JGG 2023;71:47-60
doi: 10.36150/2499-6564-N540

A randomized controlled trial on impact of group exercise programme on fall risk, balance, strength, fear of fall and quality of life of older adults

Nupoor Kulkarni[1], Elias Tsepis[2], Vaishali Phalke[3], Swanand Tilekar[4], Kalliopi Pouliasi[5], Marina Theodoritsi[6], Aashirwad Mahajan[1]

[1] APJ Abdul Kalam College of Physiotherapy, Pravara Institute of Medical Sciences-Deemed To Be University, Loni, Maharashtra, India; [2] Department of Physiotherapy, School of Health Rehabilitation Sciences, University of Patras, Greece; [3] Rural Medical College, Pravara Institute of Medical Sciences-Deemed To Be University, Loni, Maharashtra, India; [4] Centre for Social medicine, Pravara Institute of Medical Sciences-Deemed To Be University, Loni, Maharashtra, India; [5] Physiotherapist at Athens Naval Hospital, Greece; [6] Physiotherapist, Laboratory of Special Professional Education and Training, Zakynthos, Greece

Received: May 24, 2022
Published: December 19, 2022

Correspondence
Nupoor Kulkarni
APJ Abdul Kalam College of Physiotherapy, Pravara institute of medical sciences-deemed to be university, Loni, 413736, Maharashtra, India.
E-mail: nupoor.kulkarni22@gmail.com

How to cite this article: Kulkarni N, Tsepis E, Phalke V, et al. A randomized controlled trial on impact of group exercise programme on fall risk, balance, strength, fear of fall and quality of life of older adults. Journal of Gerontology and Geriatrics 2023;71:47-60. https://doi.org/10.36150/2499-6564-N540

Introduction. A parallel group Randomized Controlled Trial was aimed to determine the impact of a group exercise programme on fall risk and its modifiable risk factors in older adults.
Methods. 86 older adults having increased fall risk were assigned to group exercise programme or individualized exercise programme. Intervention consisted of warm up, balance retraining exercises and cool-down and lower limb strengthening exercises derived from Otago Exercise Programme (OEP) forming the core program for 2 times in a week for the period of 10 weeks. Demographic data, Timed Up and Go test, 5-times sit to stand test, sway index and dynamic postural stability,fear of fall and physical and mental components of Quality of Life were assessed before and after 10 weeks and after 6 months of intervention.
Results. A significant intra-group effect was demonstrated for both groups at post-intervention in all the outcomes, ($p < 0.005$). No differences were observed between groups for any outcome ($p > 0.005$) except SF 12 score which was improved more in experimental group($p > 0.005$).
Conclusions. Group exercise program was effective in reducing fall risk and fear of fall, improving balance and lower extremity strength and enhancing the quality of life of older adults.

Key words: fall, balance, strength, geriatrics

INTRODUCTION

Aging is generally associated with progressive decline in functional status and psychological health, as well as increased risk of co-morbidities [1]. These health-related impairments are primarily responsible for falls, which represent one of the most common and serious public health problems for older adults [2].
Falls are a significant contributor to hospital admissions in older adults [3]. Approximately 30% of generally healthy adults over the age of 60 years experience a fall every year, and roughly half of them have recurring falls [4]. The consequences of falls can range from minor injuries, such as soft tissue

injuries, sprains, and strains to fractures and sometimes even death [5]. Falls may affect the confidence level of an individual leading to functional decline, dependency, and reduced quality of life [6]. WHO defines Quality of Life as an individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns [7].

The fall risk factors in older adults consist of intrinsic factors, such as physiological changes of aging, frailty, pathological changes, and extrinsic factors including environmental and situational factors [8]. Previous study demonstrated that impaired balance and decreased lower extremity strength are important and modifiable risk factors for the loss of physical function and falls in older adults. Maintaining balance requires complex interactions between peripheral and central factors, such as vision, somato-sensation, vestibular sensation, motor output, and musculature. These factors decline with advancing age, further decreasing strength and balance [9,10]. Along with a loss of balance, increased fall risk is associated with aging because decreased muscle mass leads to atrophy, which, in turn, decreases muscle function [11,12]. Age-related deterioration in balance negatively impacts daily activities and is a major cause of falls [13].

Among behavioral risk factors, alcohol use, sleep disorders,some medications, fear of falling due to previous fall history, and poor footwear often contribute to falls [14,15]. Fear of falling is defined as a lasting concern about falling that can lead an individual to avoid activities in spite of being capable of performing [16]. Therefore psychological consequences of falls can lead to de-conditioning,increased risk of falling, limiting social interaction, isolation, further leading to anxiety and depression [17].

Environmental factors also contribute to the risk of falls in older adults. Many of the households of older adults contain a variety of environmental hazards which are some of the causes of falls among older adults [18].

The economic consequences of falls are a major problem for older adults, their caregivers, and the society which include potential healthcare costs, such as medical treatment, rehabilitation, and home modification after falls [19]. Therefore, savings in healthcare costs can be expected if falls are reduced. From a public health perspective, it is also important to assess the effectiveness of interventions to determine if they are cost effective, sustainable, and acceptable to older adults in the long term [20].

Researchers stated that therapeutic exercise maximizes stability in older adults through balance and mobility improvement, thus reducing fall risk [21]. Effective interventions contain balance training, supervised strength and endurance training, Tai Chi and home exercise prescribed by a physiotherapist. Supervised general group exercise has also been found to be effective in reducing the risk of falls in older adults [22]. The Otago Exercise Programme (OEP) is a well-designed, thoroughly tested fall prevention programme that targets strength and balance deficits and can lead to a reduction in falls by approximately one-third [19]. However, it is not known whether implementing the programme in a group setting will be effective in reducing falls and subsequent injuries by achieving the required outcomes.

Various reasons were proposed for implementing group exercising, including creating a sense of responsibility for exercise among the participants, and having a positive effect on psychological function [23]. However, few studies have been conducted to determine the effectiveness of group exercise targeted to older adults in preventing falls [24]. Although many studies have been conducted in the area of fall prevention, reevaluations of those strategies in different modes are warranted. Therefore, this study was conducted to determine the impact of a group exercise programme on fall risk and its modifiable risk factors in older adults.

MATERIALS AND METHODS

The present study received approval from the Institutional Ethics Committee of the Pravara Institute of Medical Sciences [DU], Loni, Taluka Rahata, Ahmednagar, Maharashtra, India 413736 (PMT/PIMS/IEC/2014/161). The study was a parallel group, randomized, controlled trial (Reg.no: CTRI/2016/06/007014). This study was conducted in Technological Educational Institute of Western Greece under Erasmus Mundus Action 2, Lot 13, 1st cohort of Euphrates Scholarship programme of European Union which was awarded to principal investigator (Project no. 2013-2540/001-001).

We approached older adults visiting the Open Day Care Centers for the Elderly (KAPI in Greek) and asked them if they were concerned about their balance. Then, they were screened for eligibility based on the criteria. i.e. older adults of both genders who were over 60 years of age, had fall risk (TUG score > 12 seconds), fear of falling (FES score > 19), were not involved in a regular exercise program, and who volunteered to participate were included in the study. We excluded older adults with a history of traumatic falls in past year, those with uncontrolled cardiovascular disease, cognitive impairments, physical deterioration due to the severity of associated comorbidities, neurological disorders, and severe depression, along with those who were undergoing palliative care, had an amputation, and had a prosthetic limb.

Procedure

Individuals were briefed about the study through an informative lecture and a detailed information sheet. Afterwards, written informed consent was obtained from each participant. The demographic data and baseline assessments were performed. The experimental group consisted of 47 older adults who participated in a group exercise program supervised by a physiotherapist, with assistance of another physiotherapist to ensure the safety of the participants and the accuracy of the intervention protocol. Each group consisted of six participants.

In the control group, 47 older adults received individualized exercise program, under the supervision of the physiotherapist. Both groups performed the intervention 2 times in a week for 10 weeks. The duration of each session was initially 30 minutes, then progressed to 60 minutes. The intervention for both groups included warm up, lower limb strengthening with resistance bands, balance retraining, and cool down. Warm up consisted of spot marching for 30 seconds progressing to 1 minute and mild stretching of the large muscle groups. Each stretch was held for 8-10 seconds. Lower limb strengthening exercises were performed using elastic resistance bands varying from low resistance to high resistance. The lower limb strengthening exercises and balance retraining exercises that were performed by both intervention groups were derived from the Otago exercise program. However, in our study, the strengthening exercises were performed with the resistance bands of different colors. The intensity of the exercise was based on the Borg Rating of Perceived Exertion (RPE), which was defined by level of difficulty and fatigue, with the number of repetitions starting from 12-13 RPE (somewhat hard) and progressing to 14-16 RPE (hard) with 10-15 repetitions (moderate resistance until muscle fatigue) and then 8-12 (high resistance until muscle fatigue). The resistance was increased by adding difficulty level by using bands with a different color or by increasing the number of sets that were performed. The program began with 1 set and progressed to 2-3 sets of exercises, with 2 minutes of rest between sets. Target muscle groups were hip extensors and abductors, knee flexors and extensors, quadriceps, ankle plantar, and dorsiflexors [19].

Balance retraining exercises consisted of sit-to-stand and knee squats, starting with 10 repetitions with support and progressing to 3 sets of 10 repetitions without support. The exercises included tandem stance and single limb standing with support and eyes open. Then, the exercises progressed to tandem standing and tandem walking with eyes closed for 10 seconds without support. Walking backwards, sideways walking, walking, and turning around 10 steps was performed 4 times by the participants with support and without support. The difficulty level was increased by minimizing the support. The cool down included mildly stretching the large muscles groups, where each stretch was held for 12-20 seconds [19].

Randomization and allocation

The sample size for the present study was 86 which was estimated with open epi software. The randomization of the participants for the two groups was undertaken using permuted block randomization method. A blind investigator generated the sequence using computer generated blocks in software and prepared sealed envelopes, which were opaque for confidentiality. Participants were randomly assigned to intervention groups with a block size of six. The allocation ratio was 1:1 (intervention group: control group).

Blinding

Investigators who performed baseline and post intervention assessment and the statistician who analyzed the data were blinded to the intervention group allocation.

Outcome measures

Timed Up and Go test

This test was used to assess fall risk and functional performance of the participants. The TUG is a timed performance of getting up from a chair, walking 3 m, turning around, and walking back to sit down again The cutoff point was 12 seconds based on the findings from previous study [25]. It has a high retest reliability in healthy older patients (ICC = 0.92) and high inter- and intrarater reliabilities (ICC = 0.99 for both) [26].

The Falls Efficacy Scale International (FES-I) Greek version

This is a self-report questionnaire, developed and validated by the Prevention of Falls Network Europe (ProFaNE). This provides information on level of concern regarding falls for a range of daily living activities. FES-I scores range from 16 to 64. Scores of 16-19, 20-27, and 28-64 indicate low, medium, and high levels of concern about falling, respectively. The FES-I test has excellent reliability and validity across different cultures and languages.(Cronbach's alpha = 0.96; ICC = 0.96) [27,28].

Five Times sit to stand test (FTSTST)

The Five Times Sit to Stand Test (FTSTST)is used to assess lower limb strength, balance ability, and fall risk. During this test, the participants are instructed to stand up and sit down on a straight-backed firm chair with no armrests as quickly as possible five times with the arms folded. Scoring is based on the number of seconds needed to complete the test [29].

Short Form 12 (SF-12)

The Short Form 12 (SF-12) was used to examine the quality of life (QoL) of the participants and uses 12 questions to measure functional health and wellbeing from the participant's perspective. The score was given in the form of a Physical Composite Score (PCS) and a Mental Composite Score (MCS) [30].

Modified Clinical Test of Sensory Integration of Balance (m-CTSIB)

Is a standardized test for balance assessment. The Sway Index is an objective quantification of postural sway, which is assessed by the m-CTSIB using the Biodex Balance System$_{SD}$®, which identifies mild to severe balance problems with the three associated sensory systems. This test provides a more accurate and objective assessment tool for evaluating postural stability. During the test, participants who are more unsteady have higher Sway Index scores [31].

Limits of Stability (LOS)

Dynamic control using the stability index was assessed by the Limits of stability [LOS] test on Biodex Balance System$_{SD}$® within a normalized sway envelope, which challenges participants to move and control their center of gravity within their base of support [31].

RESULTS

All data were analyzed using the Statistical Package for the Social Sciences (SPSS, version 20.0; IBM Corporation, Armonk, NY, USA). All variables were presented as means and standard deviations. A Repeated Measures Analysis of variance (ANOVA) tests with repeated measures were conducted to determine the impact of the group and individualized exercise programs on fall risk, fear of falling, sway index, limits of stability, and lower limb strength, along with quality of life measures, such as mental and physical components. Group (i.e., experimental versus control) was used as the between-subjects factor, and time of measurement (baseline versus 10 weeks versus 6 months) as a within-subjects factor. *F*-statistic, eta-squared (η^2), and *p*-values were reported. The alpha level was adjusted to 0.05 to control for Type I errors using the Bonferroni method. If an interaction was significant, a Repeated Measures ANOVA test was performed for the time factor. A conservative *p*-value cutoff of 0.01 was used to determine statistical significance for the Repeated Measures ANOVA tests. Based on the data of the participants in the study, Experimental Group A consisted of 2 (4.4%) males and 45 (95.7%) females, while control group B consisted of 10 (21.2%) males and 37 (82.2%) females. The above distribution suggests female predominance in these groups (Tabs. I-II).

Repeated measures ANOVA: FES-I

To investigate the temporal relationships of the group scores with the follow-up, contrasts were investigated, comparing all time points against the initial score (baseline) (Tabs. III-IV)

Repeated measures ANOVA: TUG

(Tabs. V,VI)

Repeated measures ANOVA: Five Times Sit to Stand Test (5TSTST)

(Tabs. VII,VIII)

Repeated measures ANOVA: modified Clinical Test of Sensory Integration of m-CTSIB

(Tabs. IX,X)

Repeated measures ANOVA: Limits of Stability (LOS)

(Tabs. XI,XII)

Repeated measures ANOVA: Physical Component Summary (PCS)

(Tabs. XIII,XIV)

Repeated measures ANOVA: Mental Component Summary (MCS)

(Tabs. XV,XVI)

DISCUSSION

This study evaluated the impact of a group exercise program, as compared to individualized interventions,

Table I. Demographic data of participants.

	Group			Total (n = 94)
Variables	Experimental (n = 47)	Control (n = 47)	F/χ2	
	Mean ± SD	Mean ± SD		Mean ± SD
Age	69.02 ± 5.15	71.11 ± 4.16	4.66 $_{(1, 93)}$ *	70.06 ± 4.77
BMI	23.88 ± 1.91	25.26 ± 1.62	14.16 $_{(1, 93)}$ **	24.57 ± 1.89

* p< 0.05 ** p< 0.01

Table II. RM-ANOVA Tests of Within – subject effects showing changes in variables.

Variable	Group	Mean SD			Significance				
		Pre	Post	Follow-up	Time	Group X Time	Time X Age	Time X Gender	Time X BMI
TUG	EG	13.69 ± 1.12	8.44 ± 1.84	9.67 ± 2.04	0.000	0.13	0.02	0.81	0.31
	CG	13.47 ± 1.6	9.15 ± 1.9	10.45 ± 2.0					
5TSTST	EG	21.11 ± 4.8	12.08 ± 3.66	13.08 ± 4.16	0.54	0.08	0.68	0.54	0.9
	CG	19.64 ± 4.36	12.54 ± 3.87	14.1 ± 3.82					
FES	EG	30.08 ± 8.3	21.2 ± 5.6	20.3 ± 4.02	0.9	0.01	0.24	0.09	0.68
	CG	29.4 ± 8.8	21 ± 4.9	23.3 ± 5.72					
m-CTSIB	EG	1.76 ± 0.43	1.35 ± 0.37	1.56 ± 0.38	0.39	0.54	0.95	0.82	0.58
	CG	2.0 ± 0.56	1.41 ± 0.48	1.68 ± 0.48					
LOS	EG	40.9 ± 12.2	53.7 ± 14.1	47 ± 12.6	0.2	0.09	0.24	0.46	0.98
	CG	38.8 ± 11.4	57.6 ± 13.5	49.8 ± 12.8					
PCS	EG	44.1 ± 6.31	50.1 ± 5.75	±	0.78	0.00	0.62	0.63	0.77
	CG	47.5 ± 6.96	48.9 ± 6.4	±					
MCS	EG	50.4 ± 5.89	54.9 ± 5.22	52.45 ± 5.43	0.49	0.00	0.37	0.2	0.01
	CG	47.2 ± 7.84	49.8 ± 8.71	48.6 ± 8.39					

Table III. Simple main effect: Pair wise comparisons: groups – FES.

Time	(I) Group_N	(J) Group_N	Mean difference (I-J)	Std. Error	Sig. [a]	95% Confidence interval for difference [a]	
						Lower bound	Upper bound
1	Experimental	Control	1.79	2.17	.414	-2.55	6.12
	Control	Experimental	-1.79	2.17	.414	-6.12	2.55
2	Experimental	Control	0.58	1.37	.675	-2.17	3.32
	Control	Experimental	-0.58	1.37	.675	-3.32	2.17
3	Experimental	Contro	-2.40	1.21	.051	-4.82	0.01
	Control	Experimental	2.40	1.21	.051	-0.01	4.82

on fall risk and it's modifiable risk factors for fall in older individuals and increasing participation in the exercises. Fear of falling is considered to be a strong predictor of falls for older adults [16], In our study, the fear of falling and fall risk appeared to be common in participants with an average age of 70.06 ± 4.77 years. The results of the study showed that within each group, the baseline FES scores showed a statistically significant difference from both short-term (10 weeks) post-intervention scores and long-term (6 months) post-intervention scores ($p < 0.005$). A comparison of the short-term and the long-term post-intervention FES scores within the experimental group showed no statistically significant difference ($p = 0.21$), stating that the effect declined in long-term follow up, whereas these FES scores for the control group showed a statistically significant difference ($p < 0.005$). On the other hand, between group comparison showed no statistically significant difference in the FES scores between the experimental group and the control group post intervention ($p = 0.67$) and in long term follow up ($p = 0.51$).These results were consistent with findings reported by Gusi et al. (2012) who studied a 12-week dynamic balance training program in a geriatric setting and achieved a 3% decrease in the fear of falling, as measured by the Falls Efficacy Scale International questionnaire [32]. The study also stated that the intervention was feasible and effective in reducing the fear of falling and improving dynamic balance and isometric strength [32]. Similarly, other studies that evaluated the effects of various exercise programs on the fear of falling in older adults support these results. FOF is associated with intrinsic properties, such as physical strength and balance. Therefore, improvements in strength and balance may lead to a reduction in FOF, improvements in functional status, and the prevention of deconditioning, which may ultimately reduce fall risk [33].

Fall risk and functional status of older adults was assessed with Timed Up and Go test. No statistically significant difference was present between the groups when comparing their respective short-term

Table IV. Simple main effect: Pairwise comparisons: time – FES.

Group	(I) Time	(J) Time	Mean difference (I-J)	Std. Error	Sig.[b]	95% Confidence interval for difference[b]	
						Lower bound	Upper bound
Experimental	1	2	9.60*	.91	.000	7.38	11.82
		3	10.44*	.93	.000	8.16	12.72
	2	1	-9.60*	.91	.000	-11.82	-7.38
		3	.842	.46	.210	-.28	1.97
	3	1	-10.44*	.93	.000	-12.72	-8.16
		2	-.84	.46	.210	-1.97	.28
Control	1	2	8.39*	1.04	.000	5.84	10.94
		3	6.25*	1.07	.000	3.64	8.86
	2	1	-8.39*	1.04	.000	-10.94	-5.84
		3	-2.14*	.52	.000	-3.43	-.85
	3	1	-6.25*	1.07	.000	-8.86	-3.64
		2	2.14*	.52	.000	.85	3.43

Table V. Simple main effect: Pairwise comparisons of groups – TUG.

Time	(I) Group_N	(J) Group_N	Mean difference (I-J)	Std. Error	Sig.[a]	95% confidence interval for difference [a]	
						Lower bound	Upper bound
1	Experimental	Control	.516	.332	.125	-.146	1.179
	Control	Experimental	-.516	.332	.125	-1.179	.146
2	Experimental	Control	-.044	.443	.922	-.928	.840
	Control	Experimental	.044	.443	.922	-.840	.928
3	Experimental	Control	-.092	.464	.844	-1.018	.835
	Control	Experimental	.092	.464	.844	-.835	1.018

Table VI. Simple main eEffect: Pairwise comparisons of time – TUG.

Group			Mean difference (I-J)	Std. Error lower bound	Sig. [b] upper bound	95% Confidence interval for difference [b]	
Experimental	1	2	5.03*	0.22	.000	4.49	5.58
		3	3.80*	0.23	.000	3.24	4.36
	2	1	-5.03	0.22	.000	-5.58	-4.49
		3	-1.24	0.17	.000	-1.65	-0.83
	3	1	-3.8	0.23	.000	-4.36	-3.24
		2	1.24*	0.17	.000	0.83	1.65
Control	1	2	4.47*	0.26	.000	3.85	5.10
		3	3.19*	0.26	.000	2.55	3.83
	2	1	-4.47	0.26	.000	-5.10	-3.85
		3	-1.29	0.19	.000	-1.75	-0.82
	3	1	-3.19	0.26	.000	-3.83	-2.55
		2	1.29*	0.19	.000	0.82	1.75

Table VII. Simple main effect: Pairwise comparisons: groups – 5TSTS.

Time	(I) Group_N	(J) Group_N	Mean difference (I-J)	Std. Error	Sig. [a]	95% Confidence interval for difference [a]	
						Lower bound	Upper bound
1	Experimental	Control	2.346*	1.137	.043	.077	4.615*
	Control	Experimental	-2.346*	1.137	.043	-4.615	-.077*
2	Experimental	Control	.414	.924	.656	-1.430	2.257
	Control	Experimental	-.414	.924	.656	-2.257	1.430
3	Experimental	Control	.717	.981	.468	-1.241	2.674
	Control	Experimental	-.717	.981	.468	-2.674	1.241

Table VIII. Simple main effects: pairwise comparison of time-5TSTST.

Group	Time (I)	Time (J)	Mean difference (I-J)	Std. Error	Sig. [b]	95% Confidence interval for difference [b]	
						Lower Bound	Upper Bound
Experimental	1	2	9.030*	.647	.000	7.442	10.618*
		3	7.205*	.621	.000	5.680	8.730*
	2	1	-9.030*	.647	.000	-10.618	-7.442*
		3	-1.825*	.303	.000	-2.569	-1.082*
	3	1	-7.205*	.621	.000	-8.730	-5.680*
		2	1.825*	.303	.000	1.082	2.569*
Control	1	2	7.097*	.742	.000	5.277	8.918*
		3	5.575*	.712	.000	3.827	7.323*
	2	1	-7.097*	.742	.000	-8.918	-5.277*
		3	-1.522*	.347	.000	-2.374	-.670*
	3	1	-5.575*	.712	.000	-7.323	-3.827*
		2	1.522*	.347	.000	.670	2.374*

Table IX. Simple main effects pairwise comparison of groups-m-CTSIB.

Time	(I) Group_N	(J) Group_N	Mean difference (I-J)	Std. Error	Sig. [a]	95% Confidence interval for difference [a]	
						Lower bound	Upper bound
1	Experimental	Control	-.195	.125	.124	-.444	.055
	Control	Experimental	.195	.125	.124	-.055	.444
2	Experimental	Control	.023	.105	.830	-.187	.233
	Control	Experimental	-.023	.105	.830	-.233	.187
3	Experimental	Control	-.054	.107	.617	-.266	.159
	Control	Experimental	.054	.107	.617	-.159	.266

post-intervention scores ($p = 0.922$) and their long-term post-intervention scores ($p = 0.844$). However, within each group, the scores showed statistically significant differences when comparing the baseline scores to the short-term and long-term scores ($p < 0.005$). These results suggest that the supervised group exercise program and the individualized exercise program had a positive impact on reducing fall risk. However, based on the analysis, there was no statistically significant difference between the groups. This result was attributed to improvements in the balance and strength of the participants, which are strong factors related to fall risk in older adults. These results are also supported by findings from a study by Zhuang J. et al. (2014), which evaluated the effectiveness of a 12-week, balance exercises, strength training, Tai-Chi, and flexibility/stretching exercises for older Chinese community-dwellers. And suggested that there was significant improvement in mobility and balance, which was required to perform basic daily living activities [34].

Table X. Simple main effects pairwise comparison of time: m-CTSIB.

Group	Time(I)	Time(J)	Mean difference (I-J)	Std. Error	Sig.[b]	95% Confidence interval for difference[b]	
						Lower bound	Upper bound
Experimental	1	2	.402*	.069	.000	.233	.571*
		3	.198*	.044	.000	.090	.305*
	2	1	-.402*	.069	.000	-.571	-.233*
		3	-.204*	.045	.000	-.315	-.093*
	3	1	-.198*	.044	.000	-.305	-.090*
		2	.204*	.045	.000	.093	.315*
Control	1	2	.619*	.079	.000	.426	.813*
		3	.339*	.050	.000	.216	.462*
	2	1	-.619*	.079	.000	-.813	-.426*
		3	-.280*	.052	.000	-.408	-.153*
	3	1	-.339*	.050	.000	-.462	-.216*
		2	.280*	.052	.000	.153	.408*

Table XI. Simple main effects pairwise comparison of groups -LOS.

	Time	(I) Group	(J) Group_N	Mean difference (I-J)	Std. Error	Sig.[a]	95% Confidence interval for difference [a]	
							Lower bound	Upper bound
LOS	1	Experimental	Control	1.45	3.11	.644	-4.77	7.66
		Control	Experimental	-1.45	3.11	.644	-7.66	4.77
	2	Experimental	Control	-4.49	3.70	.229	-11.87	2.89
		Control	Experimental	4.49	3.70	.229	-2.89	11.87
	3	Experimental	Control	-3.60	3.37	.290	-10.33	3.13
		Control	Experimental	3.60	3.37	.290	-3.13	10.33

Table XII. Simple main effects: Pairwise comparisons: time – LOS.

Group	(I) Time	(J) Time	Mean difference (I-J)	Std. Error	Sig.[b]	95% Confidence interval for difference [b]	
						Lower bound	Upper bound
Experimental	1	2	-12.84 *	1.49	.000	-16.49	-9.18
		3	-6.01 *	1.12	.000	-8.75	-3.27
	2	1	12.84 *	1.49	.000	9.18	16.49
		3	6.83 *	1.13	.000	4.05	9.60
	3	1	6.01 *	1.12	.000	3.27	8.75
		2	-6.83 *	1.13	.000	-9.60	-4.05
Control	1	2	-18.77 *	1.71	.000	-22.97	-14.58
		3	-11.05 *	1.28	.000	-14.20	-7.91
	2	1	18.77 *	1.71	.000	14.58	22.97
		3	7.72 *	1.30	.000	4.54	10.91
	3	1	11.05 *	1.28	.000	7.91	14.20
		2	-7.72 *	1.30	.000	-10.91	-4.54

Similar results were obtained in a study by Maritz et al. (2013), which evaluated the impact of a 10-week, moderate intensity, group-based exercise program focusing on strength, condition, and balance training on the lower extremity muscle strength and the functional mobility of healthy elderly individuals. The results suggested that the exercise intervention had a positive effect on lower extremity strength and functional mobility,

Table XIII. Simple main effects: Pairwise comparisons: group: PCS.

Time	(I) Group	(J) Group_N	Mean difference (I-J)	Std. Error	Sig.[a]	95% Confidence interval for difference [a]	
						Lower bound	Upper bound
1	Experimental	Control	-1.85	1.78	0.30	-5.40	1.69
	Control	Experimental	1.85	1.78	0.30	-1.69	5.40
2	Experimental	Control	2.16	1.68	0.20	-1.20	5.51
	Control	Experimental	-2.16	1.68	0.20	-5.51	1.20
3	Experimental	Control	0.24	1.71	0.89	-3.18	3.65
	Control	Experimental	-0.24	1.71	0.89	-3.65	3.18

Table XIV. Simple main effects: Pairwise comparisons: time-PCS.

Group	(I) Time	(J) Time	Mean difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for difference [b]	
						Lower bound	Upper bound
Experimental	1	2	-6.00 *	0.38	0.00	-6.95	-5.06
		3	-3.01 *	0.27	0.00	-3.68	-2.33
	2	1	6.00 *	0.38	0.00	5.06	6.95
		3	3.00 *	0.28	0.00	2.31	3.69
	3	1	3.01 *	0.27	0.00	2.33	3.68
		2	-3.00 *	0.28	0.00	-3.69	-2.31
Control	1	2	-1.99 *	0.44	0.00	-3.08	-0.91
		3	-0.91 *	0.32	0.02	-1.69	-0.14
	2	1	1.99 *	0.44	0.00	0.91	3.08
		3	1.08 *	0.32	0.00	0.29	1.87
	3	1	0.91 *	0.32	0.02	0.14	1.69
		2	-1.08 *	0.32	0.00	-1.87	-0.29

Table XV. Simple main effects: Pairwise comparisons: groups – MCS.

Time	(I) Group	(J) Group_N	Mean difference (I-J)	Std. Error	Sig. [a]	95% Confidence interval for difference [a]	
						Lower bound	Upper bound
1	Experimental	Control	2.05	1.79	0.26	-1.52	5.61
	Control	Experimental	-2.05	1.79	0.26	-5.61	1.52
2	Experimental	Control	4.78 *	1.84	0.01	1.12	8.45
	Control	Experimental	-4.78 *	1.84	0.01	-8.45	-1.12
3	Experimental	Control	3.28	1.82	0.08	-0.35	6.92
	Control	Experimental	-3.28	1.82	0.08	-6.92	0.35

also reduced the fall risk among community-dwelling adults [35]. These results have been ascribed to the relationship between the fear of falling and the balance during functional tasks. A previous study indicated that older adults with impaired balance have a fear of falling due to these balance limitations. Hence, improvements in balance may reduce the fear of falling [36].

Similarly, a study done by Robertson et al. (2001) stated that Otago Exercise Program (OEP) can improve functional capacity, which is a good predictor for balance, and can increase physical performance [19]. Another study, conducted by Lindy Clemson et al. (2012) on a structured Lifestyle integrated Functional Exercise (LiFE) program, consisting of balance and lower limb strength training into daily routines led to improved static and dynamic balance, thus highlighted the importance of balance exercises in mitigating fall risk. Also showed steady improvements in their functional activities, and variable gains for knee and hip strength [37].

Studies have confirmed that impaired balance is a

Table XVI. Simple main eEffects: Pairwise comparisons: time – MCS.

Group	(I) Time	(J) Time	Mean difference (I-J)	Std. Error	Sig. [b]	95% Confidence interval for difference [b]	
						Lower bound	Upper bound
Experimental	1	2	-4.91 *	0.45	0.00	-6.01	-3.80
		3	-2.32 *	0.36	0.00	-3.21	-1.43
	2	1	4.91 *	0.45	0.00	3.80	6.01
		3	2.59 *	0.31	0.00	1.82	3.36
	3	1	2.32 *	0.36	0.00	1.43	3.21
		2	-2.59 *	0.31	0.00	-3.36	-1.82
Control	1	2	-2.17 *	0.51	0.00	-3.43	-0.91
		3	-1.08 *	0.42	0.03	-2.10	-0.06
	2	1	2.17 *	0.51	0.00	0.91	3.43
		3	1.09 *	0.36	0.01	0.20	1.97
	3	1	1.08 *	0.42	0.03	0.06	2.10
		2	-1.09 *	0.36	0.01	-1.97	-0.20

strong risk factor for falls and exercise improves balance and mobility, thus preventing falls among older adults [37]. Improving balance was an important outcome for participants in both groups. The results of the study showed improvements in balance by reducing the sway index and by improving dynamic stability. In this study, sway index was measured in terms of m-CTSIB. RM-ANOVA tests of within subject effects showed statistically significant differences between time from baseline to 10 weeks post intervention to long term follow up ($p < 0.0001$). However, between groups, there were no statistically significant differences after 10 weeks ($p = 0.83$), as well as at the long-term follow-up ($p = 0.61$). Similar findings were reported by Barnett, Smith et al. (2003) after implementing a multi-modal, weekly, supervised exercise program with ancillary home exercises for participants over 65 years of age. They found that the rate of falls was 40% lower in the exercise group compared to the control group. In addition, the exercise group performed significantly better on balance measures. In both of the above-mentioned training programs, a decrease in falls was observed, which suggests that exercise generally has a positive impact on reducing falls and may have a greater effect on dynamic balance than on static balance [38].

The sway reduction that was observed could be partly attributed to improved strength and greater activation in the ankle muscles, which are known to play a primary role in static postural control. This consideration is further supported by previous studies that demonstrate that selectively improving the strength of the ankle dorsiflexors can be effective in reducing postural sway in older adults. This improvement was the result of an increased reliance on the ankle mechanism to maintain balance, and at the same time, older adults avoided using the more “fall-prone” hip strategy [39]. Supporting this evidence, Sofianidis et al. (2009) stated that practicing traditional Greek dances may also increase the contribution of the ankle mechanism in static postural control, possibly by enhancing the active control of ankle stiffness [40].

Dynamic stability, which was measured in terms of LOS, both training groups showed a significant difference between the baseline, post intervention, and long-term scores ($p < 0.0001$).However, there was no statistically significant difference between the experimental and the control groups after 10 weeks ($p = 0.22$), as well as at the long-term follow-up ($p = 0.29$). These results are in accordance with a study conducted by Islam et al. (2004), who reported an increase in the limits-of-stability maximum excursion in both anteroposterior (AP) and mediolateral (ML) directions after a 12-week balance-training program [41]. The balance retraining exercises in the current intervention integrated both static and dynamic balance activities. These results are consistent with findings from previous research, which stated that the integration of balance and strength training into daily life reduces the rate of falls and maintains optimal levels of function in older people. One of the possible explanations may be improved neuromuscular control during standing, which may have resulted from the hip load/unload mechanism being challenged during balance retraining activities [37,42].

Similarly, Seidler and Martin (1997) reported an increased backward leaning distance in both fallers and non-fallers after a short-term balance-training program [49]. These results suggest that both group exercise and individualized exercise programs were similar in scope and specificity, while providing sufficient intensity, to produce gains in balance. The increase in the limits-of-stability test scores may be sign of the improved ability of the individuals to utilize an ankle strategy in balance control. Dynamic exercises during the intervention challenged the contribution of the somatosensory system to balance the input of cutaneous receptors, which increased their reliance on muscle and joint proprioception, as well as visual and vestibular inputs. In the eyes-closed condition, balance control shifts to vestibular and proprioceptive control. Determining the difference between the eyes-open and eyes-closed conditions assists in identifying the contribution of vision to balance. Reliance on visual inputs in balance control increases with age. However, at the same time, a general reduction in visual functioning also occurs. Therefore, the contribution of other systems to postural control becomes increasingly important with age [43].

Another study done on older adults demonstrated that the adults who participated in proprioceptive physical activities utilized greater proprioceptive inputs to regulate their balance. Thus, balance-specific training and proprioceptive activities appear to help train vestibular and proprioceptive systems for better balance control [44].

Previous studies suggested various mechanisms for improvements in balance, which can be achieved by strengthening the effectors system. Repeated motor practice enhances motor strength, speed, and endurance. Improving proprioception, reaction time, and sensorimotor coupling contributes to the adaptation and recovery of neuronal pathways [45].

In this study, improvement in lower extremity strength was shown by both groups after 10 weeks and 6 months post intervention compared to baseline ($p < 0.0001$). without any statistically significant difference in between group comparison post intervention ($p = 0.65$) and long-term follow-up ($p = 0.46$).The possible explanation increased muscle strength in both the groups can be the result of neural adaptations and an increase in muscle fiber size. In accordance with the specificity principle of exercise training, the adaptive effects of training are highly specific to the training method employed [46].

Researchers have stated that fall risk increases with age because of a decrease in muscle mass, which decreases muscle function. Studies also provide evidence that older muscles respond vigorously to resistance training with increased motor activation, while myofiber hypertrophy can increase muscle mass, strength, and power. These improvements facilitate the performance of daily activities, enhance energy expenditure and body composition, and promote participation in spontaneous physical activity [47]. Another study reported that improvements in lower extremity strength improve balance in older adults [42].

In addition to these findings, researchers have reported that strength exercises using elastic resistance are practical as they have a small risk of injury, provide consistent tension, and are easily portable and inexpensive. Elastic-resistance exercises help during rehabilitation by improving the muscle strength and stability of the neuromuscular system through muscle contraction and the stimulation of the proprioceptive senses [12]. Weight-bearing exercises help to maintain bone strength and density, thus reducing the risk of fractures. They also have long-term protective effects against falls and fractures. The acute risk for falls increases during physical activities, such as walking, climbing stairs, biking, and other sporting activities, suggesting the need for safety when implementing weight-bearing exercise interventions for older adults) [48]. The exercise intervention utilized in this study was conducted in a safe environment under the supervision of physiotherapists.

Previous studies have shown that increased muscle strength in lower limbs was associated with better balance, which may improve the ability of older individuals to successfully perform daily tasks [34,45]. Moreover, a study conducted by Rubenstein et al., (2006) showed that 12 weeks of strength and balance training increased isokinetic strength for knee flexors and knee extensors, as well as walking speed, while reducing fall rates [14]. Another explanation for the improvement in balance may be the increase in neuromuscular control due to exercise, along with an increase in fitness, strength, and motion domain, as well as improvements in mental status [49].

An improvement in Quality of Life (QoL) was reported by both groups in terms of the Mental and the Physical Component Summary scores of SF12RV. No statistically significant difference was observed between the experimental and control groups. RM-ANOVA Tests showed that the interaction effect of Time to Group was significant on the PCS ($F_{(1.77,\ 120.61)} = 5.09$, $p < 0.01$)and MCS($F_{(1.84,\ 125.22)} = 10.23$, $p < 0.01$). This result implies that there is a significant change in the group scores over time. Both intervention programs showed improvements in the mental and physical components of QoL. Furthermore, when compared to the individualized program, participants in group exercise programs showed improved psychological status (e.g., self-esteem), and enhanced socializing [42]. Accumulated data from previous research has stated that participation in social activities in the form of group exercise activities contributes to successful aging, maintains independence in the activities of daily living (ADLs), and improves the physiological status and self-efficacy of older adults [50].

In the current study, the experimental group received additional benefits, such as increased adherence, cost-effectiveness, and social support, as compared to the participants in the individualized exercise program. There are several possible explanations for varying results. Our participants were engaged in an exercise program with age-related peers from the same day care center. This closeness promoted a collegiality that fostered a motivating environment. Previous studies have also shown that group exercise led to encouragement and stimulation, as participants knew that they were working towards a common goal and helping each other attain those goals, which led to more adherences. Participants learned to work with others, which increased social interaction and provided confidence when group members performed exercises together. The social aspect of a group-based intervention showed positive benefits for adults who needed an external means of encouragement [20]. This finding was supported by a study conducted by Barnett et al., (2003), who stated that group exercise programs are easily accessible and affordable [38].

Previous studies on psychosocial aspects have also shown that a group exercise program can enhance social interaction and motivation. It also improves self-esteem and enjoyment, which are important for exercise adherence. These aspects may partially explain the significant improvements that were observed in 10 weeks, despite previous studies reporting that 10 weeks was not enough time to achieve change [51,52]. An individualized exercise program allows the participant to receive intensive, focused attention and to discuss difficult issues in a private setting [53,54]. Hence, this group of participants showed significant improvements in various outcomes, such as reduction in fall risk, improved balance, lower extremity strength, fear of fall, and QoL components after 10 weeks of intervention. However, the adherence to the individualized exercise program was less than group exercise programs, which may be due to the lack of motivation from group members or boredom, as the intervention was given to one participant at a time. Moreover, this type of intervention is time-consuming, as it requires one-on-one interactions. Due to a significant increase in older adults, the need for increased healthcare utilization is constantly rising and serving large numbers of participants is difficult with individualized exercise programs [54].

Studies have shown that alternative modes of exercise interventions, which are appropriate for larger populations, are group-based and home-based exercise programs. They are considered to be more suitable and cost-effective for older adults [53]. The beneficial effects of group exercise programs are also supported by previous clinical studies, which have shown that fall-related injuries are reduced after the implementation of an exercise program [54]. Therefore, this study supports research that suggests that exercise is an effective intervention strategy for preventing falls in older adults.

An important issue in intervention studies is the extent to which the effects of an intervention were retained after the intervention has ended. In our study, many of the effects, such as reduction in fall risk, improvement in balance, and Quality of Life components of the intervention persisted after 6 months. However, the reduction in fear of fall that occurred immediately or after 10 weeks of intervention was not evident after 6 months.

Limitations

The current study was single blinded. We couldn't do post-intervention assessment on the participants who dropped out.

Clinical implications

The group exercise program has been shown to be a safe, effective, practical, feasible, and low-cost fall prevention intervention that is beneficial for elderly individuals.

CONCLUSIONS

Group exercise program had a positive impact on elderly individuals. It was effective in reducing fall risk and fear of fall, improving balance and lower extremity strength and enhancing the quality of life after the intervention.

FUTURE SCOPE

A double blinded Randomized Controlled Trial to assess it's effect on the incidence of falls, is required to evaluate the true potential of the training that has been presented in this study. Furthermore, potential transfer effects related to interactive balance training i.e., cognitive and visuoperceptual effects should be assessed in future studies.

Acknowledgements

The Authors would like to thank all the elderly participants in the study, Also the Authors would like to express deep gratitude towards Erasmus Mundus Euphrates scholarship programme funded by European Union. Special thanks to the directors of elderly day care centres from Greece.

Conflict of interest statement

The Authors declare no conflict of interest.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Author contributions

NK, ET: conceptualization, writing original draft, design

and methodology; KP, MT, AM: methodology; ST: data analysis; VP: supervision and reviewing.

Ethical consideration

The present study received approval from the Institutional Ethics Committee of the Pravara Institute of Medical Sciences [DU], Loni, Taluka Rahata, Ahmednagar, Maharashtra, India 413736 (PMT/PIMS/IEC/2014/161). The study was a parallel group, randomized, controlled trial (Reg.no: CTRI/2016/06/007014). This study was conducted in Technological Educational Institute of Western Greece under Erasmus Mundus Action 2, Lot 13, 1st cohort of Euphrates Scholarship programme of European Union which was awarded to principal investigator (Project no. 2013-2540/001-001).The research was conducted ethically, with all study procedures being performed in accordance with the requirements of the World Medical Association's Declaration of Helsinki. Written informed consent was obtained from each participant/patient for study participation and data publication.

References

1 Guccione AA, Avers D, Wong R. Geriatric physical therapy - ebook. New York, NY: Elsevier Health Sciences 2011, p. 734.

2 Gschwind YJ, Kressig RW, Lacroix A, et al. A best practice fall prevention exercise program to improve balance, strength/power, and psychosocial health in older adults: study protocol for a randomized controlled trial. BMC Geriatr 2013;13:105.

3 Tiedemann A, Sherrington C, Lord SR. The role of exercise for fall prevention in older age. Mot Rev Educ Física 2013;19:541-547.

4 Beaulieu L. Balance Rehabilitation using Xbox Kinect among an Elderly Population: A Pilot Study. J Nov Physiother [Internet] 2015;05.

5 Berg RL, Cassells JS. Second fifty years: promoting health and preventing disability. Washington: National Academies Press 1992 (https://public.ebookcentral.proquest.com/choice/publicfullrecord.aspx?p=3376581, accessed: 24 June 2020).

6 Mittaz Hager AG, Mathieu N, Lenoble-Hoskovec C, Swanenburg J, et al. Effects of three home-based exercise programmes regarding falls, quality of life and exercise-adherence in older adults at risk of falling: protocol for a randomized controlled trial. BMC Geriatr 2019;19:13.

7 https://www.who.int/tools/whoqol

8 Moylan KC, Binder EF. Falls in older adults: risk assessment, management and prevention. Am J Med 2007;120:493.E1-493.E6.

9 Lombardo S. Fallproof! A Comprehensive Balance and Mobility Training Program, by Debra Rose: Champaign, IL: Human Kinetics 2010, pp. 312.

10 Kumar S, Vendhan GV, Awasthi S, et al. Relationship between fear of falling, balance impairment and functional mobility in community dwelling elderly. Indian J Phys Med Rehabil 2008;19:48-52.

11 Lord S, Sherrington C, Menz H, et al. Falls in older people: risk factors and strategies for prevention, second ed. Cambridge, UK: Cambridge University Press 2007, pp. 1-395.

12 Cho SI, An DH. Effects of a fall prevention exercise program on muscle strength and balance of the old-old elderly. J Phys Ther Sci 2014;26:1771-1774.

13 Alfieri FM, Riberto M, Gatz LS, et al. Functional mobility and balance in community-dwelling elderly submitted to multisensory versus strength exercises. Clin Interv Aging 2010;5:181-185.

14 Rubenstein LZ. Falls in older people: epidemiology, risk factors and strategies for prevention, Age Ageing 2006;35(Suppl 2):ii37-ii41. https://doi.org/10.1093/ageing/afl084

15 Inventory prevention falls (https://novascotia.ca/seniors/pub/InventoryPreventionFalls.pdf).

16 Deshpande N, Metter JE, Lauretani F, et al. Interpreting fear of falling in the elderly: what do we need to consider? J Geriatr Phys Ther 2009;32:91-96.

17 Mane AB, Sanjana T, Patil PR, et al. Prevalence and correlates of fear of falling among elderly population in urban area of Karnataka, India. J -Life Health 2014;5:150-155.

18 Lord SR, Menz HB, Sherrington C. Home environment risk factors for falls in older people and the efficacy of home modifications. Age Ageing 2006;35(Suppl 2):ii55-ii59. https://doi.org/10.1093/ageing/afl088

19 Robertson MC, Campbell AJ. Otago exercise programme to prevent falls in older adults. Wellington, N.Z.: ACC Thinksafe 2003.

20 Kulkarni N, Pouliasi K, Theodoritsi M, et al. Impact of group exercise programme on fall risk in elderly individuals: a pilot study. IJHSR 2017;7:2657.

21 Thaweewannakij T, Suwannarat P, Mato L, et al. Functional ability and health status of community-dwelling late age elderly people with and without a history of falls. Hong Kong Physiother J 2015;34:1-9. https://doi.org/10.1016/j.hkpj.2015.08.001

22 Parab K, Hande D, Kulkarni N, et al. Effectiveness of progressive stepping program on balance performance in geriatrics: a randomized controlled trial. Romanian J Phys Ther 2014;20:51-59.

23 Mutrie N, Campbell AM, Whyte F, et al. Benefits of supervised group exercise programme for women being treated for early stage breast cancer: pragmatic randomised controlled trial. BMJ 2007;334:517.

24 Dionyssiotis Y. Analyzing the problem of falls among older people. Int J Gen Med 2012;5:805-813.

25 Bischoff HA, Stähelin HB, Monsch AU, et al. Identifying a cut-off point for normal mobility: a comparison of the timed "up and go" test in community-dwelling and institutionalised elderly women. Age Ageing 2003;32:315-320.

[26] Bohannon RW. Reference values for the timed up and go test: a descriptive meta-analysis. J Geriatr Phys Ther 2006;29:64-68.

[27] Delbaere K, Close JC, Mikolaizak AS, et al. The Falls Efficacy Scale International (FES-I). A comprehensive longitudinal validation study. Age Ageing 2010;39:210-216. https://doi.org/10.1093/ageing/afp225

[28] FES-I (https://sites.manchester.ac.uk/fes-i).

[29] Guralnik JM, Simonsick EM, Ferrucci L, et al. A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. Journal of gerontology 1994;49:M85-M94.

[30] Ware J, Kosinski M, Keller S. SF-12: how to score the SF-12 physical and mental health summary scales. Boston MA: Health Institute, New England Medical Center 1995.

[31] https://www.biodex.com/sites/default/files/950300man_08060.pdf

[32] Gusi N, Carmelo Adsuar J, Corzo H, et al. Balance training reduces fear of falling and improves dynamic balance and isometric strength in institutionalised older people: a randomised trial. J Physiother 2012;58:97-104. https://doi.org/10.1016/S1836-9553(12)70089-9

[33] Boyd R, Stevens JA. Falls and fear of falling: burden, beliefs and behaviours. Age Ageing 2009;38:423-428.

[34] Zhuang J, Huang L, Wu Y, et al. The effectiveness of a combined exercise intervention on physical fitness factors related to falls in community-dwelling older adults. Clin Interv Aging 2014;9:131-140.

[35] Maritz CA, Patel N, Varughese L, et al. The effects of a 10-week group-based exercise program on lower extremity strength, balance and functional mobility in community-dwelling older adults: a pilot study. Int J Physic Med Rehab 2013;1:1-5.

[36] Kumar S, Vendhan GV, Awasthi S, et al. Relationship between fear of falling, balance impairment and functional mobility in community dwelling elderly. Indian J Phys Med Rehabil 2008;19:48-52.

[37] Clemson L, Singh MA, Bundy A, et al. Integration of balance and strength training into daily life activity to reduce rate of falls in older people (the LiFE study): randomised parallel trial. BMJ 2012;345:E4547.

[38] Barnett A. Community-based group exercise improves balance and reduces falls in at-risk older people: a randomised controlled trial. Age Ageing 2003;32:407-414.

[39] Amiridis I, Arabatzi F, Violaris P, et al. Static balance improvement in elderly after dorsiflexors electrostimulation training. Eur J Appl Physiol 2005;94:424-433.

[40] Sofianidis G, Hatzitaki V, Douka S, et al. Effect of a 10-Week traditional dance program on static and dynamic balance control in elderly adults. J Aging Phys Act 2009;17:167-180.

[41] Islam MM, Nasu E, Rogers ME, et al. Effects of combined sensory and muscular training on balance in Japanese older adults. Prev Med 2004;39:1148-1155.

[42] Lee HC, Chang KC, Tsauo JY, et al. Effects of a multifactorial fall prevention program on fall incidence and physical function in community-dwelling older adults with risk of falls. Arch Phys Med Rehabil 2013;94:606-615.

[43] Seidler RD, Martin PE. The effects of short term balance training on the postural control of older adults. Gait Posture 1997;6:224-236.

[44] Westlake KP, Culham EG. Sensory-Specific balance training in older adults: effect on proprioceptive reintegration and cognitive demands. Phys Ther 2007;87:1274-1283.

[45] Palmgren A, Ståhle A, Skavberg Roaldsen K, et al. "Stay balanced" – effectiveness of evidence-based balance training for older adults transferred into a physical therapy primary care setting – a pilot study. Disabil Rehabil 2020;42:1797-1802.

[46] Buchner DM, Cress ME, de Lateur BJ, et al. The effect of strength and endurance training on gait, balance, fall risk, and health services use in community-living older adults. J Gerontol A Biol Sci Med Sci 1997;52:M218-224.

[47] Hunter GR, McCarthy JP, Bamman MM. Effects of resistance training on older adults. Sports Med Auckl NZ 2004;34:329-348.

[48] Cho SI, An DH. Effects of a fall prevention exercise program on muscle strength and balance of the old-old elderly. J Phys Ther Sci 2014;26:1771-1774.

[49] Gauchard G, Jeandel C, Perrin P. Physical and sporting activities improve vestibular afferent usage and balance in elderly human subjects. Gerontology 2001;47:263-270.

[50] Tsekoura M, Billis E, Tsepis E, et al. The effects of group and home-based exercise programs in elderly with sarcopenia: a randomized controlled trial. J Clin Med 2018;7.

[51] El-Khoury F, Cassou B, Charles MA, et al. The effect of fall prevention exercise programmes on fall induced injuries in community dwelling older adults: systematic review and meta-analysis of randomised controlled trials. BMJ 2013;347.

[52] Martin JT, Wolf A, Moore JL, et al. The effectiveness of physical therapist-administered group-based exercise on fall prevention: a systematic review of randomized controlled trials. J Geriatr Phys Ther 2013;36:182-193.

[53] Munro JF, Nicholl JP, Brazier JE, et al. Cost effectiveness of a community based exercise programme in over 65 year olds: cluster randomised trial. J Epidemiol Community Health 2004;58:1004-1010.

[54] O'Keeffe M, Hayes A, McCreesh K, et al. Are group-based and individual physiotherapy exercise programmes equally effective for musculoskeletal conditions? A systematic review and meta-analysis. Br J Sports Med 2017;51:126-132.