Effect of Dual Task Training on Improving Postural Stability, Cognitive Function and Quality of Life in Geriatrics.

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ABSTRACT

Background: *Aging is often accompanied by physiological changes that increase the risk of balance issues and falls in the elderly population. Dual-task training, combining cognitive exercises with physical activities, has emerged as a potential intervention to address these concerns. This study aimed to investigate the effects of an 8-week dual-task training intervention on postural stability, cognitive function, and quality of life in older adults.* ***Aim:*** *The study sought to examine the impact of dual-task training on physical stability and cognitive function in elderly participants, with the goal of reducing fall risk and enhancing overall well-being.* ***Methods:*** *A pre-test post-test randomized controlled trial was conducted with 50 elderly participants aged 60-70 years. Participants were randomized into two groups: one undergoing dual-task training (Group A) and the other engaging in single-task physical exercises (Group B). Various outcome measures, including the Timed-Up-and-Go test, Biodex postural stability tests, Mini-Mental State Examination (MMSE), and SF-12 questionnaire, were assessed before and after the intervention.* ***Results:*** *Both groups showed significant improvements in the Timed-Up-and-Go test, indicating enhanced mobility. However, Group A demonstrated greater improvements in postural stability, cognitive function (MMSE), and quality of life (SF-12) compared to Group B. These findings suggest that dual-task training is more effective in improving physical stability and cognitive function in elderly individuals.* ***Conclusion:*** *The study provides robust evidence supporting the efficacy of dual-task training in enhancing balance, cognitive function, and quality of life in older adults. Implementing multifaceted interventions that combine physical and cognitive exercises can significantly reduce fall risks and improve overall well-being in the aging population. Further research is needed to explore gender differences in intervention responses and optimize treatment parameters for personalized fall prevention strategies.* ***Key words:*** *Elderly, Dual-task training, Balance, Cognitive function, Quality of life*

INTRODUCTION

The elderly population typically aged 60 years and above, undergoes various physiological changes that can adversely affect balance, mobility, and overall quality of life (1). Age-related degeneration and disease-related declines often lead to weakened core muscles, altered muscle activation patterns, reduced proprioception, and difficulties in maintaining normal postural movements, all contributing to balance issues in older adults (1).

Balance, defined as the ability to keep the center of body mass within a stability boundary, relies on the integration of visual, vestibular, and somatosensory inputs to assess body position and movement (2). Compromised balance in older adults significantly increases the risk of falls, which can result in serious injuries and psychological distress, contributing to a cycle of reduced mobility and further health decline (2).

Falls are a prevalent occurrence among older adults and can result in severe injuries such as head trauma and fractures (2). Recurrent falls are particularly common and contribute to substantial morbidity and mortality in this demographic (3). Beyond physical harm, repeated falls can lead to fear and psychological distress, known as "post-fall syndrome," wherein older adults may become hesitant to move due to the fear of experiencing further falls and subsequent injury (4).

Cognitive functions, essential for interpreting and managing environmental information, span from optimal functioning to dementia (5). Age-related cognitive deterioration impacts the execution of both basic and complex daily tasks. Maintaining proper cognitive function is crucial for executing daily activities, and various factors can contribute to the physiological deterioration of cognitive functions associated with aging (5).

Postural stability, crucial for motor control and coordination, depends on proprioceptive input and sensorimotor mechanisms (6). This stability involves both higher-level cortical processes and lower-level brainstem functions, indicating the engagement of the basal ganglia–cortical loop for higher-level functions and brainstem synergies for lower-level functions (6),

Dual-task (DT) training, which involves performing multiple tasks simultaneously, has been explored as a method to improve balance and cognitive function in older adults (7). Studies indicate that dual-task conditions can elevate fall risks among elderly individuals with balance impairments, highlighting the need for targeted interventions (7). Recent research indicates that older adults who struggle with dual-task conditions face an elevated risk of falls, underscoring the impact of cognitive task performance on balance (7).

Dual-task training has shown promise in enhancing gait and balance, particularly for individuals with neurological conditions like stroke and Parkinson's disease, by integrating cognitive challenges with physical exercises (8). Combining traditional gait and balance exercises with dual-task challenges is believed to offer benefits for improving balance and walking impairments post-stroke (7). Utilizing DT during training has been associated with improvements in various aspects of gait, including gait speed, step length, and cadence (8).

In light of these findings, this study aims to investigate the effects of dual-task training on postural stability, cognitive function, and quality of life in older adults. By examining an 8-week dual-task training intervention, this research seeks to contribute to the development of strategies that promote holistic well-being and functional independence among the elderly

MATERIAL AND METHODS:

Methodology

2.1 Study Design and Setting:

This research employed a pre-test post-test randomized controlled trial design and was conducted at the Faculty of Physical Therapy, Cairo University between January 2024 to May 2024.

2.2 Ethical Considerations:

Informed consent was obtained from all individual participants after explaining the scope and purpose of the research, ensuring their right to decline participation at any time, and guaranteeing the privacy of their information. The study received approval from the Research Ethical Committee, Faculty of Physical Therapy, Cairo University, under the identification (number P.T.REC/012/00582)

2.3 Sample size Calculation

Using data from the Biodex balance system obtained through a pilot study with Each group contains five subjects, the G*POWER statistical software (version 3.1.9.2; Franz Faul, Universitat Kiel, Germany) was utilized to determine the sample size, which came out to be fifty subjects. $\alpha = 0.05$, power = 80%, and effect size = 0.9 were calculated.

2.4 Study population

The study's patient selection criteria included elderly men and women aged 60-70 years with a BMI of 18.5 to 29.9 kg/m², who could walk independently and had controlled metabolic and cardiopulmonary disorders. Exclusion criteria ruled out patients with physical disabilities, mental disorders or dementia, vestibular disorders, postural hypotension, surgical illnesses interfering with movement, acute infections, recent artificial joint replacements in the lower limbs, or recent bone fractures. These criteria ensured the inclusion of patients capable of safely participating in the study while excluding those with conditions that could affect the study's outcomes.

2.5 Randomization

Sixty three subjects of both genders were assembled. During the eligibility assessment, 13 patients were excluded: 6 refused to participate in the study, 4 were diagnosed with vestibular disorders, and 3 had a history of previous spine surgery. The study included a total of fifty eligible participants, consisting of 14 men and 36 women, who were randomized into tw0 equal groups (A, and B), each comprising 25 patients. Concealed allocation was implemented by an impartial individual not involved in patient treatment or recruitment. This individual utilized index cards with sequential numbers, each numbered individually, folded, and sealed in opaque envelopes containing the randomly assigned intervention group. On the initial examination day, the researcher opened the envelope and commenced treatment as per the group.

2.6 Intervention

In this study, Group A underwent dual-task training, which involved performing cognitive tasks simultaneously with exercise tasks. The cognitive tasks included number counting, simple arithmetic, word association, and picture matching, while the exercise tasks focused on aerobic, balance, and strength training. For instance, participants would stand up from the bed and count numbers silently, or stretch their arms while performing simple arithmetic. Other activities included lifting heels, alternating foot tolerance, walking on flat surfaces, and using stationary bikes, all combined with cognitive exercises such as remembering and recalling pictures, letters, and objects.

In contrast, Group B, the control group, engaged in single-task training that focused solely on physical exercises without any concurrent cognitive tasks. Their regimen included similar physical activities such as standing up from the bed, stretching arms in various directions, lifting heels, and walking on flat surfaces. Additionally, they used stationary bikes and performed exercises like placing one foot on the wall and alternating foot tolerance. This group also followed the same aerobic, balance, and strength training exercises as Group A, but without the cognitive challenges.

Both groups trained three times a week for a total of eight weeks, with each session lasting 30 minutes. Throughout the training sessions, therapists provided verbal instructions to ensure correct posture and allowed participants to rest if they experienced fatigue, discomfort, or pain. This structured approach aimed to compare the effectiveness of dual-task versus single-task training in improving the participants' physical and cognitive functions.

2.7 Outcome measures

2.7.1 Postural stability using Biodex Balance System

The overall stability index (OSI), anteroposterior stability index (APSI), and mediolateral stability index (MLSI) are recorded with a Biodex Balance System, Postural stability test will be performed in the double leg standing position with the eyes open (9).

2.7.2 Timed-Up-and-Go test (TUG)

It is used to quantify dynamic balance and functional mobility. The standard version of the test will be used, in which participants are observed and timed while rising from a chair, walking three meters at a self-selected speed, turning, walking back, and sitting down again (10).

2.7.3 Cognitive deficit: using Mini-Mental State Examination (MMSE) Questionnaire

It is a 30-point questionnaire that is used extensively in clinical and research settings to measure cognitive impairment. It is also used to estimate the severity and progression of cognitive impairment and to follow the course of cognitive changes in an individual over time; thus making it an effective way to document an individual's response to treatment Administration of the test takes between 5 and 10 minutes and examines functions including registration (repeating named prompts), attention calculation, recall, language, ability to follow simple commands and orientation (11).

2.7.4 Quality of life: using The 12 Item Short Form Health Survey (SF12) Questionnaire

The SF-12 Health Survey Questionnaire is used to evaluate the health-related quality of life (HR-QoL) before and after the interventions. The SF-12 consists of 12 questions that examine eight different health domains in order to determine physical and mental health. General Health (GH), Physical Functioning (PF), Role Physical (RP), and Body Pain (BP) are the physical health domains. Vitality (VT), Social Functioning (SF), Role Emotional (RE), and Mental Health (MH) are mental health-related scales (12).

Assessed for eligibility= 63

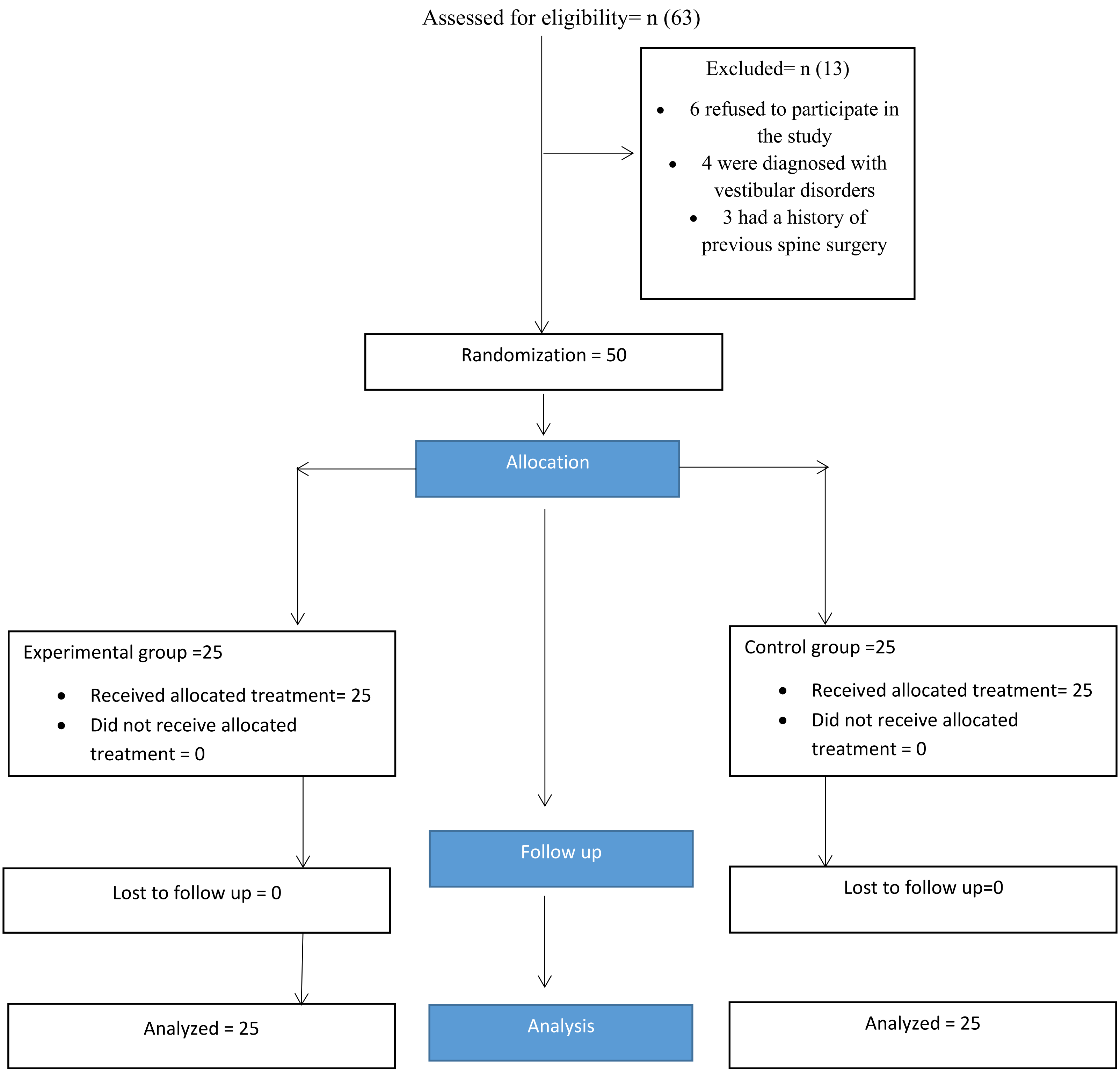

Figure 1; Randomization flow chart

DATA ANALYSIS

SPSS software version 22 was used to conduct all statistical analyses. A comparison between both groups' features, including age and BMI, was performed using an unpaired T-test. The Mann-Whitney U test was employed to conduct a comparison between the sexes of both groups. Subsequently, MANOVA was conducted to compare the variables between groups. The significance level for all statistical tests was set at P < 0.05.

RESULTS

A total of 50 participants were distributed randomly into two equal groups, with 25 subjects in every group. According to **Table 1**, there was no significant difference in the participants' characteristics, including age, BMI, or sex (p-value was 0.206, 0.201, and 1.000, respectively).

Table 1. Comparison of characteristics between groups A and B.

	Group A (n:25) Study		Group B (n:25) Control		p-value	t-value
	$\bar{X}$ ± SD		$\bar{X}$ ± SD			
Age (years)	64.8±2.8		65.8±2.7		0.206	1.282
BMI (kg/m²)	24.9±2.7		25.9±2.7		0.201	1.298
	Male	**Female**	**Male**	**Female**		
Sex	28%(7)	72%(18)	28%(7)	72%(18)	1.000	

$\bar{X}$: Mean, SD: Standard deviation, p-value: Probability value, *: significance

The outcomes indicated that the TUG was significantly decreased in both groups. Furthermore, no significant variations were observed between both groups before and after intervention (P-values were 0.216 and 0.249, respectively). Group A revealed an elevated percentage of reduction (14.18%) compared with the control group B (13.2%) (**Table. 2**).

Table 2. Comparison between groups A and B regarding TUG (sec).

		Group A (n:25) Study	Group B (n:25) Control	Comparison between groups	
		$\bar{X}$ ± SD	$\bar{X}$ ± SD	F-value	P-value
TUG (sec)	**Pre-intervention**	14.1±2.8	15.1±2.8	1.574	0.216
	Post-intervention	12.1±2.6	13.1±2.9	1.364	0.249
	Comparison within group	P<0.05*	0.006*		
	Percentage of change (%)	14.18%	13.2%		

$\bar{X}$: Mean, SD: Standard deviation, p-value: Probability value, *: significance, TUG: Time up & go test

Moreover, regarding the Biodex postural stability test, study group A revealed a significant decrease in all indexes with the percentage of change as follows: overall: 18.2%; anterior/posterior: 25.2%; medial/lateral: 16.8%. However, there was no significant change was detected in the control group B. Furthermore, no significant variation was observed before intervention; however, there was a significant difference between both groups after treatment (**Table. 3**).

Table 3. Comparison between groups A and B regarding the Biodex postural stability test.

Biodex postural stability test		Group A (n:25) Study	Group B (n:25) Control	Comparison between groups	
		$\overline{X}$ ± SD	$\overline{X}$ ± SD	F-value	P-value
Overall index	**Pre-intervention**	1.7±0.38	1.86±0.37	2.174	0.147
	Post-intervention	1.39±1.36	1.7±0.5	7.832	0.007*
	Comparison within group	P<0.05*	0.347		
	Percentage of change (%)	18.2%	8.6%		
Anterior/Posterior index	**Pre-intervention**	1.19±0.29	1.29±0.29	1.495	0.227
	Post-intervention	0.89±0.27	1.27±0.45	12.611	0.001*
	Comparison within group	P<0.05*	0.882		
	Percentage of change (%)	25.2%	1.6%		
Medial/Lateral index	**Pre-intervention**	1.07±0.3	1.068±0.1	0.004	0.950
	Post-intervention	0.8±0.25	1.1±0.5	8.604	0.005*
	Comparison within group	P<0.05*	0.446		
	Percentage of change (%)	16.8%	2.9%		

$\overline{X}$: Mean, SD: Standard deviation, p-value: Probability value, *: significance

Regarding the outcomes of MMSE, both study and control groups showed a significant change with the percentage of (7.4% and 5.2%, respectively); however, no significant difference was detected pre-intervention (P-value was 0.158), but there was a significant difference post-intervention (P-value was 0.003). Regarding the findings of SF-12, study group A revealed a significant elevation with a percentage of change of 14.4%; however, no significant change was detected in control group B. Moreover, no significant difference was observed pre-intervention, but there was a significant variation between both groups post-intervention (P-value was 0.001) (**Table. 4**).

Table 4. Comparison between groups A and B regarding MMSE and SF-12.

Questionnaire		Group A (n:25) Study	Group B (n:25) Control	Comparison between groups	
		$\overline{X}$ ± SD	$\overline{X}$ ± SD	F-value	P-value
MMSE	**Pre-intervention**	26.4±1.35	25.96±0.97	2.060	0.158
	Post-intervention	28.36±1.18	27.32±4.8	0.643	0.003*
	Comparison within group	P<0.05*	P<0.05*		
	Percentage of change (%)	7.4%	5.2%		
SF-12	**Pre-intervention**	44.4±2.6	43.96±3.69	0.107	0.745
	Post-intervention	50.8±6.1	44.68±5.5	13.75	0.001*
	Comparison within group	P<0.05*	0.500		
	Percentage of change (%)	14.4%	1.6%		

$\overline{X}$: Mean, SD: Standard deviation, p-value: Probability value, *: significance, MMSE: Mini-Mental State Examination, SF-12: 12 Item Short Form Health Survey

DISCUSSION

This study provides robust evidence supporting the efficacy of dual-task training in enhancing both physical stability and cognitive function in elderly participants, thereby reducing the risk of falls. The intervention used in this study, which included both physical and cognitive training components, resulted in significant improvements in measures of physical stability, and cognitive function, , particularly in the study group (Group A).

The improvements in the Time Up and Go (TUG) test, Biodex postural stability tests, and the MMSE and SF-12 questionnaires in Group A compared to the control group (Group B) suggest that targeted interventions can substantially enhance functional outcomes in the elderly. The Biodex tests, which showed significant gains in stability indices for Group A, underline the benefits of exercises aimed at improving balance and coordination. These findings are in line with research by Sherrington et al. (2019) and Liu-Ambrose et al. (2015), who highlighted the positive impact of balance and functional exercises on reducing fall rates and improving balance in older adults (13,14).

The cognitive improvements observed in Group A, as measured by the MMSE, are consistent with studies by Bherer et al. (2013) and Lustig et al. (2009), which demonstrated that cognitive training can enhance executive functions, memory, and processing speed, crucial for fall prevention (15,16). These cognitive benefits likely contributed to the improved physical performance and reduced fall risk, as efficient cognitive processing aids in better environmental navigation and decision-making (15).

Additionally, the psychological aspects of fall prevention, such as increased confidence and reduced fear of falling, likely played a significant role in the observed improvements. Studies by Delbaere et al. (2010) and Paddon et. al. (2024) have shown that enhancing balance confidence and reducing fear can prevent the cycle of inactivity and decline that increases fall risk. This psychological uplift can encourage elderly individuals to engage more in daily activities, further enhancing their mobility and quality of life (17,18).

The significant improvement in quality of life, as assessed by the SF-12, in Group A highlight the importance of multifaceted intervention programs. Gillespie et al. (2012) has also supported this view, showing that comprehensive programs that include exercise, home hazard assessment, and education significantly enhance overall well-being (19).

This study's findings suggest several practical steps for clinical implementation and highlight areas for future research. Clinically, it is recommended to integrate balance and strength training with cognitive exercises to comprehensively address the physical and cognitive aspects of fall risk. Development of holistic programs that encompass a variety of fall-contributing factors could broaden the effectiveness of fall prevention strategies. Regular use of assessment tools such as the TUG test, Biodex stability tests, and MMSE is advised for continuous evaluation of participant balance, stability, and cognitive function. Moreover, customizing these interventions based on ongoing assessments will help maintain their relevance and effectiveness, adapting to each individual's progress and needs. Additionally, incorporating psychological support and educational strategies could bolster participant confidence, reduce fear of falling, and improve overall adherence and sustainability of the exercise regimens.

Future research should explore several areas to enhance the understanding and effectiveness of fall prevention strategies in the elderly. Studies should consider the differences in intervention responses between genders and employ larger sample sizes for more generalizable results. Investigating the specific impacts of dual-task rehabilitation could further clarify its benefits in simultaneously enhancing both balance and cognitive functions. Determining optimal treatment parameters, such as the total number of sessions, duration of each session, and necessary frequencies, will also be crucial in optimizing fall prevention programs tailored to the elderly population's needs. These directions not only aim to refine current practices but also to expand the scope of effective fall prevention methodologies.

The study has several limitations that could impact the generalizability and interpretation of its findings. Firstly, the small sample size of 50 participants may not adequately represent the broader elderly population, limiting the statistical power and reliability of the results. There's also a potential lack of diversity if participants come from similar backgrounds, affecting external validity. The study also didn't explore gender-specific responses to the intervention, which could be significant given physiological differences. Moreover, the study has introduced new approach in dealing with the elderly to improve their balance since there is a limitation in the number of research papers that address the same research question. That’s why, the researchers have not found several papers to be discussed.

CONCLUSION

The findings of this study underscore the effectiveness of dual task training in improving balance, cognitive function, and overall quality of life in elderly individuals. Implementing these evidence-based recommendations and strategies can significantly reduce fall risks, enhance functional independence, and improve the well-being of the aging population. By adopting a multifaceted approach that includes physical, cognitive, and social elements, healthcare providers can offer comprehensive care that addresses the diverse needs of elderly individuals, thereby fostering a safer and healthier aging experience.

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