of interest "as hard as they could" for three seconds, with verbal encouragement provided to maximize effort. Peak isometric torques at each joint were adjusted to account for the weight of the dynamometer attachment and lower limb segments distal to the joint being tested. Peak isometric torques were averaged over the three angles.

Data were analysed using Matlab (v2007a, The MathWorks, Inc., Natick, USA) and SPSS (v13, SPSS, Inc., Chicago, USA). Between-group ANCOVA was used to assess group differences and binary logistic regression analysis was used to determine whether reduced lower limb strength predicted a multiple step recovery strategy. Age, sex, height and body mass were included as covariates in all statistical analyses. Significance was provisionally accepted at  $p < 0.05$ .

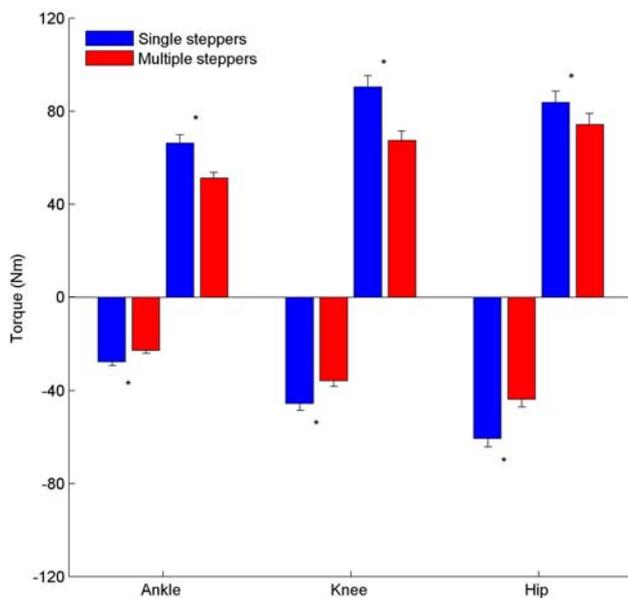
### RESULTS AND DISCUSSION

As the lean magnitude increased there was a decrease in the number of older adults who could recover using a single step (Figure 1). The 20%BW lean magnitude resulted in an approximately equal number of single and multiple steppers.



**Figure 1:** Stepping strategy used by participants at each lean magnitude.

Single steppers at each joint were significantly stronger than multiple steppers in flexion and extension (Figure 2).



**Figure 2:** Differences in mean peak isometric lower limb strength between single and multiple steppers as classified by the 20%BW lean magnitude.

The finding that older adults who required multiple steps to recover from forward loss of balance were significantly

weaker on all strength measures is consistent with Grabiner et al. [5] who reported that older adults in the lower quartile for maximal recoverable forward lean magnitude were significantly weaker than those in the upper quartile. These findings suggest that multiple steppers are weaker than single steppers.

Odds ratios indicated that individuals in the lower strength tertile for ankle dorsiflexion, knee extension and hip flexion strength were respectively 14.6, 12.1 and 10.5 times more likely to require a multiple step recovery strategy when exposed to the 20%BW lean magnitude compared to those in the upper strength tertile (Table 1).

**Table 1:** Odds ratios for prediction of older adults who require multiple steps to recover balance following release from a forward lean magnitude corresponding to 20%BW.

	Odds ratio	95% CI
<b>Ankle dorsiflexion</b>		
Low strength	14.6*	1.9-115.3
Moderate strength	6.6*	1.3-35.1
High Strength	1.0	
<b>Knee Extension</b>		
Low strength	12.1*	1.9-76.6
Moderate strength	3.7	0.8-18.5
High Strength	1.0	
<b>Hip Flexion</b>		
Low strength	10.5*	1.7-64.1
Moderate strength	2.6	0.7-10.3
High Strength	1.0	

Ankle dorsiflexion, knee extension and hip flexion moments all relate to the moment requirements during the initial stages of the swing phase. Thus, the odds ratio results suggest that the ability to translate the stepping limb forward during the initial stages of swing is important for single step recovery following a forward fall.

## CONCLUSION

Lower limb muscles that assist in foot placement (i.e., ankle dorsiflexors, knee extensors and hip flexors) following a forward fall are important for balance recovery.

## ACKNOWLEDGEMENTS

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