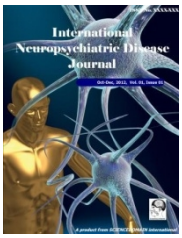

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Fall Related Self-efficacy among Elderly: A Comparison of Resistance Training with Balance Exercise

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Authors' contributions

This work was carried out in collaboration between all authors. Author AMJ wrote the protocol, managed the literature searches, and wrote the first draft of the manuscript. Author BU designed the study, and assisted in writing the protocol. Author VD read and approved the final manuscript. Author PM improvised the study protocol, managed the literature searches and the first draft of the manuscript. Author AK performed the statistical analyses. Author VA organized and scrutinized the contents, and language of the article. All authors read and approved the final manuscript.

Original Research Article

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ABSTRACT

Aims: To evaluate the effectiveness of individualized progressive resistance strength training (PRT) program in improving the confidence level among the institutionalized elderly with balance impairment, in comparison with traditional balance exercise (TBE), and combination of both (COMBI).
Place and Duration of Study: The study was conducted between June 2008 and December 2012 in the geriatric care homes, Mangalore, India.
Methodology: The eligible subjects were assigned to 3 groups (TBE, PRT and COMBI) using block randomization technique and allocation concealment was done. PRT group received strength training for the key muscles (hip flexors, extensors and abductors, knee flexors and extensors, ankle dorsiflexors and plantar flexors) essential for maintenance of balance. TBE group received conventional balance training and the participants of the COMBI group received TBE and PRT interventions alternately. All the three groups received their respective interventions 4 times a week for 6 months. The

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data was collected at baseline, 3rd and 6th month and the analysis was performed using Statistical Package for Social Sciences (SPSS) version 15. Both per-protocol and intention to treat methods of analyses were used.

Results: Mean age of the 54 elderly participants (18 in each group) was 75.17 years and the comparison of the baseline variables revealed homogeneity between the groups. Between the baseline and six months, all the three groups showed notable reduction in Falls Efficacy Scale (FES) scores. The change scores (pre-post intervention) of FES were notable for all the three groups, but the statistical test did not reveal any significant differences between the groups.

Conclusion: Individualized structured PRT intervention targeting the key muscles of lower limbs for balance maintenance, for a period of 6 months, is comparable to TBE in improving the falls efficacy. This in turn reduces self-induced functional restrictions among the non-frail elderly people living in geriatric homes.

Keywords: Balance exercise; elderly; falls efficacy; resistance training; self-efficacy.

1. INTRODUCTION

Elderly people sustain very high rates of falls every year and they increase with the advancing age. Yearly, about 30% of community dwelling elderly, over 65 years of age, sustain falls [1,2]. Falls are associated with psychological repercussions such as fear of falling and loss of confidence, which may result in self-imposed functional limitations [3,4]. Even falls with no physical injuries can lead to loss of confidence [5] and may predispose to repeated falls [6,7]. Most falls in elderly result from number of factors affecting the balance [3,8] and its maintenance is a complex mechanism [9]. Physiological changes related to ageing such as reduced muscle strength and joint range of motion are known factors that predispose to poor balance control [10-12]. Among the elderly, poor balance control is known to reduce the self-confidence and may lead to functional decline and disability [12,13].

Studies on balance and strength training exercises among the elderly have shown improvement in fear of falling and self-efficacy [14-15]. Balance exercises train individuals to maintain or regain the center of gravity inside the base of support, thereby controlling the postural sway. Many of the earlier studies attribute this finding to better neuromuscular coordination and “specificity of the training”[10,16]. For the above-mentioned reasons, this study used traditional balance training as an intervention program.

Progressive resistance strength training (PRT) is a type of strength training program where the resistance is progressively increased as the subject’s strength improves. Among the elderly, PRT is found to improve gait speed, functional mobility and balance [17]. Studies have identified, hip flexors, extensors and abductors, knee flexors and extensors, and ankle dorsiflexors and plantar flexors as the key muscles of lower extremities essential for balance control [18-21]. Despite the well documented beneficial effects of strength and balance training exercises on fear of falling and self-efficacy, there is dearth of evidence on the influence of resistance training of key muscles on fall related self-efficacy among the elderly living in geriatric homes. The hypothesis of our study is that the PRT as a stand-alone program will improve the falls efficacy.

2. METHODOLOGY

The present interventional study was conducted on elderly participants, aged 65 years and above, residing in 4 geriatric care homes, Mangalore, India, between June 2008 and December 2012.

A ready reckoner table [22] was used to calculate the sample size, anticipating intraclass correlation coefficient of 0.3 with 3 repeated measures, expected standard deviation of 5 each, a significance level of 5%, a power of study of 80% and an expected 10% dropout for each group; the sample size derived was 54 elderly participants; i.e. 18 participants in each group.

Participants aged 65 years and older, of both gender, fit for exercise as per medical screening, Berg balance scale (BBS) score of 41 to 52 [23], a minimum score of 23 for Mini-mental state examination (MMSE), and a muscle strength of 4 or above as per Medical Research Council (MRC) grading for the lower limb key muscles were considered as the criteria for including participants for the study. Symptomatic cardiovascular diseases, musculoskeletal conditions which could interfere with training, neurological conditions, polypharmacy, malignancies, diagnosed vestibular disorders and participants who underwent lower limb strength training and/or balance training during the past 3 months were the exclusion criteria.

The materials used for the study were a Tinneti's Falls Efficacy Scale (FES) [24], 3"-4" thick foam mattress with length of 6.5 feet and width of 3 feet, standard treatment plinth, sand bags of weights ranging from 250grams to 5 kilograms, and a medium size gym ball.

After attaining the clearance from the Institutional Ethics Committee (IEC) of Kasturba Medical College (Manipal University), Mangalore, the list of geriatric care homes, located within and the adjoining places of Mangalore was prepared. Among the 12 geriatric care homes identified, 8 consented to participate in the study. Out of the 8 geriatric care homes, 4 of them were excluded due to predominance of mentally challenged and distressed elderly or presence of regular exercise therapy including balance training for the inmates (Fig. 1). From the remaining geriatric care homes, written informed consent was collected from the interested participants. Medical screening was performed by a qualified medical practitioner, and then an independent blinded assessor administered the MMSE, BBS, manual muscle testing and FES, on the identified participants.

To meet the sample size, a total of 268 participants were screened. The eligible participants were assigned to the intervention groups by sequence generation using block randomization. A block size of 6 was used in this trial to allocate the participants to the three interventions i.e. each block had 2 PRT, 2 TBE and 2 COMBI participants. The allocation concealment was done using sealed opaque envelopes which were sequentially arranged.

The participants of the PRT group received strength training for the key muscles of both lower limbs. Each strength training session lasted approximately an hour and DeLormes and Watkins protocol [25] was used for progression of resistance. The participants were instructed to lift or raise the weight (sand bags) within 1-2 seconds and then lower the weight within 2-3 seconds. To determine Max load or 1RM for each muscle group Brzycki's equation [26] was used, i.e. 1 RM=Weight÷[1.0278-(0.0278×Number of repetitions)].

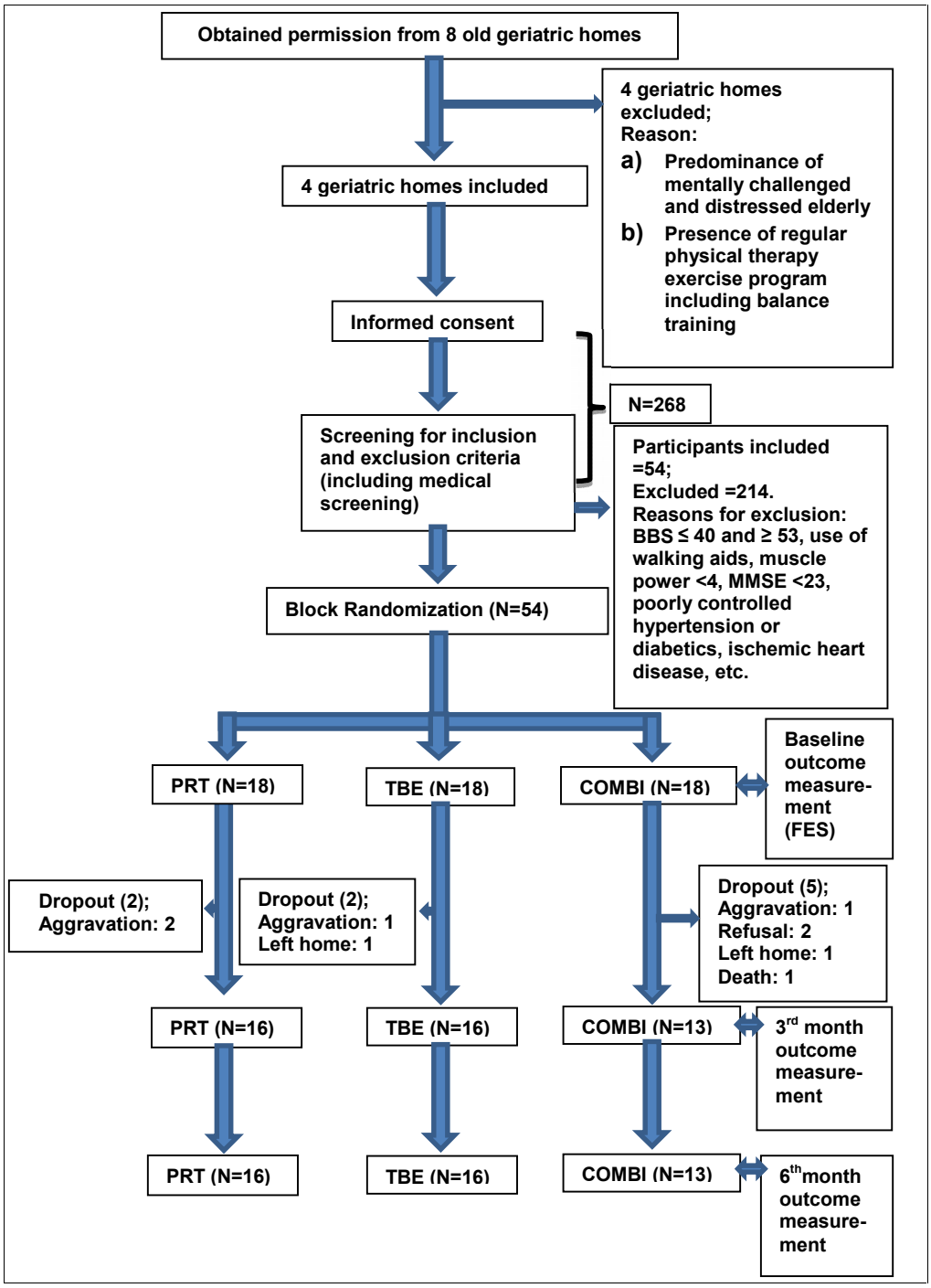

Fig. 1. Flow chart of the participants' enrolment, allocation and analysis

N, Number of participants; MMSE, Mini-mental status examination; BBS, Berg balance scale; FES, Falls efficacy scale; PRT, Progressive resistance strength training; TBE, Traditional balance exercise; COMBI, Combination of both progressive resistance strength training and traditional balance exercise.

Traditional balance exercise, which lasted for an approximate duration of 45-minutes, consisted of 8 components and they were reach out activities in standing, standing on one leg, tandem walking, figure of eight walking, braiding, forward, backward and sideways walking on foam mattress, sitting balance on a medium size gym ball and perturbations of balance in all four and diagonal directions while sitting on plinth, foam mattress and gym ball. The complexity of the balance training was augmented, based on the ability of the participant.

The participants of the COMBI group received TBE and PRT interventions alternately, thus making 2 days of TBE and 2 days of PRT a week. The balance training and resistance training procedure received by COMBI group was identical to the exercise regimen of TBE and PRT groups.

To minimize musculoskeletal injuries, the PRT and COMBI participants were given 15RM instead of prescribed 10RM of DeLormes and Watkins protocol during the first 4 weeks [27]. The position of sand bag (resistance) and/or the number of sets of resistance training were modified for those participants who had Delayed Onset Muscle Soreness (DOMS) or temporary worsening of arthritic pain. All the training programs were performed under supervision of physiotherapists and were given for 4 times a week for a period of 6 months. The participants irrespective of the intervention received were encouraged to perform to his/her best capability at all times including the 1RM calculation test. At the end of 3rd and 6th month the blinded assessor re-assessed and recorded the outcome measure.

The collected data was analyzed using SPSS version 15. One way and repeated measures ANOVA were used for the continuous variables and chi square test for the categorical variables. The change scores (pre-post intervention) was analyzed using Kruskal Wallis test. The analysis was performed using both per-protocol and intention to treat. *P* value <.05 was considered as statistically significant.

3. RESULTS AND DISCUSSION

The study included 54 elderly participants aged 65 years and older. The baseline values of age, gender, MMSE, BBS and other variables of the participants are shown in Table 1. The mean scores of most of the variables other than incidence of falls last year (Table 1), were not significantly different, suggesting that the three groups were essentially homogeneous with respect to the baseline values.

Among the baseline values of FES, the TBE group had a mean score of 20.72, which was lower than the score of 28.67 for COMBI group, but the difference was not statistically significant (*P*=.081). With regard to incidence of falls last year, PRT and COMBI had a median value of 1.5 each, whereas, TBE group did not had any falls and the data analysis detected a statistically significant difference between the three groups (*P*=.049). But, the pairwise comparison did not show statistically significant difference between any of the groups (*P*=.09).

As shown in Table 2, all the three groups showed notable reduction in FES scores from the baseline to third month beyond which the difference in the reduction across the groups was reduced Fig. 2. However, the reduction in FES scores for all the three groups was statistically significant for both per-protocol and intention to treat analysis.

Table 1. Baseline characteristics of the study groups

Baseline Characteristics	PRT (n=18)	TBE (n=18)	COMBI (n=18)	TOTAL (n=54)	*P* value
AGE (mean±SD)	75.11±5.5	75.17±5.9	75.22±5.25	75.17±5.45	.998*
GENDER Male	6 (33.3%)	6 (33.3%)	1 (5.6%)	13 (24.1%)	.100**
[n (%)] Female	12 (66.7%)	12(66.7%)	17 (94.4%)	41 (75.9%)	
MMSE (mean±SD)	25.67±2.17	26.44±2.15	25.72±2.32	25.94±2.2	.506*
BBS (mean±SD)	46.5±3.9	48.72±2.68	48.61±2.7	47.94±3.25	.067*
FES (mean±SD)	25.06±12.13	20.72±6.65	28.67±11.47	24.81±10.69	.081*
PVD [n (%)]	4 (22.2%)	1 (5.6%)	4 (22.2%)	9 (16.7%)	.354**
Peripheral Neuropathy [n (%)]	8 (44.4%)	9(50.0%)	7 (38.9%)	24 (44.4%)	.940**
Musculoskeletal disorder [n (%)]	9 (50.0%)	5(27.8%)	7 (38.9%)	21 (38.9%)	.449**
Incidence of falls last year [median (IQR)]	1.5 (0,3.0)	0 (0,1.0)	1.5 (0,3.25)	1 (0,3.0)	.049†
Hypertension [median (IQR)]	5.5 (0,9.25)	6 (0,8.5)	2 (0,8.0)	4.5 (0,8.0)	.739†
Diabetic Mellitus [median (IQR)]	7.5 (0,13.5)	8.5 (0,12.25)	7.5 (0,12.25)	8 (0,12.25)	.827†

One way ANOVA; Chi-Square test; † Kruskal-Wallis test; PRT, Progressive resistance strength training; TBE, Traditional balance exercise; COMBI, Combination of both progressive resistance strength training and traditional balance exercise; n, Number of participants; SD, Standard deviation; MMSE, Mini-mental state examination; BBS, Berg balance scale; FES, Falls efficacy scale; PVD, Peripheral vascular disease; IQR, Inter-quartile Range*

Table 2. Changes in FES scores in study groups from baseline to 3 months and 6 months of intervention

Variable	Groups	Analysis	Baseline Mean±SD (n)	3 months Mean±SD (n)	6 months Mean±SD (n)	F value	*P* value
FES	PRT	PP	25.06±12.13(18)	14.91±4.28(16)	11.94±2.82(16)	17.173	.001¥
		ITT		15.67±4.78(18)	13.06±4.32(18)	15.348	.001¥
	TBE	PP	20.72±6.65(18)	14.69±2.5(16)	11.94±1.84(16)	24.518	<.001¥
		ITT		16.22±6.01(18)	13.78±6.5(18)	20.903	<.001¥
	COMBI	PP	28.67±11.47(18)	15.23±3.98(13)	12.23±2.98(13)	14.978	.002¥
		ITT		20.06±9.42(18)	17.89±10.39(18)	11.379	.003¥

¥ Repeated measures ANOVA; SD, Standard deviation; n, Number of participants; FES, Falls efficacy scale; PRT, Progressive resistance strength training; TBE, Traditional balance exercise; COMBI, Combination of both progressive resistance strength training and traditional balance exercise; PP, Per-protocol; ITT, Intention to treat

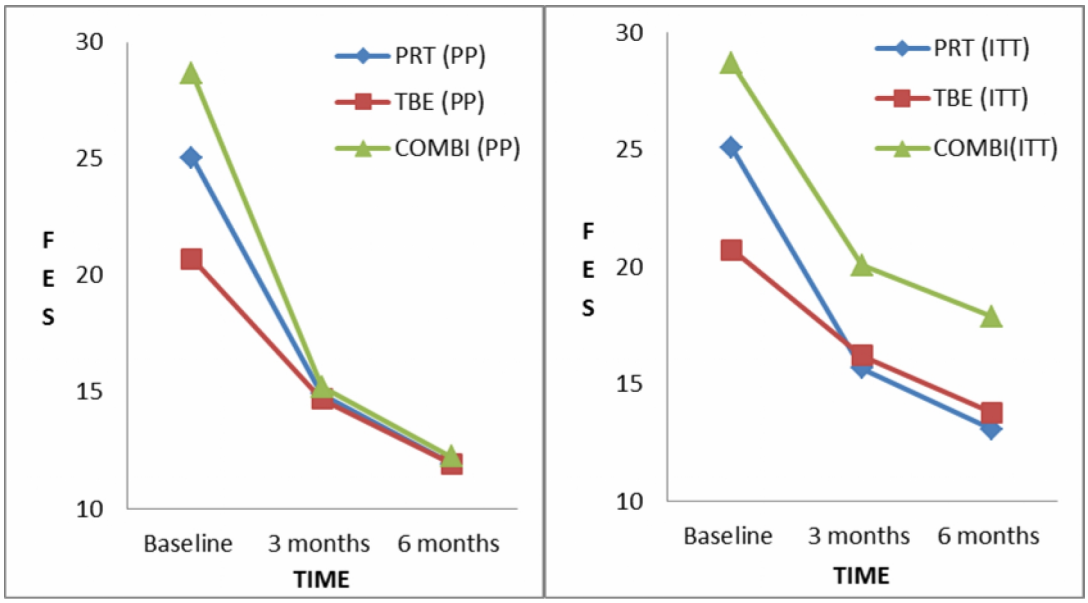

Fig. 2. Graphical representation of change in FES scores in study groups from baseline to 3 months and 6 months of intervention

FES, Fall efficacy scale; PRT, Progressive resistance strength training; TBE, Traditional balance exercise; COMBI, Combination of both progressive resistance strength training and traditional balance exercise; PP, Per-protocol; ITT, Intention to treat.

Table 3 depicts the comparison of FES change scores (pre-post intervention) among the groups. Though the FES change scores were notable for both PRT and COMBI groups, both per-protocol and intention to treat analyses did not reveal any statistical significance among the three groups.

The aim of the study was to compare the effect of individualized, supervised and structured PRT, TBE and combination of both among the non-frail elderly residing in geriatric homes aged 65 years and older on fall-related self-efficacy.

Table 3. Comparison of change scores of FES between the groups

Variables	Analysis	PRT group Median (IQR)	TBE group Median (IQR)	COMBI group Median (IQR)	*P* value
FES change scores	PP	9 (8.25, 11.75)	6.5 (3.5, 11)	11(7, 17)	.077†
	ITT	9 (6.75, 11.25)	5.5 (3, 11)	8 (0, 12.5)	.368†

† Kruskal-Wallis test; PRT, Progressive resistance strength training; TBE, Traditional balance exercise; COMBI, Combination of both progressive resistance strength training and Traditional balance exercise; IQR, Inter-quartile Range; FES, Falls efficacy scale; PP, Per-protocol; ITT, Intention to treat.

With advancing age, the fear of falling increases and the falls efficacy reduces and may lead to high rates of falls among the elderly. It can affect physical, functional, psychological and social domains of functioning, predisposing to reduced physical activities and self-efficacy, depression, and lower quality of life [28-30]. Though several tools are available for fear of

falling and falls efficacy, our study incorporated FES to subjectively measure individual's level of confidence only for routine physical activities prior, during and post intervention.

The present study has shown statistically significant improvement in falls efficacy among all three groups. The PRT group has shown higher change in FES value from baseline to 6 months. Meta-analysis of several studies suggests a strong positive relationship between fall-related self-efficacy and physical activity. Higher fall-related efficacy in performing certain daily tasks without falling or losing balance is associated with higher levels of functional ability [30]. Improvement in the strength of key muscles essential for maintenance of balance may have benefitted the PRT participants to handle daily tasks with higher confidence.

Reduction in physical activity is attributed to the age related decline in muscle strength which is predominant in locomotor muscles than non-locomotor muscles. The hip flexors and extensors, the knee flexors and extensors, and the ankle dorsiflexors and plantar flexors which are the key muscles for balance also play a major role in phases of gait and gait speed [19]. Progressive resistance training given for the key muscles might have reduced the gait and balance instability, translating to improved falls efficacy.

Most of the routine physical activities last for relatively short duration and these activities may not require strong aerobic or anaerobic capacity but adequate muscular strength. In addition to the above, in trained participants, resistance training programs have shown reduced energy need or demand to accomplish the functional tasks [31]. Progressive resistance training may have addressed such aspects and helped them to perform routine physical activities at ease.

Resistance training also provides number of psychological benefits including preserved cognitive function, alleviation of symptoms of depression, and anxiety which is in addition to the known benefits such as enhancement of bone mineral density and increase of the fat-free mass [32]. The current study attributes these psychological states of well-being as another possible contributor for enhancement of falls efficacy among the elderly participants.

4. CONCLUSION

Individualized structured PRT intervention targeting the key muscles of lower limbs for maintenance of balance, as a stand-alone program, 4 times a week for a period of 6 months is comparable to TBE in improving the falls efficacy and thereby, reduce the self-induced functional restrictions among the non-frail elderly people living in geriatric homes.

CONSENT

All authors declare that 'written informed consent' was obtained from the participants.

ETHICAL APPROVAL

All authors hereby declare that the research interventions have been examined and approved by the institutional ethics committee of Kasturba Medical College (Manipal University), Mangalore and therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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