



Effect of the Otago Exercise Programme Combined With Tai Chi Exercises on Reducing the Risk of Fall in Elderly

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Abstract

Background. Falls are a common and serious concern among older adults, especially women, leading to reduced independence, balance problems, and increased mortality. Exercise interventions such as the Otago Exercise Programme (OEP) and Tai Chi (TC) have individually shown efficacy in reducing fall risk by improving balance, strength, and mobility.

Aim. To evaluate the combined effect of the Otago Exercise Programme and Tai Chi on fall risk, balance, and mobility in senior Indian women.

Methods. A pre- and post-experimental study was conducted involving 30 women aged 55–70 years, randomised into three equal groups: Otago Exercise Programme only (OEP, 50 minutes/session, 3 times/week), combined Tai Chi and Otago Exercise Programme (OEP + TC, 50 minutes OEP + 30 minutes Tai Chi, 3 times/week), and a control group (walking 30 minutes, 3 times/week). Outcomes were assessed using the Timed Up and Go (TUG) test for mobility, Berg Balance Scale (BBS) for balance, and Falls Efficacy Scale-International (FES-I) to measure fear of falling. Data analyses included paired *t*-tests for within-group comparisons and one-way ANOVA for between-group differences.

Results. Significant improvements were observed in TUG, BBS, and FES-I scores post-intervention in both OEP and OEP + TC groups ($p < 0.001$). The combined OEP + TC group demonstrated the greatest gains in balance and mobility compared with OEP alone and control groups. Fear of falling was significantly reduced in intervention groups. ANOVA revealed statistically significant between-group differences favouring the combined exercise protocol for TUG and BBS ($p < 0.05$).

Conclusions. Integrating the Otago Exercise Programme with Tai Chi yields superior improvements in balance, mobility, and reduction of fall risk among senior Indian women compared to Otago exercises alone or walking. This combined exercise approach is recommended for fall prevention in elderly populations.

Keywords: fall risk; balance; Otago Exercise Programme; Tai Chi



1. INTRODUCTION

Ageing is a multifactorial process characterised by the gradual decline in physiological reserves and functional abilities, affecting the body's capacity to respond to metabolic stressors (Dziechciaż & Filip, 2014). One of the most pressing health challenges in the elderly population is falls, which represent a substantial cause of injury and disability, particularly among women. Falls are defined as unintentional events resulting in an individual coming to rest on the ground or lower surface without external provocation (Gamage et al., 2018). They often lead to fractures, loss of independence, and increased mortality rates, prominently due to osteoporotic fractures in the hip, forearm, and pelvis (Berry & Miller, 2008; Johnson, 2023). Globally, more than one-third of individuals aged 65 and above experience at least one fall annually, with women at a 50% higher risk of sustaining fall-related injuries compared to men (Kelsey et al., 2012; McCarthy, 2016). Age-related declines in sensory integration, neuromuscular coordination, and musculoskeletal strength significantly increase fall risk (Gazibara et al., 2017). Additional factors exacerbating fall susceptibility include cognitive impairment, depressive symptoms, and gait abnormalities (Rosen et al., 2013). Exercise interventions focused on strength and balance training are widely recognised as effective strategies for fall prevention (Guirguis-Blake et al., 2018). The Otago Exercise Programme (OEP), developed in New Zealand, incorporates progressive resistance strength training and balance exercises, proven to reduce fall incidence by approximately 35% among community-dwelling older adults (Albornos-Muñoz et al., 2018; Jahanpeyma et al., 2021). Its components include muscle strengthening for lower extremity joints and functional balance tasks such as tandem walking, stair climbing, and standing from a seated position.

Tai Chi (TC), a traditional Chinese martial art emphasising slow, coordinated movements and mental focus, has emerged as a complementary method improving balance, flexibility, and cognitive function among the elderly (Day et al., 2015; Wu et al., 2016). Sun-style Tai Chi, characterised by gentle motions and emphasis on upright posture and weight shifting, is particularly suited for older adults with limited physical capabilities (Choi et al., 2005). Tai Chi has demonstrated benefits in reducing falls, enhancing proprioception, muscle strength, and psychological wellbeing (Lomas-Vega et al., 2017; Penn et al., 2019). Despite evidence supporting the efficacy of both OEP and TC independently, limited research has evaluated their combined effects on fall risk reduction, particularly in the Indian elderly female population. This study aims to explore how integrating Tai Chi into the Otago Exercise Programme influences balance, mobility, and fall-related fears in Indian senior women.

2. METHODS

Study design and ethical consideration

The study utilised a pre- and post-experimental design. The study received ethical approval with reference letter No. DEC/002/23 from the Departmental Ethics Committee, Department of Physiotherapy, Galgotias University. Participants provided informed consent, with assurances of confidentiality and voluntariness. The intervention took place at Gyan Kunj Park, Bank Enclave Park, and Home Peace Association nursing home in Delhi, India. Prior to testing, participants attended an orientation session addressing study procedures and were instructed to avoid strenuous activity 24 hours before assessments.

Participants. A total of 50 elderly women having history of risk of fall were recruited from Gyan Kunj Park, Bank Enclave Park, and Home Peace Association nursing home in Delhi, India using simple random sampling (lottery method) based on predefined selection criteria. The inclusion criteria required participants to be women aged 55 to 70 years. The widely accepted standard defines elderly individuals as those aged 60 or 65 years and older. The World Health Organization (WHO) uses 60 years and above

to designate the elderly population (WHO, 2020; WHO, 2025). Research often categorises elderly age groups into subgroups such as ‘young-old’ (60–74 years), ‘middle-old’ (75–84 years), and ‘old-old’ (85+ years), recognising the varying functional and health profiles within the elderly population (Collerton et al., 2007; Salomon et al., 2012), able to stand and walk independently, capable of understanding exercise and evaluation instructions, and able to perform a chair rise without assistance. Exclusion criteria included the presence of neurological or musculoskeletal disorders affecting mobility, significant sensory impairments, recent lower limb fractures within the past six months, severe dementia, orthostatic hypotension, traumatic brain injury, or epilepsy (Biswas et al., 2022).

Group allocation

All participants were randomly assigned to one of three groups, each with 15 members initially (Figure 1).

A total of 45 elderly women were randomly allocated into one of three groups: the Otago Exercise Programme (OEP) group ($n = 15$), the Tai Chi and Otago Exercise Programme (OEP + TC) group ($n = 15$), and a control group (CG) ($n = 15$). During the study, five participants withdrew from the OEP group due to health concerns ($n = 3$), travel obligations ($n = 1$), and refusal of further follow-up ($n = 1$). In the OEP + TC group, five participants discontinued participation due to refusal of further monitoring ($n = 1$), becoming homebound ($n = 2$), or experiencing a near-fall event ($n = 2$). Additionally, five participants in the control group dropped out due to refusal of further follow-up ($n = 2$) and health concerns ($n = 3$).

Table 1. Descriptive analysis of all three groups (A ($n = 10$), B ($n = 10$), C ($n = 10$))

Variables	Group	Mean $\pm$ SD	F-value	p-value
Age (yrs.)	A	62 $\pm$ 4.59	1.02	0.37
	B	64.40 $\pm$ 3.37		
	C	64.30 $\pm$ 5.05		
Height (cm)	A	154.43 $\pm$ 11.28 *	3.21	0.05
	B	162.30 $\pm$ 5.54		
	C	166.37 $\pm$ 17.52 *		
Weight (kg)	A	78.23 $\pm$ 15.82	1.25	0.3
	B	72.40 $\pm$ 14.05		
	C	81.60 $\pm$ 13.17		
BMI (kg/m ²)	A	32.92 $\pm$ 7.00	2.05	0.14
	B	27.40 $\pm$ 4.79		
	C	30.16 $\pm$ 7.50		

Note: BMI – body mass index; SD – standard deviation; * – $p < 0.05$.

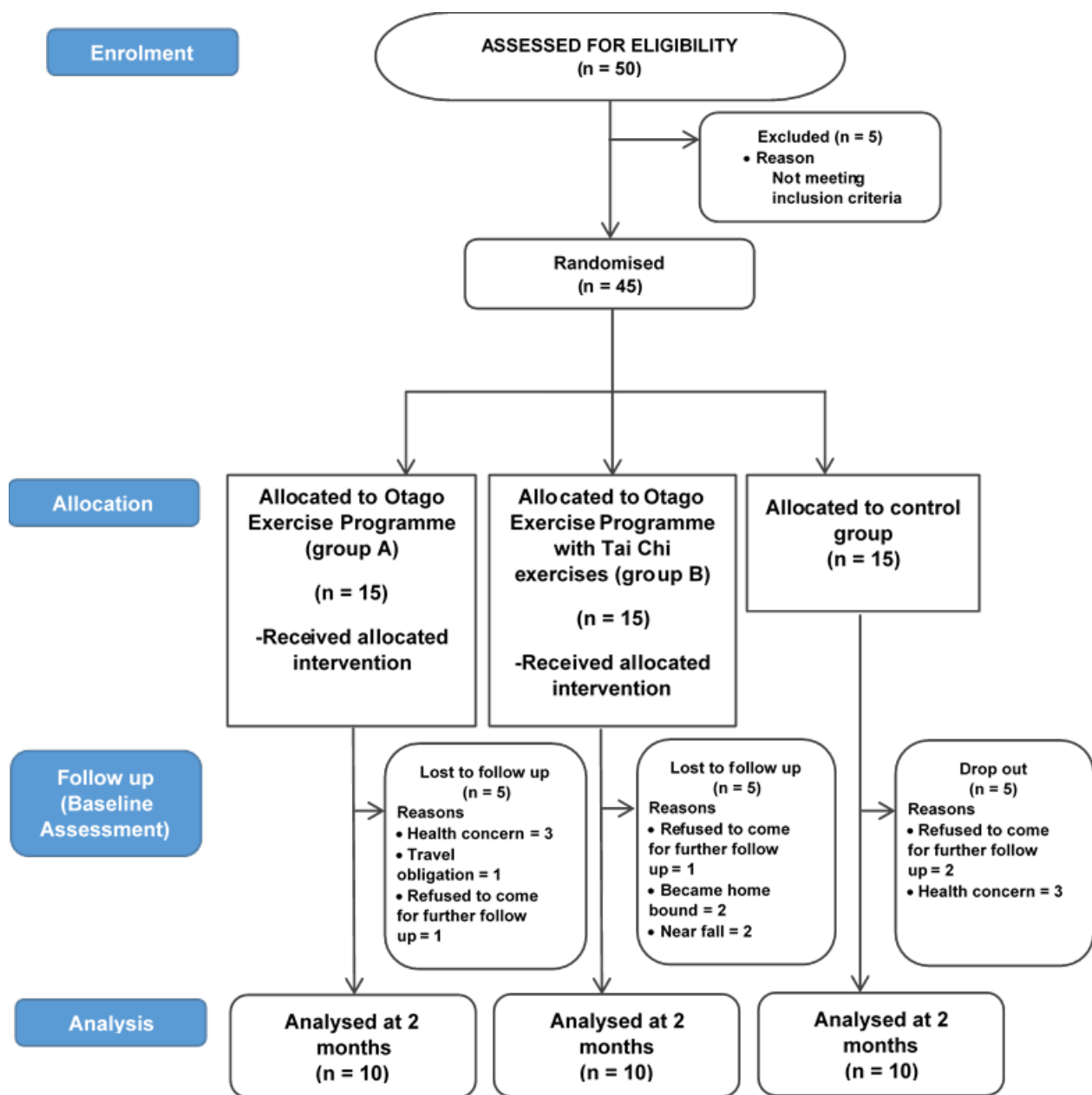


Figure 1. Flow diagram illustrating the recruitment process, randomisation, and allocation of participants

Interventions

Participants in the OEP group (experimental group A) underwent supervised Otago exercise sessions lasting 50 minutes, three times per week. Each session included a brief 5-minute warm-up at the beginning, a 40-minute main exercise component, and a 5-minute cool-down and relaxation segment at the end.

In the OEP and TC group (experimental group B), participants performed Tai Chi exercises three times per week for 30 minutes, followed by 50-minute Otago exercise sessions three times per week. These sessions also included a 5-minute warm-up at the beginning and a 5-minute cool-down at the end. Tai Chi sessions started with a 10-minute preparation phase, followed by 20 minutes of Sun-style Tai Chi movements consisting of 12 exercises, and concluded with a 5-minute recovery phase. During the

preparation phase, participants performed hand movements and gentle exercises for the neck, shoulders, trunk, hips, knees, and ankles.

The control group (group C) participated in walking activities and may have received standard primary care, health education, or lifestyle guidance to minimise placebo effects and ensure ethical standards. Control group participants engaged in walking sessions three times per week, each lasting 30 minutes on flat terrain, individually or in groups. Each session included a 2–3-minute warm-up and cool-down phase. Participants were allowed to divide the walking session into shorter segments (e.g. three 10-minute bouts) and gradually adjust their walking pace according to individual capability.

Otago Exercise Programme (OEP): The OEP is designed to reduce fall risk in the elderly by combining strength and balance training. Exercises include bending and straightening movements targeting the hip, pelvis, knee, ankle, and toe joints. Additional activities such as stair climbing, tandem walking, single-leg raises, heel-to-toe walking, backward walking, and chair rises are incorporated to improve stability and functional balance (Campbell et al., 1997).

Otago Exercise combined with Tai Chi (OEP + TC): Participants in the combined group engaged in supervised sessions three times weekly for two months, led by a physical therapist and a Sun-style Tai Chi instructor. Each session began with the 50-minute OEP, which included 17 stability and endurance exercises and a walking component, followed by a 30-minute Tai Chi session consisting of preparation, movement, and recovery phases as described above. The integrated routine aimed to enhance both balance and mobility through combined strength, coordination, and flexibility training (Ghattas et al., 2024).

Duration of interventions were two months.

Outcome measures

Timed Up and Go test (TUG): The Timed Up and Go (TUG) test was used to assess functional mobility and dynamic balance. Participants began in a seated position in a standard chair. Upon the evaluator's command, each participant stood up, walked a distance of three meters, turned around, returned to the chair, and sat down. The total time from the initial 'go' signal to sitting back was recorded in seconds using a stopwatch. A shorter completion time indicates better mobility and reduced fall risk (Bohannon, 2006).

Berg Balance Scale (BBS): The Berg Balance Scale (BBS) was utilised to measure static and dynamic balance performance through 14 standardised functional tasks (e.g. standing, sitting, reaching, transferring, and turning). Each item is scored on a 5-point scale (0–4), with 0 representing inability to perform and 4 signifying independent, safe completion. The maximum total score is 56, with higher scores denoting better balance. Interpretation thresholds are: 41–56 = low fall risk, 21–40 = medium fall risk, 0–20 = high fall risk. Assessments were performed by trained physiotherapists according to standard BBS procedures, and participants were allowed rest intervals between tasks (Berg et al., 1992).

Falls Efficacy Scale-International (FES-I): The FES-I scale was used to assess fear of falling and self-perceived confidence during daily activities. It includes 16 items (e.g. dressing, bathing, walking, reaching), each rated from 1 = not at all concerned to 4 = very concerned. Total scores range from 16 to 64, with higher scores reflecting greater fear of falling.

Participants completed the FES-I under supervision to ensure comprehension (Yardley & Smith, 2002).

Statistical analysis: Data were analysed using SPSS version 22.0. Reading comprehension was assessed using a paired *t*-test. Visual representations of the data were created using Microsoft Excel 2007. The effects of Tai Chi exercises in combination with the Otago Exercise Programme (OEP) on reducing fall risk in older women were evaluated using paired *t*-tests. Additionally, comparisons among

the three groups – experimental group A (OEP), experimental group B (OEP + TC), and the control group (group C) – were performed using one-way ANOVA.

To evaluate mobility, descriptive statistics including mean and standard deviation were calculated for fall risk, balance, and fear of falling, as measured by the Timed Up and Go (TUG) test, the Berg Balance Scale (BBS), and the Fall Efficacy Scale-International (FES-I). Standard formulas for calculating the mean and standard deviation were applied for all relevant variables.

3. RESULTS

All three interventions produced statistically significant within-group improvements across all outcome measures (TUG, BBS, and FES-I; $p < 0.01$), indicating that each programme – Otago Exercise Programme (OEP), combined Otago and Tai Chi (OEP + TC), and walking – positively influenced functional mobility, balance, and confidence in daily activities among older women (Table 2).

Timed Up and Go (TUG)

Both experimental groups (A and B) showed a marked reduction in TUG time following intervention, reflecting improved mobility and reduced fall risk. The combined OEP + Tai Chi group (B) exhibited the greatest improvement, reducing mean TUG time from 13.93 ± 1.31 s to 11.90 ± 1.02 s, while the OEP-only group (A) improved from 13.31 ± 2.04 s to 11.64 ± 1.71 s. The control group (C) also demonstrated a small but significant reduction ($p = 0.002$).

Between-group analysis ($p = 0.001$) confirmed that both exercise interventions were significantly more effective than walking alone in enhancing functional mobility. These findings support previous evidence that multimodal exercise programmes combining strength, balance, and coordination training are particularly effective in reducing fall risk in older adults.

Berg Balance Scale (BBS)

Significant improvements in BBS scores were observed in all groups ($p < 0.001$), indicating better static and dynamic balance after the interventions. The OEP + Tai Chi group again demonstrated the greatest mean improvement (from 41.60 ± 7.36 to 47.10 ± 6.38), followed by the OEP group (from 32.90 ± 5.02 to 39.40 ± 5.42). The control group improved modestly (from 31.70 ± 5.90 to 36.70 ± 7.07).

Between-group comparison revealed a significant difference ($p = 0.003$), confirming that both exercise interventions produced superior balance outcomes compared with walking alone. The integration of Tai Chi – known for promoting proprioception, postural control, and movement coordination – appears to enhance the effects of the OEP.

Falls Efficacy Scale-International (FES-I)

All three groups demonstrated significant within-group reductions in FES-I scores ($p < 0.001$), suggesting reduced fear of falling and improved self-confidence in daily activities. However, between-group differences were not statistically significant ($p = 0.890$), indicating that all three activities, including simple walking, were similarly effective in improving psychological confidence related to falls.

Table 2. Comparative analysis of outcome measures among the groups (A (n = 10), B (n = 10), C (n = 10))

Outcomes	Group	Mean $\pm$ SD		p within group	p between groups
		Pre	Post		
TUG (s)	A	13.31 $\pm$ 2.04	11.64 $\pm$ 1.71	0.001	0.001*
	B	13.93 $\pm$ 1.31	11.90 $\pm$ 1.02	0.001	
	C	14.49 $\pm$ 1.56	14.10 $\pm$ 1.49	0.002	
BBS (score)	A	32.90 $\pm$ 5.02	39.40 $\pm$ 5.42	0.001	0.003*
	B	41.60 $\pm$ 7.36	47.10 $\pm$ 6.38	0.001	
	C	31.70 $\pm$ 5.90	36.70 $\pm$ 7.07	0.001	
FES-I (score)	A	43.20 $\pm$ 6.46	36.40 $\pm$ 8.34	0.001	0.890
	B	42.80 $\pm$ 5.26	35.10 $\pm$ 5.72	0.001	
	C	42.70 $\pm$ 6.32	36.40 $\pm$ 6.50	0.001	

Notes: TUG – Timed Up and Go test; BBS – Berg Balance Scale; FES-I – Falls Efficacy Scale-International;

* – $p < 0.05$ between groups. Group A (Otago Exercise Programme), Group B (combined Otago Exercise Programme and Tai Chi), and Group C (control walking group).

4. DISCUSSION

The aim of this research was to investigate the effects of combining Tai Chi exercises with the Otago Exercise Programme (OEP and TC) on fall risk reduction, balance, and mobility in elderly women. The results clearly demonstrate that both the combined exercise regimen (OEP and TC) and the Otago Exercise Programme alone are effective in improving balance and mobility, as well as reducing the fear of falling. Notably, the group that received the combined intervention showed significantly greater functional improvements compared to the OEP-only and control groups, which underscores the synergistic benefits of integrating Tai Chi with traditional balance and strength training.

The combined OEP and TC group exhibited the most substantial improvements in the Berg Balance Scale (BBS) scores, which reflects enhanced functional balance. This observed increase is clinically meaningful as balance impairment is a major risk factor for falls among the elderly (Jahanpeyma et al., 2021). Tai Chi's focus on slow, controlled movements involving weight shifting, postural alignment, and proprioceptive feedback training likely contributed to these positive effects. These movements challenge the neuromuscular system to adapt to dynamic postural demands, improving sensory integration and reducing the incidence of balance loss (Choi et al., 2005; Wu et al., 2016).

Simultaneously, the Otago Exercise Programme strengthens lower extremity muscles and incorporates specific balance exercises such as tandem walking and single-leg stance, which are essential for functional stability during everyday activities. The observed improvements in BBS scores in the OEP-only group corroborate previous findings that this programme is effective in enhancing physical performance and reducing fall frequency (Albornos-Muñoz et al., 2018). The control group, which engaged only in walking activities, also improved but to a lesser extent, demonstrating the critical role of targeted strength and balance training rather than simple physical activity in fall prevention.

Mobility enhancements were assessed through the Timed Up and Go (TUG) test, which measures dynamic balance and walking ability. Both intervention groups showed statistically significant reductions in TUG test durations after the intervention period, indicating faster and more stable mobility. Importantly, the TUG times in the combined intervention group decreased to an average of approximately 11.9 seconds, below the 14-second threshold that has been identified as indicative of elevated fall risk

(Bohannon, 2006). This suggests that the combined OEP + TC regimen effectively reduces fall risk by improving mobility to safer functional levels.

The integration of Tai Chi may have fostered improvements in gait parameters such as stride length and postural control during ambulation, as slow and rhythmic Tai Chi steps have been biomechanically associated with enhanced lower limb coordination and reduced fall risk (Liu et al., 2020). The Otago exercises further complement these gains by strengthening the hip flexors, knee extensors, and ankle dorsiflexors involved in gait initiation and stability (Leem et al., 2019). Collectively, these effects resulted in superior functional mobility compared to either intervention or walking alone.

Fear of falling, as measured by the Falls Efficacy Scale-International (FES-I), significantly decreased in both intervention groups, indicating an improved sense of confidence and reduced anxiety during daily activities. This psychological benefit is crucial because fear of falling not only restricts physical activity, leading to muscle deconditioning and increased fall risk, but also negatively affects quality of life (Gazibara et al., 2017). The combined exercise's comprehensive emphasis on balance, strength, and mindful movement likely bolstered participants' self-efficacy, translating into reduced fall-related anxiety.

While the control group also showed reductions in fear of falling, these changes were smaller and likely attributable to increased physical activity and social engagement rather than targeted balance improvements. However, the absence of statistically significant between-group differences in FES-I post-intervention suggests that specialised exercise may not vastly differ from general physical activities in addressing fear. This highlights the complex and multifaceted nature of fall-related psychological factors and indicates that additional cognitive-behavioural interventions might further optimise these outcomes.

The present findings support prior research comparing Tai Chi and Otago Exercise programmes. For instance, Son et al. (2016) demonstrated that both interventions improve balance and fall risk in community-dwelling older women, with Otago exercises having a slightly greater effect on lower limb strength. Another study involving elderly men found both Tai Chi and Otago positively influenced balance and fall risk, with Otago showing superior results in strength and mobility (Dastmanesh et al., 2019). However, our study emphasises the advantage of combining the two: Tai Chi's neuromotor and cognitive engagement complements Otago's progressive strengthening and balance drills. This combined approach not only enhances physical function but also integrates mental focus, coordination, and relaxation, which likely explains the superior results seen.

Mechanistically, Tai Chi's slow, continuous movements improve sensorimotor integration by enhancing proprioception and vestibular function. The incorporation of weight shifting and multiaxial movements recalibrates postural control systems, reducing fall susceptibility (Choi et al., 2005). Otago exercises provide the muscular strength foundation required for functional tasks such as stair climbing, rising from a chair, and ambulation, critical for fall prevention (Jahanpeyma et al., 2021). Furthermore, Tai Chi's inclusion of cognitive elements such as focused attention and mindfulness may contribute to preserved executive function and decreased cognitive decline in the elderly, indirectly supporting motor control and fall prevention (Lam et al., 2012). The synergy of these physiological and psychological benefits likely underlies the observed functional improvements.

This study's outcomes suggest practical applicability in community and clinical settings. The combination of OEP and Tai Chi exercises can be feasibly implemented by physiotherapists and rehabilitation specialists in both group-based and home-based programmes. The minimal resource requirements and adaptability of Tai Chi, combined with the structured progression of OEP, offer scalable fall prevention strategies suitable for diverse populations in India and beyond. The additive benefits also support integrating mind-body components into conventional exercise programmes to holistically address fall

risk. Future protocols might consider incorporating Tai Chi elements into existing OEP regimens to maximise patient benefits.

While this study demonstrates promising findings, several limitations exist. The sample size was modest, and attrition reduced group numbers, potentially limiting the generalisability of results. The intervention duration of eight weeks was relatively short, and longer-term follow-up is needed to assess sustainability of improvements and actual fall incidence reduction. Future research should explore larger, multicentre trials with extended follow-up periods, inclusion of neuropsychological evaluations, and cost-effectiveness analyses. Moreover, investigations into optimal dosage, intensity, and instructor qualifications for Tai Chi and Otago programmes will enhance clinical translation.

5. CONCLUSIONS AND PERSPECTIVES

The combination of Tai Chi and the Otago Exercise Programme significantly improves balance, mobility, and reduces fall risk in senior Indian women more effectively than Otago exercises or walking alone. This exercise strategy holds promise for fall prevention programmes in clinical and community eldercare settings.

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Otago pratimų programos ir taiči poveikis senyvo amžiaus žmonių griuvimo rizikos mažinimui

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Santrauka

Tyrimo pagrindimas. Griuvimai yra dažna ir rimta problema vyresnio amžiaus žmonėms, ypač moterims, dėl kurios sumažėja jų savarankiškumas, atsiranda pusiausvyros sutrikimų ir padidėja mirtingumas. Įrodyta, kad Otago pratimų programa (OPP) ir taiči individualiai veiksmingi mažinant griuvimo riziką, gerinant pusiausvyrą, jėgą ir judumą.

Tikslas. Įvertinti Otago pratimų programos ir taiči bendrą poveikį vyresnio amžiaus indžių griuvimo rizikai, pusiausvyrai ir judumui.

Metodai. Buvo atliktas tyrimas su išankstiniu ir pakartotiniu vertinimu, kuriame dalyvavo 30 moterų (amžius 55–70 metų), atsitiktine tvarka suskirstytų į tris lygias grupes: tik Otago pratimų programa (50 min./pratybas, tris kartus per savaitę), taiči ir Otago pratimų programa (50 min. OPP ir 30 min. taiči, tris kartus per savaitę), kontrolinė grupė (30 min. ėjimas, tris kartus per savaitę). Rezultatai buvo vertinami naudojant „Stotis ir eiti“ testą, Bergo pusiausvyros skalę ir tarptautinę griuvimų efektyvumo skalę FES-I griuvimo baimei įvertinti. Analizuojant duomenis naudotas porinis *t* testas skirtumams grupėse nustatyti ir vienfaktorinė dispersinė analizė (ANOVA) skirtumams tarp grupių įvertinti.

Rezultatai. Po intervencijos, nustatyti reikšmingi „Stotis ir eiti“ testo, Bergo pusiausvyros skalės ir tarptautinės griuvimų efektyvumo skalės FES-I balų pagerėjimai tiek Otago pratimų programos, tiek Otago pratimų programos ir taiči grupėse ($p < 0,001$). Otago pratimų programos ir taiči grupėje, palyginti su kitomis grupėmis, nustatytas didžiausias pusiausvyros ir judumo pagerėjimas. Intervencijos grupėse žymiai sumažėjo baimė nugriūti. Vienfaktorinė dispersinė analizė parodė statistiškai reikšmingus skirtumus tarp grupių, ypač palankius Otago pratimų programos ir taiči grupės „Stotis ir eiti“ testo ir Bergo pusiausvyros skalės rezultatams ($p < 0,05$).

Išvados. Otago pratimų programos ir taiči derinimas užtikrina geresnius pusiausvyros, judumo ir griuvimo rizikos sumažinimo rezultatus tarp vyresnio amžiaus indžių, palyginti su vien Otago pratimais ar ėjimu. Ši kompleksinė programa rekomenduojama siekiant išvengti griuvimų tarp vyresnio amžiaus žmonių.

Reikšminiai žodžiai: griuvimo rizika; pusiausvyra; Otago pratimų programa; taiči

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