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The Effect of Balance Training on Cognitive and Occupational Performance of the Elderly

M. Azhdar (MSc)[1], N. Mirzakhani (PhD)[*1], A. Irani (PhD)[1], A. R. Akbarzadeh Baghban (PhD)[2], A. Daryabor (PhD)[3], S. Sangi (PhD)[4], N. Afshin Jah (MSc)[5]

1.Department of Occupational Therapy, School of Rehabilitation, Shahid Beheshti University of Medical Sciences, Tehran, I.R.Iran.
2.Physiotherapy Research Center, Shahid Beheshti University of Medical Sciences, Tehran, I.R.Iran.
3.Department of Physiotherapy, School of Rehabilitation, Shahid Beheshti University of Medical Science, Tehran, I.R.Iran.
4.Department of Elderly Care, University of Applied Science & Technology of Kahrizak Sanatorium for the Disabled and the Elderly, Tehran, I.R.Iran.
5.Department of Occupational Therapy, School of Rehabilitation, Toronto University, Torentto, Canada.

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ABSTRACT

Background and Objective: One of the most important problems of old age is physical health and cognitive problems that have a significant effect on their quality of life. Balance training can improve motor and cognitive function in the elderly. Therefore, the aim of this study was to investigate the effect of balance training on cognitive and occupational performance of the elderly.

Methods: This quasi-experimental study (pretest-posttest design) was performed on 13 elderly people aged 60-75 years in Kahrizak Charity Center in Tehran. Elderly people with the ability to walk independently, with a score of at least 20 on the Mini-Mental State Exam (MMSE) and a score of 20-40 on the Berg Balance Scale (BBS) underwent the cognitive tests of the Tower of London, the N-back task, and Advanced Reaction Time in the first week, each of which measures the variables of problem-solving, working memory, reaction time (simple, diagnostic, and selective), respectively, while the Canadian Occupational Performance Measure (COPM) was used to assess performance and satisfaction. Then, balance training was performed in twenty sessions for ten weeks, two sessions per week for each elderly person, and in the last week of the intervention, cognitive tests and occupational performance were repeated and the results were compared before and after the experiment.

Findings: The mean score of working memory before and after the intervention increased significantly from 21.92±5.47 to 30.38±5.36 ($p<0.001$) and problem solving from 13.15±9.92 to 19.38±11.87 ($p=0.003$), respectively. The mean score of occupational performance increased significantly from 6.47±1.53 to 7.07±1.71 ($p=0.002$) and variable of satisfaction from 6.51±1.79 to 7.10±1.61 ($p=0.02$). However, no significant change was observed in the reaction time variable (simple, diagnostic, and selective).

Conclusion: The results of the study showed that participating in a balance training program can have positive effects on a number of cognitive functions such as problem solving, working memory and also occupational performance (performance, satisfaction) in the elderly.

Keywords: *Balance, Balance Training, The Elderly, Cognition, Occupational Performance.*

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[*]Corresponding Author: N. Mirzakhani (PhD)
Address: School of Rehabilitation, Shahid Beheshti University of Medical Sciences, Damavand Street, Emam Hossein Square, Tehran, I.R.Iran.
Tel: +98 (21) 77561721. **E-mail:** mirzakhany@sbmu.ac.ir

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Introduction

According to the census in 1956, about 5% of the population of Iran were people aged 60 and older, while this percentage increased to 8.2% in 2011 and 9.3% in 2016 (1). The most important problems and limitations that older people face are the issue of physical health (2) and cognitive problems that have a significant impact on their quality of life (3, 4). The rate of cognitive problems in the population of people aged 60 years and older is about 5% and in people aged 80 years and older is more than 40% (5). As people age, changes in brain structure and function can lead to an increase in a wide range of cognitive and motor issues in the healthy elderly (6-9), which often limits participation in activities of daily living (10).

Given the high prevalence of cognitive problems among the elderly, it is important to consider ways to reduce cognitive impairment. One of the possible interventions that can be considered is physical activity (11) and lifestyle changes (12), which may maintain the daily activities of life of the elderly (13) and increase their quality of life (14). In addition, performing various physical activities and maintaining an active lifestyle can delay or even reverse the decline in cognitive function in the elderly (15-19). Sáez de Asteasu et al. in a systematic review examined the effect of aerobic training, resistance training and combination training on cognitive function in people aged 65 years and older without cognitive impairment, which significantly improved at least one cognitive domain, such as memory, executive function or a combination of several cognitive functions after the intervention (20).

Due to the prevalence of physical inactivity (18) and the increasing number of older people worldwide (21), exercise at any age is recommended to delay cognitive decline. Therefore, it is necessary to pay attention to strategies that may maintain the health of the elderly cognitively and physically (18). On the other hand, the lack of research in this field in Iran is obvious. Since the effect of participating in balance exercises on some of these cognitive functions such as problem solving has not yet been studied and most studies have examined the relationship between physical activity and cognitive function in the elderly (22-24), this study also examined the occupational performance of the elderly.

Therefore, the aim of this study was to determine the effect of balance exercises on cognitive function (problem solving, working memory, reaction time) and occupational performance (performance and satisfaction) in the elderly aged 60-75 years. The results of this study may generate new ideas about the effect of balance interventions among the elderly.

Methods

After approval in the ethics committee of Shahid Beheshti University of Medical Sciences with ethics code IR.SBMU.RETECH.REC.1397.1005 and research design code IR.SBMU.RETECH.REC.1399.371, this quasi-experimental single-blind study with pretest-posttest design was performed on the elderly aged 60 to 75 years in Kahrizak Charity Center in Tehran.

The sample size of the study was determined to be 13 according to a similar previous study (25). After obtaining written consent, eligible individuals were included in the study by convenience sampling. People with the ability to walk independently (without the use of assistive devices), no severe visual impairment and profound sensory impairment, no neurological or psychiatric disorders, age range of 60 to 75 years, the ability to follow simple instructions with a score of at least 20 on the Mini-Mental State Exam (26) and a

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score of 20-40 on the Berg Balance Scale were included in the study (27). Elderly people who did not want to continue to participate in the study, as well as people who developed neurological disorders during the study period, were excluded from the study.

Before the intervention, pre-test assessments were performed including, the Tower of London (28), the N-back task (29) and the Advanced Reaction Time (30), each of which measures the variables of problem solving, working memory, and reaction time (simple, diagnostic, selective), respectively. The Canadian Occupational Performance Measure (COPM) was also used to assess performance and satisfaction with performance. Due to the fact that the assessment period was approximately two hours for each person, in order to prevent fatigue and reduce the attention span, a 10-15 minute break was considered for the elderly after each test. Post-test evaluations were done again after 20 sessions of balance exercises. The intervention protocol was designed based on articles and evidence in this field and approved by experts in this field.

This balance program consisted of three phases: 1- Warm-up phase (5 minutes) including jogging, walking backwards and sideways and standing (31). 2- Performing static and dynamic balance exercises (20 minutes) including: holding a half-kg dumbbell in the hand while standing and performing arm abduction (32), throwing the ball to the therapist and receiving it (33), standing on one leg (32, 34), standing in a tandem stance (25, 32), holding up the opposite arm and leg in a quadruped position (35), walking in a tandem stance (forward and backward) (34), turning and bending to the sides in a standing position (32), passing through obstacles in a spiral (36), walking backwards and up and down the stairs (37), two-leg bridge as well as single-leg bridge (raising the other leg) (35), walking on the heel (31), performing rhythmic movements while stepping on a circular environment and balance board exercises. 3- Cooling phase (5 minutes) including: deep inhaling and exhaling, walking slowly and doing stretching movements in the upper limb. Reduced level of base of support and closing the eyes (38) were performed to increase the difficulty of the exercises. The intervention was presented by an occupational therapist in the form of 30-minute individual sessions twice a week for 10 weeks.

Data collection tools:

Tower of London: In this test, examinees were asked to move a set of colored beads mounted on three vertical bars to match with a specific task shown on the page. The scoring in this test is based on the number of problems solved, test time and number of errors, and in the end, the total score based on these items is calculated accurately by the software. The highest achievable score is 36 and the lowest score is zero. The validity of this test is acceptable and has been reported to be 0.79 (39).

N-back task: To measure the working memory performance, N-back task with 40 square stimuli in red, stimulus display time of 800 milliseconds and interstimulus interval 3000 milliseconds were used. If the subject answered all the stimuli correctly, he/she would get 40 points. Validity coefficients in the range between 0.54 and 0.84 show the high validity of this test. The validity of this test as an indicator of working memory performance is also acceptable (40).

Advanced reaction time test: In this study, the reaction time in the elderly was measured using the advanced reaction time test in three different ways. A) Simple (response to ten visual stimuli, which was a red circle). B) Diagnostic (response to the target stimulus, which was a sound with a frequency of 500 Hz with the space button of the laptop and no response to the non-target stimulus, which was a red circle, and a total of twenty auditory and visual stimuli were randomly provided by the software). C) Selective

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(response to visual stimulus with one key and response to auditory stimulus with another key was provided in a total of ten stimuli). The outputs of this test are test run time, number of errors and number of missed stimuli (30).

Canadian Occupational Performance Measure: This test, which is in the form of a semi-structured interview, was used to measure the occupational performance of the elderly. The score of this scale is between one and ten. The content validity of the Persian version of this scale is 80.95±0.222 (41).

All data were analyzed using SPSS 21 software. Shapiro-Wilk test was used to measure the normality of the data, the distribution was confirmed for the variables of working memory and occupational performance, so the paired t-test was used to evaluate the effect of treatment, but the variables of problem solving and reaction time did not have a normal distribution. Wilcoxon test was used and $p<0.05$ was considered.

Results

In this study, 13 elderly people with an age range of 60-75 years and a mean age of 70.6±4.5 years participated, among which 8 (61.5) were male. The test results showed that performing balance exercises caused significant changes of 8.46 units based on the result of the N-back task after the intervention compared to before the intervention and the mean value showed significant increase from 21.92±5.47 to 30.38±5.36 ($p<0.001$). Furthermore, for variables of occupational performance, the mean value of performance variable increased significantly from 6.47±1.53 to 7.07±1.71 ($p=0.002$) and the satisfaction variable from 6.51±1.79 to 7.10±1.61 ($p=0.02$) (Table 1).

Regarding the variable of problem solving, the total test result, which was the result of all test dimensions, increased significantly after balance exercises and its mean value increased from 13.15±9.92 to 19.38±11.87 ($p=0.003$). There was no significant difference in the reaction time variable (simple, diagnostic and selective) before and after the balance exercises. The mean value of simple reaction time increased from 808.62±344.70 to 956.54±401.59 ($p=0.18$), but the mean value of diagnostic reaction time increased from 954.62±314.80 to 820.00±357.32 ($p=0.14$). Moreover, the mean value of selective reaction time decreased from 1072.15±340.39 to 917.85±272.84, but this decrease was not statistically significant ($p=0.12$) (Table 2).

Table 1. Paired t-test to compare working memory (using N-back task) and occupational performance (using Canadian Occupational Performance Measure) of the elderly before and after performing balance exercises

Variable	Before	After	Mean change	p-value
	Mean±SD	Mean±SD		
Working memory				
Test time	1255.23±444.93	1510.46±250.44	255.23	0.09
Test result	21.92±5.47	30.38±5.36	8.46	*<0.001
Occupational performance				
Performance	6.47±1.53	7.07±1.71	0.60	*0.002
Satisfaction	6.51±1.79	7.10±1.61	0.58	*0.02

***p<0.05**

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Table 2. Wilcoxon test to compare problem solving (using Tower of London test) and reaction time (using simple, diagnostic and selective reaction time test) in the elderly before and after balance exercises

Variable	Before	After	Mean change	p-value
	Mean±SD	Mean±SD		
Problem solving [a]				
Number of errors	31.77±31.17	17.31±17.00	-14.46	0.17
Problem solved	8.31±4.92	8.92±4.82	0.61	0.83
Test time	498.85±377.52	481.54±218.77	-17.31	0.82
The total result	13.15±9.92	19.38±11.87	6.23	*0.003
Simple reaction time [a]				
Test time	808.62±344.70	956.54±401.59	147.92	0.18
Number of errors	0±0	0.31±1.11	0.31	0.32
Missed stimulus	1.08±1.71	1±1.41	-0.08	0.71
Diagnostic reaction time [a]				
Test time	954.62±314.80	820±357.32	-134.62	0.14
Number of errors	0.54±0.88	0.46±1.20	-0.08	0.32
Missed stimulus	2.08±2.96	0.46±0.66	-1.62	*0.03
Selective reaction time [a]				
Test time	1072.15±340.39	917.85±272.84	-154.31	0.12
Number of errors	0.77±1.24	0.31±0.85	-0.46	0.08
Missed stimulus	2.15±2.44	2.38±2.57	0.23	0.84

[a]Nonparametric test, *p<0.05

Discussion

The results of this study showed that participating in a 10-week balance training program can have a positive effect on cognitive function (working memory, problem solving) as well as occupational performance of the elderly, but in terms of reaction time (simple, diagnostic, selective), there was no significant difference before and after the balance exercises.

A possible reason for the improvement in working memory and problem solving in the elderly can be explained by the fact that after performing balance exercises, certain changes occur in the structure, function and connections of the brain, often called brain flexibility (33, 42). On the other hand, during balance exercise, the connection between the vestibular nuclei, hippocampus, as well as the frontal and parietal cortex, can provide a way to improve cognitive functions including working memory (43, 44). It is also possible that problem solving improves in the elderly after performing balance exercises and involving the prefrontal cortex, which plays a key role in both problem solving and motor functions (45, 46).

Consistent with the results of our study, Xiao et al. (10) and Rogge et al. (33) showed that balance training is related to the cognitive function of the elderly and improves the cognitive function of these individuals. Furthermore, in a study by Sone et al. with different participants from our study, they showed that regular physical activity or the intention to start physical activity may be an effective strategy to improve the ability to solve social problems (47). As a result, it can be said that dynamic environment, challenges and physical

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activity are among the balance exercises that are effective in maintaining cognitive functions. Reaction time test scores (simple, diagnostic, selective) were not statistically significant before and after balance exercises. There was a significant difference in only one item of the diagnostic response time (number of missed stimuli), but this is not enough to affect the diagnostic reaction time of the elderly. It is possible that the intensity and time of training and sample size were not sufficient to have a significant effect on the reaction time of the elderly, because research has shown that not only exercise and physical activity affect the reaction time, but also its intensity and amount affect the reaction time (48). Numerous studies have examined the effect of different types of physical activity on reaction time and have shown that physical activity has a positive effect on reaction time and reduces it (49-51), which is not in line with the results of our study. Hence more studies are needed in this area.

There was a significant improvement in the performance scores of the studied elderly in both pre-test and post-test evaluations. In explaining these findings, it can be said that independent mobility and control of healthy balance is essential for activities of daily living and considering that the physical dimension of quality of life includes concepts such as strength, energy, ability to perform daily activities and self-care, exercise is closely related to physical function and is effective in improving the physical dimension of the elderly's quality of life and increasing their life satisfaction. In a systematic review, Zhang et al. stated that interventions based on exercise have been beneficial in improving the activities of daily living and quality of life of the elderly (52). Therefore, it is speculated that performing balance exercises can increase the performance of the elderly in terms of performance and the level of performance satisfaction.

In conclusion, the results of this study showed that participating in a balance exercise program can have a positive effect on a series of cognitive functions such as problem solving, working memory as well as occupational performance (performance, satisfaction) of the elderly, but in the case of reaction time (simple, diagnostic, selective), no significant change was observed after balance exercises.

Lack of control group and small number of participants were the limitations of this study. Future studies may help to predict which age group will receive the maximum benefits from these types of interventions, as well as more closely examine the relationship between balance and reaction time in the elderly.

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