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Effectiveness of Square-Stepping Exercise to Improve Walking Speed and Functional Mobility in Elderly

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ABSTRACT

Background and objective: Ageing involves a complex interplay of biological and genetic processes leading to functional decline and reduced quality of life. In elderly individuals, fear of falling can significantly diminish independence and physical function. Precise foot placement and quick stepping movements are crucial for maintaining balance and avoiding falls. The Square-Stepping Exercise (SSE) was studied for its effectiveness in enhancing walking speed and functional mobility among the elderly, highlighting its potential to improve their overall well-being and reduce the risk of falls.
Methodology: A Quasi experimental study was conducted on 35 subjects of both gender with age group of 65-75 years with ABC scale score below 80%. Participants underwent a Square Stepping Exercise regimen for four weeks, three days per week. Walking speed and functional mobility pre- and post-treatment was assessed by 10-Meter Walk test and Timed Up and Go test.
Results: The paired t-test demonstrated a remarkable and highly significant disparity in both pre and post-test measures of Walking speed (10MWT) and functional mobility (TUG) among the participants ($p<0.001$).
Conclusion: The study concluded that Square-Stepping Exercise significantly improve functional mobility and walking speed while lowering fall risk in the elderly.

Keywords: Square stepping exercise, older adults, Fall, Fear of fall, Balance confidence, cadence, walking speed, mobility, ageing, elderly, functional fitness, physical activity.

INTRODUCTION

Ageing can be defined as the time-related deterioration of the physiological functions necessary for survival and fertility.[1] A general decrease in tissue function is a fundamental biological mechanism of ageing. Additionally, ageing poses a significant risk for several age-related disorders.[2,3] All age-related disorders are fueled by the physiological process of ageing, which is mediated by various biochemical and genetic mechanisms intimately linked to longevity.[4]

With advancing age, the likelihood of falls rises.[5] Every year, between 35 and 40 per cent of the population over 65 experience falls.[6] Skeletal fragility, a notable concern among seniors, stems from increased

vulnerability of bones to mechanical forces. Unlike younger individuals with higher bone density, older patients suffer more severe injuries from less force. The ongoing loss of bone mineral density, beginning in one's thirties and persisting throughout life, underscores the remarkable ability of skeletal tissue to adapt to daily challenges.[5]

Age-related changes often result in reduced functional capacity, affecting balance, agility, coordination, and muscle strength, which in turn impact mobility.[2] Falls can result from intrinsic or extrinsic factors. Intrinsic factors include functional impairment and balance issues, while extrinsic factors encompass adverse pharmacological effects, prosthetic devices, constraint use, and environmental conditions.[6]

Numerous factors can affect or contribute to walking speed, making it a complicated functional activity.[7] Walking is a well-established exercise that is utilized to increase functional fitness in population-based fall prevention programs.[8] In older individuals, falls often occur due to difficulties in placing their feet precisely and transferring weight properly during activities like walking. This is because aging affects stepping for balance, leading to shorter or misdirected steps, collisions between legs, slower reactions, and increased attentional demands, especially when multitasking. [9]

Shigematsu and Okura devised a cost-effective indoor regimen known as square-stepping exercise (SSE), involving multidirectional steps - forward, backward, lateral, and oblique. This program aims to enhance balance and reduce fall risks, employing narrow mat stepping as its core. Participants follow various step patterns as part of SSE training.[5,10,11]

Proactive and reactive response enhancement inspired the development of SSEs, aiming to improve reaction time for corrective stepping and stimulate muscle activity in the lower extremities, thus enhancing lower extremity fitness in older individuals.[12] SSE can be used as a novel exercise to avoid falls because it is a more effective exercise programme for older persons than normal walking.[13] SSE has advantages for older persons beyond fall prevention, such as enhancing functional ability, lower extremity fitness, and health condition.[5,10,14]

Rehabilitation programs for fall prevention should prioritize precise, rapid, and well-directed stepping movements to effectively respond to obstacles or unexpected perturbations, reducing the risk of trips or slips.[9]

Maintaining mobility is essential for preserving independence and autonomy in older individuals, crucial for lifelong health. Around 30%–40% of those aged 65 and above report mobility limitations, such as difficulty walking a quarter-mile or climbing stairs.[15] In contrast to SSE, which is low-intensity, seniors may find it challenging to engage in exercises like endurance, strength, and stretching. The study aims to evaluate whether four weeks of SSE sequences can enhance functional mobility and walking speed in older participants. Additionally, the goal is to enhance walking speed and functional mobility in older adults through training as a preventive measure and early rehabilitation aid.

MATERIALS & METHODS

Study design and Setting: The current quasi-experimental study was carried out over a period of 12 months from August 2022 to August 2023 in old age homes in and around Mangalore.

Study participants and Sampling: Sample size was estimated on the basis of the study conducted by Teixeira C V, et al. (2013)[10] in order to expect a difference of 2.28 in the pre and post-test scores of the outcome measure, assuming 95% confidence interval, 80% power with a standard deviation of 2 and precision ± 1, the sample size estimated for the study is 31.3, considering 10% of dropouts 35 individuals will be recruited for the study. The convenience sampling method was used to include the participants

in the study. 43 elderly subjects were screened for inclusion and exclusion criteria. Three participants were excluded from the study as they had neurological problems, and five were excluded as their ABC scale score was above 80%, 35 subjects falling within the inclusion criteria were recruited for the study. The inclusion criteria for the participants were the following: age group of 65- 75 years of both genders, with Activities- specific Balance Confidence (ABC) scale scoring of below 80%, leading a sedentary lifestyle and those who are willing for the study. The Participants were excluded from the study with ABC scale scoring above 80% with visual and auditory impairment, individuals with any fracture in the past one year and with neurological conditions.

Data collection tools and techniques: Prior to treatment, participants' walking speed and functional mobility were assessed using the 10-Meter Walk test and Timed Up and Go test. They underwent Square-Stepping exercise for 4 weeks, 3 days per week. After treatment, improvements in walking speed and functional mobility were evaluated using the same tests.

Exercise Intervention: The Square-Stepping Exercise (SSE), developed by Shigematsu et al., aims to enhance lower extremity functional fitness and decrease fall risk in older adults. This program involves performing stepping movements in various directions (forward, backward, lateral, and diagonal) on a designated mat (250 cm x 100 cm) divided into 40 squares (25 cm x 25 cm). Participants follow the instructor's demonstration, memorize the stepping pattern, and practice in a group setting. They walk according to the pattern from one end of the mat to the other, then return to their starting positions for the next set. Each step pattern is repeated 4-10 times once participants are familiar with them.[5,8,10,11,12]

Outcome Measures

- **10-meter walk test:** The 10-Meter Walk Test (10MWT) is utilized to assess walking speed. Participants are thoroughly briefed on the procedure before commencement. To standardize the test and exclude acceleration and deceleration factors, volunteers are instructed to initiate walking 2 meters before the starting point and conclude 2 meters beyond the finishing point at their typical pace. To mitigate any learning effects, three trials are conducted, and the average performance is utilized for analysis. Using a stopwatch, the time taken by each volunteer to traverse the course is recorded. These data are then employed to compute walking speed using the formula distance divided by time. The 10-Meter Walk Test demonstrates high validity and reliability, with Intraclass Correlation Coefficients (ICCs) ranging from 0.96 to 0.98.[16-20]
- **Timed up and go test:** The Timed Up and Go test evaluates functional mobility by having the patient transition from a seated position to standing upon the therapist's command: walks 3 meters, turns around, walks back to the chair and sits down. Completion time is recorded for analysis. Times over 30 seconds suggest high dependence, 20-30 seconds indicate uncertain mobility and fall risk, while under 20 seconds signal independence. With an ICC value of 0.99, the test is highly reliable and valid for assessing functional mobility.[21-25]

Ethical Consideration: The study participants were provided with a patient information sheet containing details about the study, and informed consent was obtained from each participant prior to their involvement in the study and Ethical clearance was obtained from the Institutional ethics committee of A J Institute of Medical Sciences and Research Centre, Mangalore on 30.08.2022. Ref. no. AJEC/REV/ 227/2022

STATISTICAL ANALYSIS

Statistical analysis and graph preparation were conducted using SPSS v 26.0.0.0

software. Participant demographics, including age and gender, were summarized using Mean and Standard Deviation. Diagrams and graphs were used for data presentation. Paired t-tests were used to assess the significance of differences between Pre and Post-test outcomes (10MWT and TUG test), with a significance level set at $p<0.05$ and a 95% confidence interval.

RESULT

The study involved 31 elderly participants who underwent a four-week regimen of Square-Stepping exercises, conducted three times a week. To evaluate changes in walking speed and functional mobility before and after the treatment, the study employed the 10-Meter Walk Test and the Timed Up and Go Test.

Table No. 1: Age and gender wise distribution of the study participants

	N	Minimum	Maximum	Mean	Std. Deviation
Age	31	65	75	70.65	3.517

Gender	Frequency	Percent
Females	16	51.6
Males	15	48.4
Total	31	100.0

Table No. 2: Comparison of Pre and Post test walking speed

	Mean	N	Std. Deviation	P value
Walking Speed (10MWT) -Pre test	.7077	31	.11687	.000
Walking Speed (10MWT) -Post test	.77129	31	.127899	

Table No.3: Comparison of Pre and Post test functional mobility

	Mean	N	Std. Deviation	P value
Functional Mobility (TUG) -Pre test	12.6626	31	1.64518	.000
Functional Mobility (TUG) -Post test	11.31581	31	1.492979	

Among 31 individuals considered for the study, the pre and post-test walking Speed is found to be 0.7077 ± 0.1168 and 0.7712 ± 0.1278 respectively. Using Paired t test statistically very high significant difference is observed in the pre and post-test Walking speed (10MWT) among the study participants ($p<0.001$). The pre and post-test functional mobility (TUG) is found to be 12.6 ± 1.6 and 11.3 ± 1.4 respectively. Using Paired t-test statistically very high significant difference is observed in the pre and post-test functional mobility among the study participants ($p<0.001$).

DISCUSSION

The study aimed to assess the impact of square-stepping exercises (SSE) on functional mobility and walking speed in elderly individuals. 35 elderly participated in the exercise regimen for three times a week for four weeks. Walking speed and mobility were evaluated using the 10-Meter Walk Test and Timed Up and Go Test before and after treatment. Paired t-tests revealed significant improvements in both measures post-treatment.

According to Fisseha B, et al. SSE was successful in improving balance and reducing fall-related anxiety.[12] Shigematsu et al claims that SSEs were created using the principles of proactive and reactive response augmentation, the study proposed that agonist and antagonist muscle contractions in the lower extremities while stepping would enhance lower extremity fitness.[8]

The primary distinction between the present study and other studies that followed the same protocol is that in the present research, SSE was not linked to any other activity, including warm-up, muscular resistance training, stretching, or relaxation, allowing the intervention's benefits to be seen independently. Due to the training session's specificity, which involves movements with steps in multiple directions, the integration

of cognitive and motor tasks to perform the correct sequence, and some degree of proprioceptive development, these effects were likely highlighted for walking speed and functional mobility. The statistical analysis of the pre-and post-test walking speed in the current investigation revealed values of 0.7077 ± 0.1168 and 0.7712 ± 0.1278, respectively. The study participants' pre- and post-test walking speeds (10MWT) showed a highly significant difference using the Paired t test (p 0.001).

Teixeira C V, et al.[10] found that low-activity older adults benefitted from the study interventions, particularly SSE, which positively impacted their functional fitness. The practice of SSE and basic exercises, whether combined or separate, maintained and even enhanced certain functional capacity components, which is crucial for aging individuals facing progressive reductions in these areas. In the current study, the functional mobility (TUG) scores before and after SSE were found to be 12.6 ± 1.6 and 11.3 ± 1.4 respectively. The study participants' functional mobility was significantly increased between the pre-and post-test using the Paired t-test (p 0.001).

SSE program provides better results than routine walking exercise to prevent falls in older individuals.[8] It is inexpensive, low-tech equipment. It provides visual feedback while executing SSE on the square stepping mat by designating the number patterns to be followed and enhancing coordination. The subjects showed greater enthusiasm, motivation, attention, concentration, participant competition, and dedicated engagement. Given that it is done in a confined indoor setting, supervising multiple elderly people were simple to complete. To avoid falls among older individuals and to support healthy ageing, it is vital to investigate and implement SSE as a key component of fall prevention programmes.

The present research indicates that a 4-week programme of physical workouts based solely on the SSE technique may be a secure, affordable, and practical substitute for engaging in physical activity that has a positive influence on ageing-related improvements in walking speed and functional mobility.

Limitations of the study

All measurements were taken by the researcher herself, and no blinding of the procedures was done. Hence bias can be expected. In this study, only the institutional elderly were included. It would be beneficial if the study could include even the community-dwelling elderly population, as they are also prone to falls. Participants were showing lack of interest towards the exercise and were demotivated as there were repetitive movements which were causing fatigue.

CONCLUSION

Given that the ageing process is marked by a steady decline in functional capacity and walking speed, the ability of SSE practice to maintain some levels while enhancing others is crucial for the elderly. The findings of the present study indicate that square stepping exercises significantly improve functional mobility and walking speed while lowering fall risk in the elderly as measured by the 10 MWT and the TUG tests. The statistical study makes it clear that walking speed and functional mobility have significantly improved.

Thus, it can be said that square stepping exercises significantly improve functional mobility and walking speed while lowering fall risk in the senior population. SSE is useful for preventing falls and is safe to administer.

Declaration by Authors

Ethical Approval: Approved

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REFERENCES

1. Angus J, Reeve P. Ageism: A Threat to "Aging Well" in the 21st Century. J Appl Gerontology. 2006; 25(2): 137-152.
2. Yu M, Zhang H, Wang B, Zhang Y, Zheng X, Shao B, et al. Key signalling pathways in ageing and potential interventions for healthy ageing. Cells. 2021;10(3):660.
3. Saul D, Kosinsky R L. Epigenetics of ageing and ageing-associated diseases. International journal of molecular sciences. 2021; 22(1):401.
4. Li Z, Zhang Z, Ren Y, Wang Y, Fang J, Yue H, et al. Aging and age-related diseases: from mechanisms to therapeutic strategies. Biogerontology. 2021; 22:165-87.
5. Thachil A, Thomas L. Effect of Square-Stepping Exercise in Improving Lower Extremity Strength, Cadence and Confidence among Female Geriatric Population. *Int J Health Sci Res.* 2022; 12(2):287-303.
6. Cesari M, Landi F, Torre S, Onder G, Lattanzio F, Bernabei R. Prevalence and risk factors for falls in an older community-dwelling population. The Journals of Gerontology Series A: Biological Sciences and Medical Sciences. 2002; 57(11):M722
7. Rahman M, Alagappan T R. The test–retest reliability of 10-meter walk test in healthy young adults-A Cross-sectional study. IOSR J Sports Phys Edu. 2019; 6(3):1-6.
8. Shigematsu R, Okura T, Nakagaichi M, Tanaka K, Sakai T, Kitazumi S, et al. Square-stepping exercise and fall risk factors in older adults: a single-blind, randomized controlled trial. The Journals of Gerontology Series A: Biological Sciences and Medical Sciences. 2008; 63(1):76-82.
9. Giannouli E, Morat T, Zijlstra W. A novel square-stepping exercise program for older adults (StepIt): rationale and implications for falls prevention. Frontiers in Medicine. 2020; 6:318.
10. Teixeira C V, Gobbi S, Pereira J R, Ueno D T, Shigematsu R, Gobbi L T. Effect of square-stepping exercise and basic exercises on functional fitness of older adults. Geriatrics & gerontology international. 2013; 13(4):842-8.
11. Lees M A, Edwards J, McCain J E, Bouchard D R. Potential value of home square-stepping exercises for inactive older adults : an exploratory case study. BMC geriatrics. 2022; 22:1-5.
12. Fisseha B, Janakiraman B, Yitayeh A, Ravichandran H. Effect of square stepping exercise for older adults to prevent fall and injury related to fall: systematic review and meta-analysis of current evidences. Journal of exercise rehabilitation. 2017; 13(1):23.
13. Shigematsu R, Okura T, Nakagaichi M, Nakata Y. Effects of exercise program requiring attention, memory and imitation on cognitive function in elderly persons: a non-randomized pilot study. J Gerontology Geriatric Res. 2014; 3(02):147.
14. Jindo T, Kitano N, Tsunoda K, Kusuda M, Hotta K, Okura T. Daily life physical activity modulates the effects of an exercise program on lower-extremity physical function in Japanese older adults. Journal of Geriatric Physical Therapy. 2017; 40(3):150-7.
15. Organisation W H. Prevalence of insufficient physical activity among adults. Global Health Observatory data repository. World Health Organisation. 2015. http://apps.who.int/gho/data/view.main.2487?lang=en. Accessed 7 2015.
16. Peters D M, Fritz S L, Krotish D E. Assessing the reliability and validity of a shorter walk test compared with the 10-Meter Walk Test for measurements of gait speed in healthy, older adults. Journal of geriatric physical therapy. 2013; 36(1):24-30.
17. Amatachaya S, Kwanmongkolthong M, Thongjumroon A, Boonpew N, Amatachaya P, Saensook W, et al. Influence of timing protocols and distance covered on the outcomes of the 10-meter walk test. Physiotherapy Theory and Practice. 2020; 36(12):1348-53.
18. Chan W L, Pin T W. Reliability, validity and minimal detectable change of 2-minute walk test, 6-minute walk test and 10-meter walk test in frail older adults with dementia. Experimental gerontology. 2019; 115:9-18.
19. Chan WL, Pin TW. Reliability, validity and minimal detectable change of 2-min walk test and 10-m walk test in frail older adults receiving day care and residential care. Aging clinical and experimental research. 2020; 32:597-604.
20. Leerar PJ, Miller EW. Concurrent validity of distance-walks and timed-walks in the

well-elderly. Journal of geriatric physical therapy. 2002 May 1;25(2):3.
21. Rydwik E, Bergland A, Forsén L, Frändin K. Psychometric properties of Timed Up and Go in elderly people: a systematic review. Phys Occup Ther Geriatr 2011; 29(2):102-25.
22. Shumway-Cook A, Brauer S, Woollacott M. Predicting the probability for falls in community-dwelling older adults using the Timed Up & Go Test. Phys Ther. 2000; 80(9):896-903.
23. Nakhostin-Ansari A, Naghshtabrizi N, Naghdi S, Ghafouri M, Khalifeloo M, Mohammadzadeh M, et al. Normative values of functional reach test, single-leg stance test, and timed "UP and GO" with and without dual-task in healthy Iranian adults: A cross-sectional study. Annals of Medicine and Surgery. 2022; 80:104053.
24. Chow R B, Lee A, Kane B G, Jacoby J L, Barraco R D, Dusza SW, et al. Effectiveness of the "Timed Up and Go" (TUG) and the Chair test as screening tools for geriatric fall risk assessment in the ED. The American journal of emergency medicine. 2019; 37(3):457-60.
25. Sakthivadivel V, Geetha J, Gaur A, Kaliappan A. Performance-Oriented Mobility Assessment test and Timed Up and Go test as predictors of falls in the elderly–A cross-sectional study. Journal of Family Medicine and Primary Care. 2022; 11(11):7294-8.
26. Pereira J R, Gobbi S, Teixeira C V, Nascimento C M, Corazza DI, Vital TM, et al. Effects of Square-Stepping Exercise on balance and depressive symptoms in older adults. Motriz: Revista de Educação Física. 2014; 20:454-60.

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