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# Transfer effects of step training on stepping performance in untrained directions in older adults: A randomized controlled trial

Yoshiro Okubo[a,b], Jasmine Menant[a,c], Manasa Udyavar[d], Matthew A. Brodie[a,d], Benjamin K. Barry[a,e], Stephen R. Lord[a,c], Daina L. Sturnieks[a,e,*]

[a] Falls, Balance and Injury Research Centre, Neuroscience Research Australia, Barker Street Randwick, Randwick, NSW 2031, Australia
[b] The Japan Society for the Promotion of Science, 5-3-1 Kojimachi, Chiyoda, Tokyo, Japan
[c] School of Public Health and Community Medicine, University of New South Wales, Sydney, 2052 NSW, Australia
[d] Graduate School of Biomedical Engineering, University of New South Wales, Sydney, 2052 NSW, Australia
[e] School of Medical Sciences, University of New South Wales, Sydney, 2052 NSW, Australia

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ABSTRACT

*Background:* Although step training improves the ability of quick stepping, some home-based step training systems train limited stepping directions and may cause harm by reducing stepping performance in untrained directions. This study examines the possible transfer effects of step training on stepping performance in untrained directions in older people.
*Methods:* Fifty four older adults were randomized into: forward step training (FT); lateral plus forward step training (FLT); or no training (NT) groups. FT and FLT participants undertook a 15-min training session involving 200 step repetitions. Prior to and post training, choice stepping reaction time and stepping kinematics in untrained, diagonal and lateral directions were assessed.
*Results:* Significant interactions of group and time (pre/post-assessment) were evident for the first step after training indicating negative (delayed response time) and positive (faster peak stepping speed) transfer effects in the diagonal direction in the FT group. However, when the second to the fifth steps after training were included in the analysis, there were no significant interactions of group and time for measures in the diagonal stepping direction.
*Conclusions:* Step training only in the forward direction improved stepping speed but may acutely slow response times in the untrained diagonal direction. However, this acute effect appears to dissipate after a few repeated step trials. Step training in both forward and lateral directions appears to induce no negative transfer effects in diagonal stepping. These findings suggest home-based step training systems present low risk of harm through negative transfer effects in untrained stepping directions.
Trial registration: ANZCTR 369066.



## 1. Introduction

Falls among older people are the leading cause of bone fractures [1], fear of falling [2] and restricted activity [3], and constitute a substantial economic burden [4]. Three decades of accumulating evidence indicates that exercise interventions can reduce falls by 15–32% [5] and that balance training is the most important component of effective exercise programs [6].

Step training is an emerging form of balance training to prevent falls and directly addresses impaired stepping capacity – an important fall risk factor in older people [7–9]. A recent systematic review and meta-analysis of 7 randomized controlled trials (RCTs) showed step training reduces falls by approximately 50% [10]. This substantial reduction in falls is thought to be due to the high task-specificity of step training to real world situations, which require quick and appropriate stepping to avoid falling [11].

Step training systems using interactive video game technology have the potential for widespread implementation because of their low-cost, and capacity to be used unsupervised by older people at home [12]. Most systems train stepping in only a few directions (e.g., anterior-posterior and lateral directions) [12–14]. However, successful balance recovery after trips, slips and lateral falls may require fast and accurate stepping in other directions [11]. With respect to the task-specific nature of training [11], a question remains as to whether the effects of step training in limited

* Corresponding author at: Falls, Balance and Injury Research Centre, Neuroscience Research Australia, Barker Street Randwick, Randwick, NSW 2031, Australia.
*E-mail address:* d.sturnieks@neura.edu.au (D. L. Sturnieks).

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directions has transfer effects to stepping performance in untrained directions [15,16].

One recent fall prevention trial reported a significantly increased incidence of falls in the exercise intervention group [17]. Commonly, such adverse findings are thought to result from increased physical activity and exposure to environmental hazards. It has not been considered that exercise with a specific set of movements may have negative effects on the adaptability of stepping required to prevent falls in daily life situations [17]. Negative transfer effects of training have been observed for upper limb movements in older adults; i.e. an RCT of upper-limb resistance training with limited motions and directions showed that outcomes of rapid movements to targets in untrained directions deteriorated because arm movements were affected by the direction of the training [15]. It is also possible that repetitive step training in limited directions [12–14] may have immediate, negative transfer effects on stepping performance in untrained directions and therefore place older adults at risk of falling after training. The purpose of this study was to examine the transfer effects of step training on stepping performance in untrained directions among older adults. This is important to ensure the safety of home-based step training systems before large scale translation into practice occurs.

## 2. Methods

### 2.1. Study design and ethics

The study design comprised a 3-group parallel, non-blinded, randomized controlled trial (RCT). The study protocol was approved by the University of New South Wales Human Research Ethics Committee (HC14300) and registered with the Australian New Zealand Clinical Trials Registry (369066). The study was conducted from March to November in 2015 at Neuroscience Research Australia (NeuRA) in Sydney, Australia.

### 2.2. Participants

Participants were recruited through the NeuRA volunteer database and flyers posted in hospitals and retirement villages in Sydney. Eligible participants were aged 65 years or older, able to step unassisted on a computerised step mat and without disabilities affecting activities of daily living. Exclusion criteria included significant visual, cognitive or neurological impairment (including dementia, Alzheimer's disease, Parkinson's disease or multiple sclerosis), and insufficient English language skills to understand the assessment procedure. All participants gave written informed consent prior to participation. Age, gender, body height and weight, fall risk score (Physiological Profile Assessment [18]) and fall history in the year prior to the assessment were ascertained.

### 2.3. Randomization

Participants were randomized into 1 of 3 groups: forward step training (FT); lateral plus forward step training (FLT); or no training (NT), with equal allocation ratio. A research assistant, who was not a co-author, recruited the participants and performed the simple randomization using a random number created with Excel 2010 in a locked electronic file.

### 2.4. Intervention protocol

A choice stepping reaction time (CSRT) system [7,19] was used for step training. The step training system consisted of a modified version of the CSRT step mat, integrated with a computer via Bluetooth. The computer unit and monitor were placed on the ground 50 cm in front of the step mat (Fig. 1). The step training program, written in Python (Version 2.7), displayed step stimuli in forward, diagonal and lateral directions for both the left and right foot. Participants were asked to view the screen that displayed the

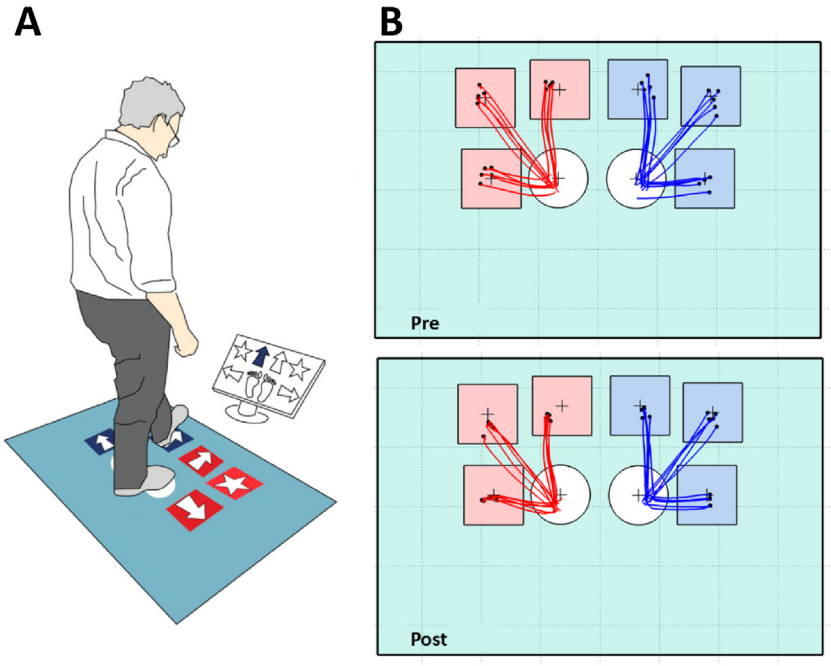


**Fig. 1.** A) The step mat and screen display used in the step training interventions and stepping performance assessments. B) A typical example of stepping trajectory for 1 participant (FT group). This participant improved in stepping precision in all directions, as indicated by more converged step landing position at post-assessment, compared with pre-assessment.