



Lower limb muscle moments and power during recovery from forward loss of balance in male and female single and multiple steppers

Christopher P. Carty ^{a,*}, Neil J. Cronin ^b, Glen A. Lichtwark ^c, Peter M. Mills ^a, Rod S. Barrett ^a

^a Centre for Musculoskeletal Research, Griffith Health Institute & School of Rehabilitation Sciences, Griffith University, Queensland, Australia

^b Department of Biology of Physical Activity, University of Jyväskylä, Finland

^c School of Human Movement Studies, The University of Queensland, Queensland, Australia

ARTICLE INFO

Article history:

Received 30 October 2011

Accepted 17 July 2012

Keywords:

Ageing

Falls

Muscle power

Forward loss of balance

ABSTRACT

Background: Studying recovery responses to loss of balance may help to explain why older adults are susceptible to falls. The purpose of the present study was to assess whether male and female older adults, that use a single or multiple step recovery strategy, differ in the proportion of lower limb strength used and power produced during the stepping phase of balance recovery.

Methods: Eighty-four community-dwelling older adults (47 men, 37 women) participated in the study. Isometric strength of the ankle, knee and hip joint flexors and extensors was assessed using a dynamometer. Loss of balance was induced by releasing participants from a static forward lean (4 trials at each of 3 forward lean angles). Participants were instructed to recover with a single step and were subsequently classified as using a single or multiple step recovery strategy for each trial.

Findings: (1) Females were weaker than males and the proportion of females that were able to recover with a single step were lower than for males at each lean magnitude. (2) Multiple compared to single steppers used a significantly higher proportion of their hip extension strength and produced less knee and ankle joint peak power during stepping, at the intermediate lean angle.

Interpretation: Strength deficits in female compared to male participants may explain why a lower proportion of female participants were able to recover with a single step. The inability to generate sufficient power in the stepping limb appears to be a limiting factor in single step recovery from forward loss of balance.

Crown Copyright © 2012 Published by Elsevier Ltd. All rights reserved.

1. Introduction

Falls in older adults are a significant public health concern, with an estimated one in three community dwelling older adults falling each year (Tinetti and Speechley, 1989). Most falls occur whilst walking with trips being the most frequently cited mechanism (Berg et al., 1997). An experimental approach for simulating recovery from forward loss of balance associated with trips is the tether release method (Do et al., 1982), which involves tilting a participant into a static forward lean position via the use of a horizontal tether that is subsequently released after a random time delay (Do et al., 1982; Thelen et al., 1997). To recover balance an individual must initially take a rapid forward step, which requires concentric contractions of the hip flexors and knee extensors in the stepping leg (Madigan, 2006; Wojcik et al., 2001). During the subsequent landing phase, eccentric contractions of the hip and knee extensors of the stepping leg are required to arrest the body's anterior and inferior momentum

(Hsiao-Weckler and Robinovitch, 2007; Madigan, 2006; Madigan and Lloyd, 2005; Wu et al., 2007).

Studies using the tether release method have reported that older compared to younger men have a lower maximum lean magnitude from which they can recover with a single step (Thelen et al., 1997), a lesser tendency to increase lower limb joint moments and powers as lean magnitude is systematically increased (Madigan, 2006; Madigan and Lloyd, 2005) and is more likely to require multiple steps to recover from a given lean magnitude (Carty et al., 2011). Older women have been shown to be less capable of recovering from a given lean magnitude with a single step than older men (Carty et al., 2012b; Wojcik et al., 1999), however the mechanisms underlying these sex differences in balance recovery are not well established. A possible explanation for the poor ability of older women to recover from a forward loss of balance is that the moment requirements of the balance recovery task exceed the maximum strength capacity of one or more key muscle groups (Hurley, 1995; Pincivero et al., 2003). This premise is supported by the findings of Wojcik et al. (2001) who reported that older women compared to older men were weaker and used approximately equivalent, or greater, lower limb joint moments when recovering from the same or maximal recoverable initial forward lean angle. However, Wojcik et al. (2001) did not statistically compare proportional strength

* Corresponding author at: Centre for Musculoskeletal Research, Griffith Health Institute, Griffith University, Gold Coast campus, Queensland 4222, Australia.

E-mail address: c.carty@griffith.edu.au (C.P. Carty).

requirements during balance recovery between older men and women, and only measured the strength of the ankle plantarflexors and hip flexors. Another possible explanation for the poorer ability of older women to recover from a forward loss of balance compared to older men might be that older women lack the ability produce sufficient lower limb muscle power. This view is supported by the findings that muscle power is a strong predictor of functional status in older women (Foldvari et al., 2000).

It is important to determine the mechanisms underlying the biomechanical differences between older adults who can recover balance with single compared to multiple steps because a multiple step recovery strategy following loss of balance is predictive of a future fall (Maki et al., 2001). Studies of multiple and single steppers using the tether release method indicate that multiple steppers have reduced dynamic stability (Hof et al., 2005) at the time the stepping foot contacts the ground, which is explained by a reduced step length and a greater forward velocity of the whole body centre-of-mass during recovery (Arampatzis et al., 2008; Carty et al., 2011). Furthermore, factors associated with the reactive stepping response, rather than the subsequent support phase have been shown to play a key role in determining whether an individual can recover from forward loss of balance with a single step (Carty et al., 2011, 2012b). These results suggest that muscles responsible for rapid translation of the stepping leg during the stepping response are crucial for single step balance recovery. Indeed, Carty et al. (2012b) showed that hip flexion and knee extension weaknesses are independent predictors of a multiple step recovery strategy following a forward loss of balance in older adults. Furthermore, Madigan (2006) reported that older compared to young adults produce less lower extremity muscle power during the stepping phase of balance recovery following release from their maximal recoverable lean angle. However, at present it is not known how muscle moments and powers during the stepping phase of balance recovery contribute to the differences in balance recovery ability between older single and multiple steppers.

The purpose of the present study was to assess whether male and female older adults, and those that require single versus multiple steps to recover from forward loss of balance, differ in the proportion of lower limb strength used and power produced during the stepping phase of recovery from forward loss of balance. Our primary hypotheses were that (1) females compared to males, and (2) multiple compared to single steppers, would use a higher proportion of their available joint specific strength and exhibit smaller lower limb powers in the stepping limb. A secondary hypothesis was that group differences in proportional strength during the stepping phase of balance recovery would be explained by muscle weakness rather than differences in moment production in females compared to males and multiple compared to single steppers.

2. Methods

2.1. Participants

Eighty-four community dwelling older adults aged 65 to 80 years (47 men, 37 women; mean (standard deviation); age: 69.5 (3.3) years; height: 1.67 (0.09) m, mass: 76.2 (12.7) kg) were recruited at random from the local electoral roll. Group comparisons by sex and recovery

strategy (Table 1) revealed that that women had lower mass and stature compared to men. Individuals previously diagnosed with neurological, metabolic, cardio-pulmonary, musculoskeletal and/or uncorrected visual impairment were excluded. Ethics approval was obtained from the Institutional Human Research Ethics Committee and all relevant ethics guidelines including provision of informed consent were followed.

2.2. Experimental protocol

Participants attended the biomechanics laboratory on a single occasion and initially underwent a balance recovery assessment across a range of initial lean magnitudes using the tether release method (Do et al., 1982; Thelen et al., 1997; Wojcik et al., 1999). Isometric lower limb strength of the stepping lower limb was subsequently assessed across the range of joint motion using a dynamometer.

2.3. Balance recovery assessment

The balance recovery protocol was undertaken as reported in Carty et al. (2012a). Participants stood barefoot with their feet shoulder-width apart in an upright posture and were subsequently tilted forward, with their feet flat on the ground, until 15, 20 or 25% of body weight (BW) was recorded on a load cell (S1W1kN, XTRAN, Australia) placed in-series with an inextensible cable. One end of the cable was attached to a safety harness worn by the participant at the level of their sacrum and the other end was attached to a rigid metal frame located behind the participant. An electric winch, mounted on the frame, was used to adjust the length of the cable until the required force on the cable was achieved. Care was taken to ensure the cable was aligned parallel with the ground and that participants kept their head, trunk and extremities aligned prior to cable release. The cable was released at a random time interval (2–10 s) following achievement of the prescribed posture and cable force ($\pm 1\%$ BW), through the disengagement of an electromagnet located in-series with the cable. No differences in cable force or release angle (computed from the sagittal plane angle between the vertical, and a line connecting the ankle joint centre with the whole body centre-of-mass) at cable release between single steppers and multiple steppers, or between men and women were detected for any lean magnitudes ($P > 0.05$). Participants were instructed to relax their muscles whilst leaning and to regain balance with a single step using the stepping lower limb of their choice, once they perceived that they were falling. The instruction to attempt to recover using a single step was reiterated prior to every trial. A second cable, instrumented with a load cell (S1W1kN, XTRAN, Australia), attached the safety harness to the ceiling, and was used to prevent participants from contacting the ground in the event of a fall. Centre of pressure location was displayed in real time on a computer monitor and was visually inspected by the investigator to ensure that anticipatory actions (e.g., antero-posterior and medio-lateral weight shifting) were not evident in the period immediately prior to cable release. Following an initial trial at the 15%BW lean magnitude, participants performed 4 trials at each lean magnitude, with block randomisation used to determine the lean magnitude sequence (i.e., 15, 20 or 25%BW) for the 12 trials, however only results from the 20%BW condition were considered in this report.

Table 1

Mean age, height and weight of participants by stepping strategy and sex. Bracketed terms are one standard error of the mean.

	Stepping strategy		F, P	Sex		F, P	Interaction F, P
	Single steppers	Multiple steppers		Men	Women		
Age (years)	69.2 (3.2)	69.6 (3.0)	0.44, 0.50	69.8 (3.3)	68.8 (2.8)	2.03, 0.16	1.04, 0.31
Height (m)	1.68 (0.08)	1.65 (0.10)	0.03, 0.86	1.73 (0.06)	1.59 (0.06)	81.1, <0.01*	0.89, 0.35
Mass (kg)	75.9 (11.0)	75.7 (12.8)	2.03, 0.16	81.9 (10.1)	67.7 (8.6)	40.2, <0.01*	0.05, 0.83

* $P < 0.05$.

Download English Version:

<https://daneshyari.com/en/article/6204917>

Download Persian Version:

<https://daneshyari.com/article/6204917>

[Daneshyari.com](https://daneshyari.com)