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Original Article

Physiotherapy Section

Effect of Lower Limb Strengthening Exercises and Motor Dual Task Training in Elderly People with Impaired Balance: An Experimental Study

SARULATHA HARIDASS[1], MANIKUMAR MUTHAIAH[2], R VIJAYARAGHAVAN[3], RAMESH KUMAR JEYARAMAN[4]

ABSTRACT

Introduction: Ageing progressively declines movements and functions, thereby impacting muscle strength, endurance, and power. Impaired mobility and muscle strength gradually lead to loss of balance, instability, and an increased risk of falls. The declines in these physical components must be identified early to prevent and control activity loss.

Aim: To compare the efficacy of Progressive Resistance Exercises (PRE) and Motor Dual Task (MDT) on balance, gait, functional performance, self-confidence, and Health Related Quality of Life (HRQOL) in elderly people with impaired balance.

Materials and Methods: This experimental study was conducted at selected elderly care homes at Bangalore, from November 2016 to May 2020. A total of 69 elderly individuals aged between 60 and 75 years were recruited according to the inclusion criteria from three residential homes in East Bangalore (Sarjapur), Karnataka. Participants included in the study were cognitively intact with a minimum Performance Oriented Mobility Assessment score (POMA) score of 24 and an Activity Specific Balance Confidence (ABC) scale score of 70% or less. Baseline data on age, sex, Body Mass Index (BMI), number of falls, and presence of physical discomfort were recorded and preserved for data analysis. Pre and post-test measures of balance and lower limb mobility, functional independence, balance confidence, and HRQOL were measured using the POMA, Short Physical Performance Battery (SPPB), ABC scale, and Euro Quality of Life (EQOL), respectively. Participants in all groups underwent eight weeks of supervised exercise training, with each exercise group performing three sessions per week for a total of 24 sessions. Each session consisted of 10 minutes of warm-up exercises, followed by main exercises (MDT training/PRE/conventional exercises) specific to their assigned groups for approximately 40 minutes, and concluded with 10 minutes of cool down exercises similar to the warm-up session. The data were analysed using Systat SigmaPlot software. A probability of 0.05 or less was considered statistically significant.

Results: The between-group analysis of the POMA and SPPB was analysed using Kruskal-Wallis one-way analysis of variance, while within-group analysis used the Wilcoxon signed rank test, revealing significance in the conventional, PRE, and MDT groups ($p<0.001$). ABC and EQOL scores were analysed using 2-way RM ANOVA. The results showed statistically significant differences in the post-test scores of all three groups. Among the three groups, the improvement in balance (50%), functional performance (42.8%), balance confidence (24.8%), and QOL (28%) was highest in the MDT group (n=2).

Conclusion: MDT training is more effective than PRE and conventional balance exercises, leading to improvements in balance, walking ability, functional performance, balance-related self-confidence, and HRQOL in elderly participants with impaired balance.

Keywords: Ageing, Fall, Quality of life

INTRODUCTION

The life expectancy of elders is rapidly increasing due to enhanced healthcare facilities. By 2025, approximately 840 million people in the geriatric population are anticipated. A steep increase in the ageing proportion from 7.5% to 11.1% is observed between 2010 and 2025, resulting in an elderly population estimated to reach 198 million by 2030 [1]. This will place a burden on the healthcare maintenance and resources of the country to meet the healthcare needs of the elderly [2]. An international report from the World Health Organisation declared that individuals aged 65 and above experience falls at a rate of 28% to 35% each year, and this rate increases with advancing age and associated risk factors [3].

Exercise programs addressing functional declines include resistance exercises, balance training, endurance training, coordination exercises, and multiple component exercises. Daily activities involve dynamic functional tasks that require the simultaneous performance of combined motor activities. In individuals with poor balance control due to various reasons, the ability to perform dual task activities will be impaired. In the elderly, age-related physiological and physical declines contribute to reduced Motor Dual Task (MDT) ability [4]. However, the motor component of dual task activities seems to be underexplored in the literature.

On the other hand, it remains unclear whether strength training improves dual task abilities. When falls occur during dual task activities or settings, it is evident that adults need motor task management strategies to mitigate the risk of falls in such situations. The benefits of motor dual training or strength training for this purpose have not yet been thoroughly explored in the literature. This study addresses the underexplored area of MDT training in fall prevention for the elderly, offering a novel approach that integrates dynamic, real life dual task activities. Unlike traditional balance or resistance exercises, MDT uniquely targets the motor component of dual task performance, an area that has received limited prior investigation.

By comparing MDT, Progressive Resistance Exercises (PRE), and conventional balance training, the study provides fresh insights into their relative impacts on balance, gait, functional performance, and HRQOL. Notably, it breaks new ground by evaluating the long term benefits (3 month follow-up) of these interventions, particularly MDT, and highlights its broader effects on self-confidence and QOL. This innovative focus on MDT underscores its potential as a superior approach compared to single task methods.

Hence, the study aims to compare the efficacy of PRE and MDT on balance, gait, functional performance, self-confidence, and QOL in elderly individuals with impaired balance. The primary objective of

the present study is: (i) To compare the efficacy of PRE and MDT on balance, gait, functional performance, self-confidence (related to ADL), and HRQOL in elderly individuals with impaired balance. The secondary objective is: (ii) To analyse the follow-up effects of PRE, MDT, and conventional balance exercises on HRQOL in elderly individuals with balance impairment.

Hypotheses of the study:

Alternate Hypotheses:

I. There will be a significant difference in balance and gait among elderly individuals with impaired balance when comparing PRE, MDT, and conventional balance exercises.

II. There will be a significant difference in functional performance, self-confidence, and HRQOL among elderly individuals with impaired balance when comparing PRE, MDT, and conventional balance exercises.

III. There will be a significant difference during the follow-up in HRQOL among elderly individuals with impaired balance when comparing PRE, MDT, and conventional balance exercises.

Null Hypotheses:

I. There will not be a significant difference in balance and gait among elderly individuals with impaired balance when comparing PRE, MDT, and conventional balance exercises.

II. There will not be a significant difference in functional performance, self-confidence, and HRQOL among elderly individuals with impaired balance when comparing PRE, MDT, and conventional balance exercises.

III. There will not be a significant difference during the follow-up in HRQOL among elderly individuals with impaired balance when comparing PRE, MDT, and conventional balance exercises.

MATERIALS AND METHODS

This experimental study was conducted at selected elderly care homes at Bangalore, from November 2016 to May 2020. The experimental study commenced after obtaining approval from the Institutional Ethics Committee (001/03/2016/IEC/SU). Elderly individuals who volunteered were screened and recruited after signing the institutionally approved consent form. A patient information sheet was provided, and confidentiality and ethical principles were adhered to as required in this study. A total of 69 elderly participants were recruited from a residential care set-up in Bangalore East (Sarjapur), Karnataka, according to the inclusion and exclusion criteria.

The participants were randomly allocated to the three groups using sequence generation performed by block randomisation. Each block consisted of two PRE, two MDT, and two Conventional Group (CG) participants, resulting in a block size of six, with a total of 12 blocks prepared. The allocation concealment was conducted using sealed opaque envelopes, which were sequentially numbered.

Inclusion and Exclusion criteria: Elderly individuals aged between 60 to 75 years of both genders, who were able to ambulate atleast 5 meters with or without assistance, able to stand independently for one minute without support, and had a POMA and ABC score of less than 24 and 70%, respectively, with no apparent cognitive impairment, were included. Participants with unstable medical conditions, significant visual or auditory impairments, vestibular disorders, severe pain on weight bearing during activities (such as chronic osteoarthritis and osteoporosis), or musculoskeletal disorders of the lower extremity that would interfere with the intervention and outcome measures were excluded. Individuals who had engaged in regular exercise in the past three months, or who had conditions such as stroke, Parkinson's disease, or cancer (either under treatment or in a metastatic stage), were also excluded from participating in the study.

Sample size calculation: The sample size was estimated using SigmaPlot 13.0 (Systat Software USA). For an outcome variable based on the total SPPB score, with a minimum difference score of 2.0 and a standard deviation of 3.5, the sample size required to achieve 90% statistical power and 5% significance levels was calculated to be 60 (20 in each group) [5]. During the sample selection period, a total of 69 participants visited and were randomly allocated into three groups of 23 participants each.

Study Procedure

Around 175 elderly participants were screened from the selected old age homes to obtain a study sample of 69 based on the inclusion criteria. Baseline data on age, sex, number of falls, and the presence of physical discomfort were recorded and preserved for data analysis. Balance, lower limb mobility, functional independence, balance confidence, and QOL were measured using POMA, SPPB, ABC scale, and EQOL (EQ-5D-5L), respectively.

POMA measures evaluate balance, gait abilities, and fall risks in older adults. It has separate sub-tests for balance and gait. The total score achievable is 28; scores lower than 19 indicate a high-risk for falls [6]. SPPB scores of less than six indicate a greater risk for falls and impaired balance [7] in seniors of both genders. Its test components include the five times sit-to-stand chair test and gait speed time, which are highly sensitive for assessing fall risk. The SPPB is determined using three components: the ability to maintain balance for up to 10 seconds in three different foot positions (side-by-side, semi-tandem, and tandem), the time taken to walk three or four meters, and the time required to stand up from a chair five times. For the balance tests, scores are assigned based on how well balance is maintained in each position. For the walking and chair rise tasks, scores are based on both the ability to complete the task and the time taken. Each component is scored out of four, and the scores are combined to produce a total ranging from 0 to 12. Higher scores reflect better physical function, while lower scores indicate reduced function [8].

The ABC scale is a self-reported questionnaire used to assess an individual's confidence in performing various daily activities without losing balance or becoming unsteady. It consists of 16 items, where individuals rate their confidence on a scale from 0% (no confidence) to 100% (complete confidence) for activities such as walking around the house, stepping onto or off an escalator, or walking on a slippery floor. For older adults, an ABC Scale score below 67% indicates a risk of falling and can accurately classify individuals who fall 84% of the time [9]. Additionally, scores above 80% reflect a high level of physical functioning, scores between 50-80% indicate a moderate level of physical functioning, and scores below 50% signify a low level of physical functioning [10]. Hence, ABC scores indicate changes in functional limitations at multiple levels and predict future falls, showing strong internal consistency and reliability in seniors.

EQOL captures generic health-related QOL for measuring individuals' health and health outcomes. The EQOL 5D-5L (EQ-5D-5L) is a standardised instrument used to measure HRQOL. It includes five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression, with each dimension rated on five levels of severity: no problems, slight problems, moderate problems, severe problems, and extreme problems. Responses generate a health state profile, which can be converted into a single index value using a country specific value set. The index value typically ranges from -0.281 (worst health state) to 1.000 (perfect health state), where values below 0 represent health states considered worse than death. Additionally, the EQ-5D-5L includes a Visual Analogue Scale (VAS) for individuals to rate their overall health from 0 (worst health) to 100 (best health). This scoring provides a comprehensive view of a person's perceived health status [11]. A score drop of 0.15 indicates a detrimental impact on the HRQOL of patients [12].

The assessment scales were administered by a blinded assessor to the identified participants before randomly assigning them into

the groups. The assessor was a qualified neuro-physiotherapist with nearly 10 years of experience and knowledgeable about the measurement scales and their administration in elderly individuals. The data were collected before and after eight weeks of intervention. After the initial assessments were completed, the eligible participants at each home were randomised into the study groups: CG, PRE group, and MDT group. A therapist who was blinded to the intervention opened the sealed envelopes. Participants in all groups underwent eight weeks of supervised exercise training. Each exercise group performed three sessions per week for a total of 24 sessions. Each session consisted of warm-up exercises (stretching of major lower limb muscles) for 10 minutes, followed by main exercises specific to their allotted groups for approximately 40 minutes, and cool-down exercises similar to the warm-up session for 10 minutes.

PRE group: The PRE group received strengthening exercises for lower limb muscles. Resistance was provided through weight cuffs tied above the ankle joint; however, for the ankle plantar and dorsiflexors, it was secured around the foot. The program was based on each participant's one-repetition maximum (1 RM). Brzycki's equation, i.e., 1 RM=Weight÷{1.0278-(0.0278×Number of repetitions)}, was used to determine the 1 RM for each muscle group [13]. In the first week of training, participants were trained at 30% of their 1 RM. For the remainder of the program, the PRE load was set at 80% of the 1 RM, corresponding to a load that fatigues the muscle in 8-10 repetitions. Resistance was gradually increased every week or as tolerated by the participant, which maintained the intensity of the stimulus. The 1 RM was reassessed every two weeks, and in the final week, it was ensured that the load of resistance equaled 80% of the 1 RM. The PRE program consisted of one set of 8-10 repetitions for each muscle group during each session, with three sessions per week for a total of eight weeks [14]. A rest period of one minute was allowed between each set of training. Participants were instructed not to hold their breath while performing exercises. The lifting and lowering of the weight during every repetition facilitated concentric and eccentric muscle action. The participants in the PRE group experienced slight muscle discomfort and soreness during the initial sessions, and they were treated symptomatically [2].

MDT group: The dual task exercises were performed first in standing, then progressed to walking. The balance tasks were challenged with upper limb manipulation, changes in base of support, and activities on compliant surfaces. The participants started the exercises from normal standing and altered the base of support. This included standing with feet together side by side, progressing to semi-tandem standing, and tandem standing. The exercises also included weight shifts with active ankle rolling in both normal and tandem stances, as well as one-leg standing with the palm of the hand supported on the wall and later off the wall. MDT included semi-tandem and tandem standing with simultaneous shoulder joint flexion and abduction movements, with both open and closed eyes. This was followed by bouncing a 45 cm gym ball with both hands, catching, and throwing with a distance of 1.5 m, progressing to 2 m. Then the participants continued the previous exercises while standing on foam. Subsequent sets of exercises included walking, semi-tandem walking, and tandem walking at their comfortable speed for a distance of 4 m, as well as dynamic balance activities like walking with changing directions and speed, incorporating alternating hand motions.

Furthermore, during walking, the participants were trained to perform functional secondary tasks simultaneously, such as holding a glass of water while walking, receiving and returning the glass of water, walking while talking to a person, and walking while tossing and catching a ball. Transferring from one chair to another, both to the side and in front, was also practiced by the participants with and without the use of arms. The participants were able to effectively perform the challenging MDT exercises after 8-10 sessions, enabling them to focus on and practice more difficult dual task exercises. They were enthusiastic and actively participated in performing the tasks. A rest period of 2-3 minutes was provided after 15-20 minutes of exercise [2,15].

Conventional Group (CG): Conventional balance exercises are primarily single task exercises focused on improving static and dynamic balance components. These exercises include flexibility and postural control activities aimed at enhancing balance in elderly individuals. The CG received balance exercises that consisted of reaching activities with weight shifts in sitting and standing positions, both anteriorly and laterally, tandem standing, tandem walking, figure-eight walking, as well as forward, backward, and sideways walking. Other activities included sitting on a medium-sized Swiss ball and maintaining balance, as well as perturbations in all directions while standing on stable and unstable platforms [16]. Each of the balance activities was performed for an average of five minutes, with a rest period of one minute between each component. The total session lasted between 40-50 minutes. One participant dropped out of the study, stating severe pain in their foot.

Follow-up was conducted three months after the completion of the 24 sessions of exercise training. Participants were contacted in person and also via telephone due to the Coronavirus Disease 2019 (COVID-19) pandemic situation. Of the 69 participants recruited, approximately 50% responded during the follow-up. For various reasons, only a certain number of study participants were available for follow-up. Some participants were unreachable, while others did not respond to the questionnaire. Based on availability and responses, HRQOL was measured using the EQ-5D-5L index from 12 participants from each group. The primary outcome measures were balance and gait, while the secondary outcome measures included functional performance, balance confidence, and HRQOL.

STATISTICAL ANALYSIS

The data were analysed using SigmaPlot 13 (Systat Software Inc., USA). A probability of 0.05 or less was considered statistically significant. The variables were analysed for significance with a value of $p<0.05$ using Kruskal-Wallis One-Way analysis of variance. The pre- and post-test data between groups were analysed using multiple comparison procedures with Dunn's method, and within-group analysis was conducted using the Wilcoxon signed-rank test for the three groups. The nominal data of ABC, EQ-5D-5L index, and EQ-5D health perception were analysed using two-way repeated measures ANOVA, with a significance value of $p<0.05$. The pre- and post-test data between groups were analysed using multiple comparison procedures with the Bonferroni t-test.

RESULTS

The demographic data and baseline characteristics, such as height, weight, BMI, frequency of falls, and cognitive status, were analysed using median and percentile values for all variables [Table/Fig-1]. The median and percentile values of POMA balance, POMA gait, and POMA total, along with SPPB for the CG, PRE, and MDT groups, are presented in [Table/Fig-2a,b,3a,b]. The pretest scores

S. No.	Characteristics	CG group	PRE group	MDT group	Statistical analysis
1.	Age (years)	67.27±4.42	67.61±4.49	68.18±4.44	F=0.241 p=0.786
2.	Height (cm)	163.7±5.26	162.9±5.8	164.5±5.2	F=0.499 p=0.609
3.	Weight (kg)	65.67±6.79	64.3±6.58	63.86±6.6	F=0.430 p=0.640
4.	Frequency of falls	0.63±0.78	0.56±0.84	0.60±0.94	F=0.038 p=0.963

[Table/Fig-1]: Comparison of baseline measures.
N – CG group=23, PRE=23; MDT group=23; Values are mean±SD
The variables were analysed with significance value of $p<0.05$ using Kruskal-wallis One-way analysis of variance

for balance, gait, and POMA total of the conventional (con), PRE, and MDT groups analysed with Kruskal-Wallis One-Way ANOVA on ranks showed no statistical significance (p=0.229), (p=0.193), (p=0.267), (p=0.810). The post-test scores for the con, PRE, and MDT groups were statistically significant (p<0.001). Compared to the CG group, the PRE and MDT groups showed statistically significant improvement, and the MDT group demonstrated significant improvement compared to the PRE group. Comparing pretest and post-test results using the Wilcoxon signed-rank test revealed significance in the con, PRE, and MDT groups (p<0.001). Among the three groups, the improvement in balance and gait was highest (50%), while functional performance improvement was greatest (42.8%) in the MDT group (N=23).

S. No.	Parameters	Groups	Median	Percentile (25-75)	Z value	*p-value
1	Balance	Con-Pre-test	10.0	8.0-10.25	3.656	0.00026
		Con-Post-test	12.0	9.0-13.0		
		PRE-Pre-test	10.0	9.0-11.0	4.299	0.000017
		PRE-Post-test	13.0	12.0-14.0		
		MDT-Pre-test	10.0	10.0-11.0	4.322	0.000015
		MDT-Post-test	15.0	14.0-15.0		
2	Gait	Con-Pre-test	6.0	4.0-7.0	3.386	0.00071
		Con-Post-test	7.0	5.75-8.0		
		PRE-Pre-test	6.0	5.0-7.0	4.157	0.000032
		PRE-Post-test	9.0	8.0-10.0		
		MDT-Pre-test	7.0	6.0-7.0	4.322	0.000015
		MDT-Post-test	10.0	10.0-10.0		
3	POMA total	Con-Pre-test	16.0	11.0-18.0	4.155	0.000033
		Cont-Post-test	20.0	14.5-21.0		
		PRE-Pre-test	17.0	14.0-18.0	4.230	0.000023
		PRE-Post-test	23.0	21.0-23.0		
		MDT-Pre-test	17.0	16.0-18.0	4.248	0.000022
		MDT-Post-test	25.0	25.0-25.0		

[Table/Fig-2a]: Comparison of conventional (con), Progressive Resisted Exercise (PRE) and Motor Dual Task (MDT), within the groups on POMA-balance, POMA-gait, POMA in elderly population with impaired balance.
n: conventional group=22, PRE=23, MDT=23. *Wilcoxon sign rank test

S. No.	Parameters	Groups	Q value	*p-value
1	Balance	Con vs PRE	2.756	0.018
		PRE vs MDT	2.677	0.022
		MDT vs Con	5.403	<0.001
2	Gait	Con vs PRE	3.444	0.002
		PRE vs MDT	3.199	0.004
		MDT vs Con	6.607	<0.001
3	POMA Total	Con vs PRE	3.301	0.003
		PRE vs MDT	3.292	0.003
		MDT vs Con	6.556	<0.001

[Table/Fig-2b]: Comparison of conventional (con), Progressive Resisted Exercise (PRE) and Motor Dual Task (MDT), between the groups on POMA -balance, POMA-gait, POMA in elderly population with impaired balance.
n- conventional group=22, PRE=23, MDT=23. *Kruskal-Wallis one way analysis of variance on ranks

ABC

The mean ABC scores for all groups are shown in [Table/Fig-3a,b]. Two-way RM ANOVA and Bonferroni t-test showed no significance among the groups (p=0.165). Compared to the CG group, the PRE group was not significant, whereas the MDT group showed significance. The PRE and MDT groups were not significant compared to each other. Statistical significance between the pretest and post-test was observed in the con, PRE, and MDT groups (p<0.001) [Table/Fig-3a]. Among the three groups, the improvement in ABC was highest (24.8%) in the MDT group.

S. No.	Parameters	Groups	Median	Percentile 25-75	Z value	*p-value (Wilcoxon signed rank test)
1	SPPB	Con-Pre-test	8.0	7.0-8.25	3.358	<0.001
		Con-Post-test	8.0	8.0-9.0		
		PRE-Pre-test	7.0	7.0-8.0	4.091	<0.001
		PRE-Post-test	9.0	9.0-10.0		
		MDT-Pre-test	7.0	7.0-8.0	4.248	<0.001
		MDT-Post-test	10.0	9.0-10.0		
S. No.	**Parameters**	**Groups**	**Mean**	**SEM**	**Bonferroni t-test**	**p-value**
2	ABC	Con-Pre-test	60.50	2.164	6.236	<0.001
		Con-Post-test	63.955	2.065		
		PRE-Pre-test	61.08	2.134	16.024	<0.001
		PRE-Post-test	69.768	1.632		
		MDT-Pre-test	60.14	2.151	27.446	<0.001
		MDT-Post-test	75.014	1.728		
3	EQOL-5D-5L index	Con-Pre-test	0.54	0.026	0.576	0.56
		Con-Post-test	0.55	0.023		
		PRE-Pre-test	0.55	0.024	3.126	0.003
		PRE-Post-test	0.63	0.021		
		MDT-Pre-test	0.57	0.022	6.661	<0.001
		MDT-Post-test	0.73	0.021		
4	EQOL-Health perception	Con-Pre-test	64.22	2.13	1.868	0.066
		Con-Post-test	68.04	2.39		
		PRE-Pre-test	61.22	2.62	4.522	<0.001
		PRE-Post-test	70.78	2.41		
		MDT-Pre-test	62.95	2.79	9.357	<0.001
		MDT-Post-test	82.22	2.34		

[Table/Fig-3a]: Comparison of conventional, Progressive Resisted Exercise (PRE) and Motor Dual Task (MDT) within group analysis on SPPB, ABC, EQOL in elderly population with impaired balance.

S. No.	Parameters	Groups	Dif of ranks	Q value	p-value (Kruskal wallis One-way analysis of variance)
1	SPPB	Con vs PRE	14.428	2.447	0.043
		PRE vs MDT	15.022	2.576	0.030
		MDT vs Con	29.450	4.994	<0.001
S. No.	**Parameters**	**Groups**	**Dif of means**	**Bonferroni t-test**	**p-value**
2	ABC	Con vs PRE	11.060	2.060	0.130
		PRE vs MDT	5.247	1.880	0.193
		MDT vs Con	11.060	3.919	<0.001
3	EQOL	Con vs PRE	0.177	5.492	<0.001
		PRE vs MDT	0.101	3.155	0.006
		MDT vs Con	0.117	5.492	<0.001
4	EQOL Health perception*	Con vs PRE	8.109	2.239	0.083
		PRE vs MDT	8.783	2.452	0.049
		MDT vs Con	16.891	4.663	<0.001

[Table/Fig-3b]: Comparison of conventional, Progressive Resisted Exercise (PRE) and Motor Dual Task (MDT) between group analysis on SPPB, ABC, EQOL in elderly population with impaired balance.

HRQOL

The mean EQ-5D-5L scores for all groups are shown in [Table/Fig-3a,b]. Two-way RM ANOVA and Bonferroni t-test showed statistical significance among the groups (p<0.001). The post-test showed statistical significance among the groups. Compared to the CG group, the PRE group was not significant, while the MDT group showed significance. Furthermore, the MDT group showed significant improvement compared to the PRE group. Statistical significance

was observed only in the MDT group between the pretest and post-test (p<0.001). Among the three groups, the improvement in the EQ-5D-5L index was highest (28%) in the MDT group.

Follow-up

The mean and SEM of the EQ-5D-5L index for the con, PRE, and MDT groups are provided in [Table/Fig-4a,b]. The difference between the post-test and follow-up mean values was analysed using ANOVA and Bonferroni t-test. Two-way RM ANOVA showed significance among the groups (p<0.001). Statistical significance was also observed for the tests as well as for the group and tests interaction (p=0.0527). Statistical significance was found in the MDT group only during the post-test. Compared to the CG group, the PRE group was not significant, whereas the MDT group was significant. The follow-up showed statistical significance between the two groups. Again, the PRE group was not significant compared to the CG group, while the MDT group showed significance. The PRE and MDT groups also showed significance. However, between the post-test and follow-up, statistical significance was not observed in the con, PRE, or MDT groups (p<0.001). Among the three groups, the improvements in the EQ-5D index were highest (11%) in the MDT group.

S. No.	Parameter	Groups	Mean	SEM	Bonferroni t-test	p-value
1	EQ-5D-5L index	Con-Post-test	0.526	0.03	0.149	0.883
		Con-Follow-up	0.534	0.036		
		PRE-Post-test	0.612	0.05	0.194	0.848
		PRE-Follow-up	0.624	0.04		
		MDT-Post-test	0.719	0.04	1.571	0.126
		MDT-Follow-up	0.812	0.038		
2	EQOL- Health perception	Con-Post-test	65	2.98	0.309	0.759
		Con-Follow-up	65.83	3.30		
		PRE-Post-test	69	2.94	0.743	0.463
		PRE-Follow-up	70.42	3.45		
		MDT-Post-test	69	3.37	3.094	0.004
		MDT-Follow-up	88.33	3.03		

[Table/Fig-4a]: Comparison of conventional (Con), Progressive Resisted Exercise (PRE) and Motor Dual Task (MDT) within group on EQ-5D-5L follow-up in elderly population with impaired balance.

S. No.	Parameter	Groups	Dif of means	Bonferroni t-test	p-value
1.	EQOL	Con vs PRE	0.0892	1.601	0.343
		PRE vs MDT	0.188	3.374	0.004
		MDT vs Con	0.277	4.975	<0.001
2.	EQOL Health perception	Con vs PRE	5.750	1.468	0.444
		PRE vs MDT	19.583	5.001	<0.001
		MDT vs Con	25.333	6.469	<0.001

[Table/Fig-4b]: Comparison of conventional (Con), Progressive Resisted Exercise (PRE) and Motor Dual Task (MDT) between group on EQ-5D-5L follow-up in elderly population with impaired balance.

DISCUSSION

The present study demonstrated significant improvements in balance and gait in the MDT group compared to the PRE and CG groups validating the null hypothesis. This aligns with previous research highlighting the critical role of dual task training in improving gait parameters and mitigating fall risks among older adults. For example, dual task interference has been identified as a significant predictor of falls, and interventions targeting this factor often lead to notable improvements in gait performance and balance [17,18]. Similar to findings from a previous study [19], proprioceptive balance motor dual task training in the current study enhanced ankle range of motion and postural responses, directly contributing to improved gait performance. Unlike protocols that fail to adequately address dual task contributors [20], our study incorporated task-specific interventions, leading to clinically meaningful improvements in the POMA scores. While previous studies have reported improved gait performance and reduced fears of falling with dual task training [21], our findings underscore the greater efficacy of MDT in addressing underlying gait abnormalities, such as a wider base of support or altered gait lines observed in older adults at high-risk of falls. The MDT group exhibited a more significant mean difference in functional performance scores (1.37) compared to the PRE group (0.67) and the CG (0.69), consistent with studies identifying Minimal Clinically Important Differences (MCID) in SPPB scores between 0.54 and 2.9 [22]. These results highlight the superior impact of balance-specific MDT on functional outcomes. Unlike interventions lacking targeted balance components, which fail to produce significant physical performance gains [23], the current study demonstrates that progressively challenging postural stability exercises significantly enhance functional mobility.

The active ankle movements practiced during MDT sessions may have further amplified these gains by improving postural control and gait mechanics, as corroborated by earlier findings [24,25]. Significant improvements in the ABC scores were noted with MDT training, achieving a clinically relevant mean difference of 11.06. This surpasses the typical cut-off values used to identify fall risks in Indian populations [26]. Earlier research corroborates that dual task interventions can effectively reduce fall-related concerns, thereby increasing physical activity and self-confidence in older participants [25,27]. The gradual progression from basic to complex dual task exercises in the present study appears pivotal, as it facilitated a smooth adaptation to balance challenges. This contrasts with studies employing less structured progression, which may fail to build sustained confidence in balance-related activities [28].

Improvements in EQ-5D-5L domains, particularly mobility and self-care, reflect the broader impact of MDT training on HRQOL. The present findings are consistent with studies reporting associations between improved physical performance and enhanced HRQOL [29,30]. Previous studies have linked poor balance confidence with lower HRQOL scores, as seen in a 0.15-point deficit on EQ-5D-5L indexes among those with fall-related fears [30]. The current study's results support this relationship, showing that balance-focused MDT not only improves functional abilities but also translates into better overall health perceptions. The follow-up assessment revealed sustained improvements in HRQOL metrics among participants who underwent MDT training. These findings align with long term observations from studies on elderly populations that show sustained functional and quality of life gains post-intervention [30,31]. Despite challenges in participant retention during follow-up due to the COVID-19 pandemic, the responses gathered reinforce the robustness of the MDT approach in imparting long term benefits.

Limitation(s)

While the study initially recruited 69 participants, only a limited number (12 per group) were available for follow-up. This reduces the statistical power and generalisability of the long term findings. The intervention lasted for only eight weeks, which may not be sufficient to assess the long term impact of the training programs, especially since the follow-up was limited to three months post-intervention. Although the study focused on MDT, it did not address cognitive dual tasking, which is also a significant factor in fall prevention and functional performance in older adults. Furthermore, self-reported QOL and confidence may be influenced by participant perception and bias, which could impact the objectivity of the results.

CONCLUSION(S)

Compared to conventional and resistance-based training protocols, MDT demonstrated consistently superior outcomes across all

measured domains. These findings not only validate the efficacy of MDT in addressing dual task deficits but also highlight the need for structured, progressive interventions tailored to the specific balance and functional requirements of older adults. The study emphasizes the superior efficacy of MDT training over PRE and conventional training for improving balance, gait, functional performance, balance confidence, and HRQOL in elderly individuals with impaired balance. MDT interventions effectively address dual task deficits, which are critical for fall prevention and enhancing mobility. These findings suggest that incorporating structured, progressive MDT programs into geriatric physiotherapy protocols can significantly reduce fall risks and improve the overall wellbeing of older adults.

Future research should focus on exploring the benefits of MDT in elderly populations with co-morbidities and should incorporate more extensive follow-up periods to evaluate the long term retention of gains. Additionally, integrating dual task assessments in clinical balance and gait evaluations may refine targeted interventions. Developing cost-effective MDT modules for large-scale implementation in community and clinical settings can further enhance accessibility and address the growing burden of falls in ageing populations.

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PARTICULARS OF CONTRIBUTORS:
1. Professor, Department of Physiotherapy, Sri Devaraj Urs Academy of Higher Education and Research, Bangalore, Karnataka, India.
2. Professor, Department of Physiotherapy, Saveetha Institute of Medical and Technical Sciences, Chennai, Tamil Nadu, India.
3. Director, Department of Research, Saveetha Institute of Medical and Technical Sciences, Chennai, Tamil Nadu, India.
4. Professor, Department of Physiotherapy, Danalakshmi Srinivasan University, Trichy, Tamil Nadu, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Sarulatha Haridass,
Professor, Department of Physiotherapy, Sri Devaraj Urs Academy of Higher Education and Research, Bangalore, Karnataka, India.
E-mail: charuparthe@gmail.com

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