

Effect of square stepping exercise for older adults to prevent fall and injury related to fall: systematic review and meta-analysis of current evidences

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Falls and fall related injuries become an emerging health problem among older adults. As a result a review of the recent evidences is needed to design a prevention strategy. The aim of this review was to determine the effect of square stepping exercise (SSE) for fall down injury among older adults compared with walking training or other exercises. An electronic database search for relevant randomized control trials published in English from 2005 to 2016 was conducted. Articles with outcome measures of functional reach, perceived health status, fear of fall were included. Quality of the included articles was rated using Physiotherapy Evidence Database (PEDro) scale and the pooled ef-

fect of SSE was obtained by Review Manager (RevMan5) software. Significant effect of SSE was detected over walking or no treatment to improve balance as well to prevent fear of fall and improve perceived health status. The results of this systematic review proposed that SSE significantly better than walking or no treatment to prevent fall, prevent fear of fall and improve perceived health status.

Keywords: Square stepping exercise, Older adults, Fall, Strength, Balance


INTRODUCTION

Square stepping exercise (SSE) comprises multiple directional step patterns performed on a thin mat which is partitioned into squares; 25 cm² each and may include toe walking or complex pattern of walking as a progression. SSE can also be performed indoors so certainly appears to be advantageous over unidirectional and outdoor walking which is less beneficial pertaining to fall prevention and it is also unsafe for older adults (McClure et al., 2005).

SSEs were designed based on the principles of proactive and reactive responses enhancement which logically may improve reaction time during corrective stepping during recovering balance after tripping among the older subjects. Further it is hypothesized to induce agonist and antagonist muscle activations in lower ex-

trémities thus improving lower extremities fitness. The benefit of SSE also extends beyond preventing fall such as improving functional ability, fitness of lower extremities and health status among older adults (Shigematsu et al., 2008a; Shigematsu et al., 2008b).

Falls are the leading cause of unintentional injury and premature death among community dwelling older adults (Kannus et al., 2005). Falls among older adults are a serious public health problem that can cause fatal injuries sometime, also affects psychosocial status and more importantly quality of life. About 80% of disability stemming from unintentional injuries; which excludes traffic accidents in adults aged 50 years and over resulted from falls in year 2010 (Karlsson et al., 2013). Physical and mental changes associated with advancing age and frailty increases risk of fall and susceptibility of unintentional injury among older population (Rubenstein, 2006).

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Nationally representative standardized data collected from adults aged 50 years and over participating in the World Health Organization (WHO) SAGE (Study on global AGEing and adult health) Wave 1 in China, Ghana, India, Mexico, the Russian Federation and South Africa reported that the proportion of all previous year injuries that were fall related ranged from 73.3% in the Russian federation to 44.4% in Ghana (Stewart Williams et al., 2015). Every year one-third of community-dwelling older adults fall. About 10%–15% subsequently endures an injury. Approximately 3% of community-dwelling older adults sustain significant injuries due to falls in any given year, resulting in substantial costs to individuals and society (Kannus et al., 2005). In 2013, about 2.5 million older adults were treated for nonfatal fall related injuries and more than 734,000 were hospitalized in 2015. In that year the direct medical cost for older adult falls was 34 billion United States dollars. Even in the absence of injury; a fall has potential consequences on the psychological aspects and quality of life (Kannus et al., 2007).

About 70% of world’s older population resides in developing countries. This proportion will increase in coming decades. There is a fear that a larger burden of morbidity and mortality due to falls along with other chronic conditions will occur in low and middle income countries (LMICs) (Beard et al., 2011).

This review explicitly assesses the advantages of SSE (Fig. 1) compared with other conventional exercises for older adults experiencing fall and suffering fall related injuries. Data were extracted to identify how the outcomes of exercise have been measured and to summarize the components of SSE and other exercise programs.

MATERIALS AND METHODS

Search strategy and inclusion

An electronic database search for relevant randomised control trials published in English (as translation funding was not available) was conducted from 2005 to 2016 on the following databases: PubMed through Hinari, Cochrane, Google scholar, CINAHL (Cumulative Index to Nursing and Allied Health Literature), MEDLINE, AMED (Allied and Complementary Medicine), Embase, and Physiotherapy Evidence Database (PEDro). Search key words included; randomized controlled trial, old age, Fall down injury, Balance, SSE and square stepping training. Full texts of peer-reviewed relevant articles were retrieved, assessed and their reference lists were hand searched to identify further relevant studies.

Elementary 1	Elementary 2	Intermediate 1	Advanced 3



Fig. 1. Example of indoor square stepping exercise.

Selection of studies

The method segment of listed trials was extracted and employed the predetermined inclusion criteria to screen for relevant full text trials. An article was removed from the list if it was determined not to meet the inclusion criteria. Studies were included for data extraction and analyses, if they met the predetermined inclusion criteria (Table 1).

Quality assessment

For all the selected articles randomization method, blinding, selection criteria and dropouts from follow-up were seen critically to assess risk of bias. Articles selected were critically appraised with 11 items (Table 2). PEDro scale scores extracted from the Physiotherapy Evidence Database (www.pedro.org.au). PEDro scale is a useful tool to assess the methodological quality of physical therapy and rehabilitation trials. Studies were excluded in subsequent analysis if the cutoff of 6 points was not reached on PEDro scale score.

Data extraction and management

After searching relevant articles to this systematic review data were extracted from the studies using standard checklist. The information's collected from each articles were:

1. Patients details (including age, gender, occupation, and residence)
2. Method (the inclusion and exclusion criteria)
3. Intervention including (duration, intensity, and frequency)
4. The comparison intervention
5. Description of the SSE
6. Outcome measures used
7. Follow-up period

Table 1. Inclusion criteria

Study type
Randomised controlled trials
Full text published in English
Published 2005 to 2016
Concerned on fall down injury
Participants
Older adults (> 60 years)
Male and female
Interventions
Experimental group: square stepping exercise
Control group (walking training, other exercises and/or no exercise)
Outcome measures
Functional reach
Perceived health status
Fear of fall

Data at baseline, post treatment and follow-ups were extracted for interested outcomes. Findings were putted in logical order, discussed their similarity and differences on the effectiveness of SSE for fall down injury among old age adults (Table 3).

Meta-analysis

Meta-analysis was done using Review Manager (RevMan5, Cochrane Collaboration, Oxford, UK) software. The postintervention data's were used to obtain the pooled estimate of the effect of intervention. Heterogeneity between trials was assessed using the I^2 statistic. Heterogeneity was considered substantial if I^2 was greater than 50% and a random effects model applied; otherwise a fixed effects model was used for the analysis. The pooled data for each outcome were reported as weighted mean differences with a 95% confidence interval (CI).

RESULTS

A total of 46 papers were identified from the electronic search, but only 5 articles were found to fulfill the inclusion criteria. Included articles were high quality trials with their scores in PEDro scale average and above. All the included five studies were done on the effect of SSE on old age adults (> 60 years of age).

Effect of SSE to prevent fall down injury

Functional reach is found as an outcome measure in three randomized controlled trials (Shigematsu et al., 2008a; Shigematsu et al., 2008b; Shigematsu et al., 2013) which can deal with bal-

Table 2. PEDro criteria and summary of quality assessment scores of included studies (n=5)

PEDro criteria	Shigematsu et al., 2008a	Shigematsu et al., 2008b	Shigematsu et al., 2013	Teixeira et al., 2013	Pereira et al., 2014
1. Eligibility criteria	√	√	√	√	√
2. Random allocation	1	1	1	0	1
3. Allocation concealed	1	1	0	0	0
4. Baseline similarity	1	1	1, Functional fitness	1	1
5. Patient blinding	1	1	1	1	1
6. Therapist blinding	0	0	0	0	0
7. Assessor blinding	0	0	0	1	1
8. < 15% drop outs	1	1	1	0	1
9. ITT analysis	1	1	1, Per-protocol based	1	1
10. Between group comparison reported	1, Analysis of covariance	1, Analysis of covariance	1	1, Analysis of covariance	1, Analysis of covariance
11. Post intervention point & variability measures	1, Chi-square test	1, Chi-square test	1, Chi-square test	1, Chi-square test	1, Chi-square test
Total	7/10	7/10	7/10	6/10	8/10

PEDro, Physiotherapy Evidence Database; ITT, intention-to-treat; √, yes (not scored); 1, yes (scored); 0, no.

Table 3. Summary of included studies (n=5)

Study	Participants	Outcome measures	Intervention	Results
Shigematsu et al. (2008a)	68 Community-dwelling older adults (age 65–74 years)	Self-reported scales consisted of the fear of falling, perceived health status and physical performance tests	Intervention group: SSE Control group: walking	Significant time effects were observed in the tests involving chair stands, functional reach, and standing up from a lying-down position. During the follow-up period, the fall rates per person-year in the SSE and W groups were 23.4% and 33.3%, respectively (p¼.31).
Shigematsu et al. (2008b)	The study included 39 community-dwelling adults aged 65 to 74 years. The participants were randomized to either group SSE (n=20) or SB (n=19).	Fear of falling, pleasure in exercise, perceived health status	Intervention group: SSE for 70 min twice a week Control group: strength balance exercise for 70 min twice a week	During the 14-month follow-up period, 7 falls in 6 participants in the SSE group and 12 falls in 11 participants in the SB group were reported. The incidence rate per person in the SSE group (30.0%) was not significantly different from that in the SB group (57.9%).
Shigematsu et al. (2013)	Sixty-eight people (SSE group, n=32; walking group, n=36) participated.	Reported incidence of fall	Intervention group: SSE Control group: walking	Among the 22 (1 year) and 20 (4 years) SSE participants, none reported adverse events such as falling, severe muscle soreness or dizziness but among the 22 (1 year) and 20 (4 years) walking group.
Teixeira et al. (2013)	A total of 86 community-dwelling older adults (aged > 60 years)	Functional fitness	One group practised only SSE sequences (n=21), the second group practised basic physical exercises (n=20), the third group practised both SSE sequences and physical exercises (n=25); and the fourth group was the control group.	Participants who practised basic physical exercises improved in agility and aerobic endurance, and SSE improved balance tests.
Pereira et al. (2014)	60 Years of age or older: intervention group (n=15), control group (n=17)	The Berg Balance Scale Timed Up and Go Test (TUG) Geriatric Depression Scale-short-form (GDS-15)	Intervention group: SSE Control group: no treatment	Significant improvements were observed in the TG with the maintenance of GDS-15 scores and on the time to perform the TUG test which reflects better functional mobility than the control group.

SSE, square stepping exercise; TG, treatment group; SB, strength and balance

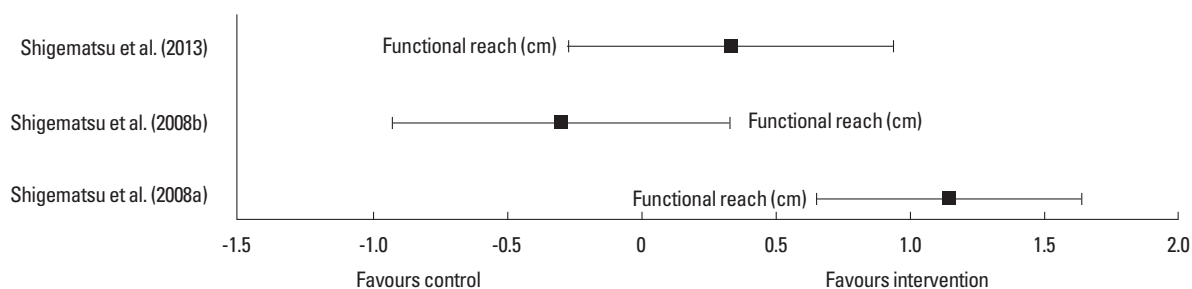


Fig. 2. Mean difference (95%) of effect of square stepping versus control group for balance improvement (n= 146).

ance as a result that can affect fall. The effect of SSE was examined by pooling data from three trails (Shigematsu et al., 2008a; Shigematsu et al., 2008b; Shigematsu et al., 2013) involving 146 participants. The mean effect of square stepping in all the included

studies in this meta-analysis favors SSE than walking to prevent fall among older adults (Fig. 2).

From the three studies included significant effect of SSE was detected over walking or no treatment with $P = 0.0015$ (95% CI,

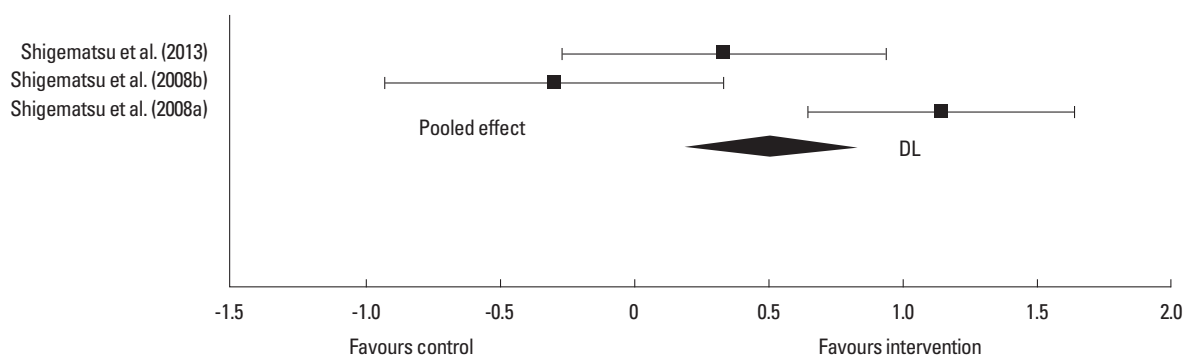


Fig. 3. Overall pooled fixed effect model of square stepping exercise versus control group to improve balance with $P=0.0015$ (95% confidence interval, 0.1900–0.8436) ($n= 146$).

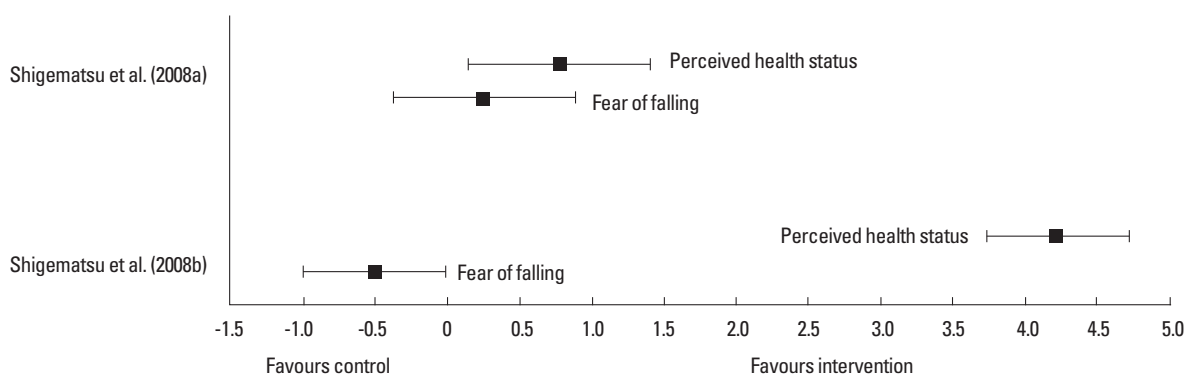


Fig. 4. Mean difference (95%) of effect of square stepping versus control group prevent fear of fall ($n= 102$).

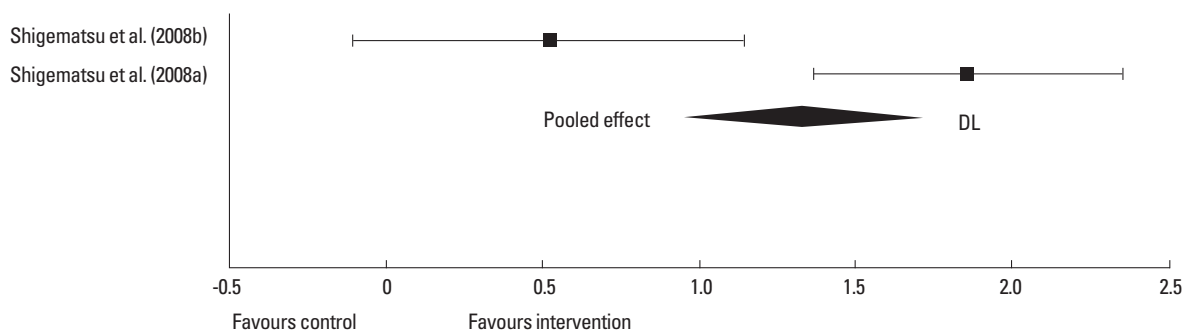


Fig. 5. Overall pooled fixed effect model of square stepping exercise versus control group to improve balance with $P=0.0010$ (95% CI= 0.9560, 1.7325) ($n= 102$).

0.1900–0.8436). Heterogeneity between studies was substantial ($I^2 = 84%$) hence random effect model was used for analysis (Fig. 3).

Effect of SSE to prevent fear of fall and to improve perceived health status

Group analysis was done in two studies which had both fear of fall and perceived health status as outcome measures after intervention with SSE. The mean effect of SSE in both the included

studies (Shigematsu et al., 2008a; Shigematsu et al., 2008b) In this meta-analysis favors SSE than walking to prevent fear of fall and to improve perceived health status among older adults (Fig. 4).

From the two studies included significant effect of SSE was detected over walking or no treatment to prevent fear of fall and to improve perceived health status with $P = 0.0010$ (95% CI, 0.9560–1.7325). Heterogeneity between studies was very high ($I^2 = 90.77%$) and random effect model was used for analysis (Fig. 5).

DISCUSSION

It is known that older adults are prone to fall related risks which can make them totally or partly dependent on their family and the community. Significant number of older adults could be permanently disabled or even death can occur as a result of fall down injury. So designing an exercise program is mandatory to prevent fall eventually eliminate fall related injuries and related risks. Most of the included studies (Pereira et al., 2014; Shigematsu et al., 2008a; Shigematsu et al., 2008b; Shigematsu et al., 2013) showed the effectiveness of SSE but the significance of SSE over walking, other exercises or no treatment was controversial and inconclusive. The present review was aimed at updating the current evidences of SSE and to distinguish the effect of SSE to prevent fall due to improving in balance, prevent fear of fall and improve perceived health status compared to walking or no intervention. SSE is found to be effective in balance improvement from the meta-analysis done with three studies (Shigematsu et al., 2008a; Shigematsu et al., 2008b; Shigematsu et al., 2013) with $P = 0.0015$. The studies were found to be heterogeneous which could be due to the exercises used for comparing with SSE were different, for instance one study used balance and strengthening exercise (Shigematsu et al., 2008b) but the other two studies used walking as a treatment for the controlled groups (Shigematsu et al., 2008a; Shigematsu et al., 2013).

SSE is found to be significantly effective in preventing fall down injuries by improving balance. SSE is also effective to prevent fear of fall and to improve perceived health status among older adults. When we see the applicability of SSE to our setup it is easy, cost effective and can be applied in group. So it is mandatory for resource limited countries like Ethiopia to incorporate SSE as an integral part of fall prevention strategy to prevent fall among older adults and also determine the efficacy of SSE in other risk population. Therefore awareness and practice training shall be conducted for health professionals and the health care community on the effectiveness of physical exercises (SSE) to prevent fall and improve perceived health status among community dwelling older adults.

From a public health perspective, concerted efforts should be directed to reduce fall among elderly population to lessen the burden of fall related injuries and complications. This review outlines the importance of SSE which requires to be implemented among elderly population.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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