DOI: 10.22122/jrrs.v16i1.3502 Published by Vesnu Publications

The Effects of Core Stability Exercises on Balance and Walking in Elderly Fallers with Mild Cognitive Impairment: A Randomized Control Trial

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Original Article

Abstract

Introduction: Falling is a serious concern among elderly which have made a lot of discussions between gerontologists and physical therapists. Falling is common, dangerous, and costly among the elderly population. Fear of falling again among elderly faller leads to decrease self-confidence, loss of life quality, and inability. The purpose of this study was to find the effects of core stability exercise on balance and functional mobility among elderly with a history of falling.

Materials and Methods: Thirty elderly people with a history of falling were randomly divided into control (n = 15) and experimental (n = 15) groups. The experimental group performed a 40-minute core stability exercise for eight weeks and three sessions per week. Before and after eight weeks of exercise program, static balance with open and closed eyes, Timed Up and Go (TUG) test for dynamic balance, and 10-meter walking were taken in both groups. The control group only have the daily activities. The two-way ANOVA test was used to compare the mean differences between groups.

Results: Central stability training had a significant effect on static balance with open and closed eye, TUG, and 10-meter walking (P = 0.001). The control group did not show a significant effect on the factors of static balance with open eyes, static balance of closed eyes, TUG, and 10-meter walking. Following training period, the experimental group showed significantly better status in all variables compared to control group ($0.91 \leq \eta^2 \leq 0.94$, P = 0.001).

Conclusion: It seems that strengthening the muscles in the central area of the body leads to maintaining balance in the elderly during daily activities. Since independency is very important in people with a history of falling, it can improve their independence and active participation by performing these exercises as simple, low-cost, and appropriate activities for home exercise.

Keywords: Balance; Core stability; Elderly fallers; Functional mobility; Walking, Mild cognitive impairment

Citation: Sadeghi H, Shojaedin SS, Alijanpour E, Abbasi A. **The Effects of Core Stability Exercises on Balance and Walking in Elderly Fallers with Mild Cognitive Impairment: A Randomized Control Trial.** J Res Rehabil Sci 2020; 16: 110-7.

Received: 01.03.2020 Accepted: 02.06.2020 Published: 05.07.2020

Introduction

Aging is an important process from the perspective of sociologists and geriatricians (1). According to the World Health Organization (WHO), most developed countries face this problem, and developing countries will also face this in the near future (2). According to these reports, only 5.4% of the Iranian population was over 60 years old in 1975, which will increase to about 10.5% by 2025 and surprisingly, it will reach 21.7% by 2050 (3). With age, physical and mental functions among the elderly gradually decrease, which leads to greater dependence on others in daily activities and, therefore, isolation of individuals (4). Falling occurs as a result of disruption of the balance and deviation of the center of gravity from the support surface. Falls are a serious issue among the elderly that has caused widespread controversy among experts. Apart from external factors that are caused by the environment, internal factors such as weakness of lower limb muscles, decreased mental and sensory abilities, decreased balance and instability in the body, and slowing of sensory and

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motor responses are involved in falling (5).

One-third of people over the age of 65 have a history of falls at least once a year, with about 6% of these injuries leading to various fractures, including wrist, pelvis, and thigh fractures (5). Decreased life expectancy, loss of self-confidence, frequent falls, and high financial costs can be attributed to the consequences of falling (6). Physical activities aimed at increasing balance significantly improve balance, gait, muscle strength, and in some cases, reduce the rate of falls in the elderly (8, 7). Older people with a history of falls are different from healthy older ones (9). Frequent falls can jeopardize a person's performance (10) and lead to a series of falls, which can lead to a lack of independence, reduced quality of life, and increased costs of care (11).

Older people with cognitive problems are at a higher risk of falling (12). Sensory, motor, and nervous systems are closely related to cognition, which is very important for planning movements such as walking and balance and responding to environmental changes (13). Therefore, improving mobility, such as balance and gait pattern, helps reduce the risk of falls and injuries in the elderly with cognitive impairment, and a history of falls.

Previous studies have employed many exercises in the elderly to improve balance and prevent falls among them. For example, in a study that looked at the effect of a one-month balance exercise program on muscle strength and the ability to walk to prevent falls in the elderly, the beneficial effect of exercise therapy on improving flexibility, body balance, muscle strength, and ability to walk in preventing falling was observed (14,15). Research has shown that strengthening the trunk muscles plays an essential role in the balance of the elderly and improves the functional ability of the body (16). On the other hand, the weakness of these muscles and their role in the balance of the elderly with a history of further falls has been proven (9,17).

Maintaining balance is an important factor in daily activities and is directly related to the muscular strength of the body's center of gravity muscles (18). The trunk muscles include the back, pelvis, and thigh muscles (19). The trunk strength is very effective in performing movements with optimal acceleration, reducing acceleration, and maintaining stability in all movements that are performed in a chain during daily activities (15). The core stability muscles are the basis of all body movements, which play an essential role in the balance and better execution of body movements (20), with their weakness impairing the performance of these activities. Additionally, these muscles, as body stabilizers, have a very important effect on a person's posture, which stabilize the pelvis and spine and control postural fluctuations (18,21).

The results of the study by Arnold et al. indicated that 18 sessions of exercises in the central area of the body were effective on the balance of the elderly (18). Moreover, a study by Bostani et al. confirmed that core stability exercises increased balance in the elderly with a history of falls (22). Despite these findings, research on the effects of core stability exercises in the elderly with a history of falls and cognitive problems is very limited. Therefore, the present study aims to investigate the effect of core stability muscle exercises on balance and gait in elderly people with a history of falls and mild cognitive problems.

Materials and Methods

This study was a single-blind clinical trial in which none of the group members were aware of the training process. 30 elderly individuals living in Sarai Mahalla participated in the study voluntarily after the announcement and information of the health unit in this neighborhood in District 7 Municipality of Tehran, Iran. The proposal of this plan was reviewed and approved by the ethics committee of the Sport Sciences Research Institute of Iran (SSRI). Besides, it was registered and approved in the Iranian Registry of Clinical Trials (IRCT) System with number IRCT20180627040251N3.

The study inclusion criteria included age range of 60 years and above, history of falling twice or more in the last six months, not participating in sports during the past year, ability to walk without aids, and performing the desired exercise program and getting a score of 21-25 (indicating a mild cognitive disorder) from the Mini-Mental State Examination (MMSE) questionnaire (23). Existence of orthopedic and neurological problems that prevented participation in exercises, diabetes mellitus (DM), mental disorders, hypertension, dizziness, severe deformity, especially in the lower extremities, severe joint problems (including severe osteoarthritis or arthritis), severe cardiopulmonary disorders, and acute vision and hearing problems (to the extent that they interfered with the study) were considered as the exclusion criteria. The demographic information questionnaire including gender, age, education, history of falls during the last year, and history of diseases and surgery were completed.

After the initial evaluation, the participants' information was recorded by the researchers and the musculoskeletal evaluation was performed by a physiotherapist and then based on the inclusion and

exclusion criteria, the subjects were divided into the two control (who performed only daily activities) and experimental (core stability exercises) groups. The subjects then completed a form of informed consent.

After initial evaluation of patients, randomization was performed based on four blocks. A series of consecutive numbers generated by a number table in the computer were randomly placed in opaque envelopes. A person blinded on the participants and study groups, performed randomization and assignment of the numbers to the groups. Additionally, the patients in each group were unaware of how randomization and intervention were performed in the other group. Then the instructions for interventions and exercises were explained separately to the experimental group.

Exercise protocol

Exercise protocol: The exercises were performed for eight weeks and three sessions per week for the exercise group on even days of the week in Sarai Mahalla. Each training session lasted 40 minutes and included 5 minutes of warm-up and 5 minutes of cooling-down.

The exercises consisted of three levels based on the core stability exercises suggested by Jeffreys (24) and were started from level 1 involving static contractions in a fixed position. Level 2 exercises included static contractions in an unstable environment, and finally, Level 3 exercises included dynamic movements in an unstable environment. The basis of the exercises used in the protocol was specific exercises for stabilizing the spinal muscles, retraining of proprioception of the lumbar-pelvic region, maneuver of twisting the abdomen with contraction of the multifidus muscle and then with maintaining the stabilizing maneuver, using the dynamic stability obtained in different postures (supine, prone, squatting), as well as adding dynamic components to it (moving the limbs, using a Swiss ball) in the next steps. In order to evaluate the intensity of exercise at the end of each week, the exercise pressure was measured by the Borg Rating of Perceived Exertion (RPE) scale with a scoring of 6-20 and a validity of 0.555 (25). In the first week, the perceived exertion was very, very light and gradually increased given the ability and progress of the participants, and finally reached moderate to severe in the last week. The control group did not have any regular physical exercise during the study period and continued their daily activities during this period.

Assessment

All assessments were performed on participants before and after the training period.

Single leg stance test: Before and after the training period and after warming up of the subjects, to measure static balance, the Sharpened Romberg test was performed unilaterally with eyes open and closed. The reliability of this test for the elderly was reported to be 0.91 (26). The subject stood on the dominant leg and lifted the other leg off the ground while his hands had to be kept on the waist. In order to maintain safety, one of the testers was present with the participants to prevent their possible fall. The time each subject maintained this position with their eyes open and closed was recorded using a Q and Q stopwatch (Model HS43, Japan). The subjects performed this test three times with their eyes open and closed, at an appropriate time interval when the person was ready, and the average of these three tests was considered as their record.

10-meter walk test: The 10-meter walk test was used to measure the walking speed of the elderly. The reliability obtained for the elderly was 0.96 (27). In the hall, which was safe and smooth in terms of flooring, a distance of 10 meters was marked. The subject was placed two meters ahead of the zero point in appropriate clothing and footwear and began to move (with the utmost readiness and without running) with the "go" command. Of course, this speed had to be safe for all subjects. The tester turned on the stopwatch at the zero point with the "go" command and turned it off after the subject passed the 10 m point. This record was recorded as a test score for the patient. This test was recorded three times and at the appropriate time interval when the person was ready, and the average of these three tests was considered as their record.

Timed Up and Go (TUG) Test: To measure dynamic balance, the TUG test was used, which has a reliability of 0.99 for the elderly (28). Performing this test required each subject to get up from a chair without arms without using his or her hands, and after walking a 3-meter path (without running), return and sit back on the chair. The total time for this test was considered. This test was repeated three times and at intervals when the person did not feel tired, and the average of the three tests was recorded as the record of each person (29).

The mean was calculated using descriptive statistics. First, the Shapiro-Wilk test was used to examine the normal distribution of the quantitative variables of this part and paired t-test was applied for intra-group investigations. Moreover, the two-way analysis of variance (ANOVA) test was used to examine the inter-group differences of changes in balance and gait scores. Finally, the data were analyzed in SPSS software (version 20, IBM Corporation, Armonk, NY, USA). $P < 0.05$ was considered as the significant level.

Table 1. Demographic characteristics of the subjects by groups

Group	Number of men	Age (years)	Height (cm)	Weight (kg)	BMI (kg/m^2)
	n (%)	Mean ± SD	Mean ± SD	Mean ± SD	
Control	6 (40)	72 ± 7	176.0 ± 5.4	66 ± 10	23.69
Experimental	6 (40)	70 ± 5	166.0 ±8.5	71 ± 11	25.63
(Intergroup) P value	0.769	0.188	0.773	0.665	0.584

SD: Standard deviation; BMI: Body mass index

Results

The dropout of participants of the two groups is presented in figure 1 and the demographic characteristics of the participants are presented in table 1.

Comparison of balance and gait indices in the two groups before and after the end of the training period is presented in table 2. Descriptive statistics of performance accuracy of the three groups are shown in figure 1.

Intention-to-treat (ITT) was not performed because the dropout rate in the samples was less than 10%. The results of two-way ANOVA test showed that the core stability exercises had a significant effect on the open eye static balance (η^2 = 0.91, P = 0.001, $F_{(1,27)}$ = 275.889). Besides, based on the results, a significant difference was observed between the closed-eye balance of the control and experimental groups (η^2 = 0.93, P = 0.001, $F_{(1,27)}$ = 367.918). The results of two-way ANOVA test showed that there was a significant difference between the control and experimental groups in the 10-m walking (η^2 = 0.94, P = 0.001, $F_{(1,27)}$ = 501.497). The core stability exercises showed a significant effect on the dynamic balance of the individual (η^2 = 0.94, P = 0.001, $F_{(1,27)}$ = 451.008).

Discussion

The aim of this study was to investigate the effect of an 8-week period of core stability exercises on the balance of the elderly people with a history of falls and cognitive problems. The findings suggested that the core stability strengthening exercises had a significant effect on static and dynamic balance and gait of elderly people with mild cognitive problems with a history of falls.

With age and muscle wasting, it becomes difficult for older people to perform daily movements. Decreased balance due to weakness of the body's muscles, especially the trunk muscles of the body (abdomen, pelvis, and back), has a major role in the frequent falls of the elderly (15). In previous studies, various interventions such as strength training for the lower limbs (30), video games (8), water training, and Pilates and balance exercises (31) have been used to improve balance and gait in the elderly.

The results of the study by Granacher et al. revealed that 18 sessions of core stability exercises are very effective on balance, gait, and muscle strength of the pelvic girdle in the elderly without a history of falls (17). Kim et al. confirmed in their study that core stability exercises increase the activity of the body core muscles and improve balance and gait in the elderly (32). The difference between the aforementioned studies (17,32) and the present study is in the type of samples. The previous studies were performed on healthy elderly (17,32) and the present study was performed on the elderly with mild cognitive impairment and, of course, with a history of falls. Elderly people with a history of falls with cognitive problems have poor muscle activity in balance as well as weak muscle activity in the body core muscles (32).

Table 2. Comparison of balance and gait indices in the two groups

Variable	Group	Pre-test	Post-test	P value (Intragroup)
Open eye static balance (seconds)	Experimental	44.16 ±4.57	26.19 ± 3.49	0.001
	Control	12.61 ± 4.58	12.00 ± 3.48	0.081
	P value (Intragroup)	0.998	0.580	
Closed-eye static balance (seconds)	Experimental	3.35 ± 1.43	16.38 ± 2.39	0.001
	Control	3.54 ± 1.35	3.97 ± 1.55	0.120
	P value (Intragroup)	0.614	0.161	
10-m walking test record (seconds)	Experimental	11.39 ± 0.74	6.59 ± 0.80	0.001
	Control	11.33 ±0.67	11.52 ± 0.90	0.760
	P value (Intragroup)	0.314	0.088	
TUG test record (seconds)	Experimental	11.62 ± 1.19	6.39 ± 1.31	0.001
	Control	11.63 ±0.90	11.86 ±0.85	0.540
	P value (Intragroup)	0.680	0.065	

TUG: Timed Up and Go; SD: Standard deviation
Data are reported as mean ± SD.

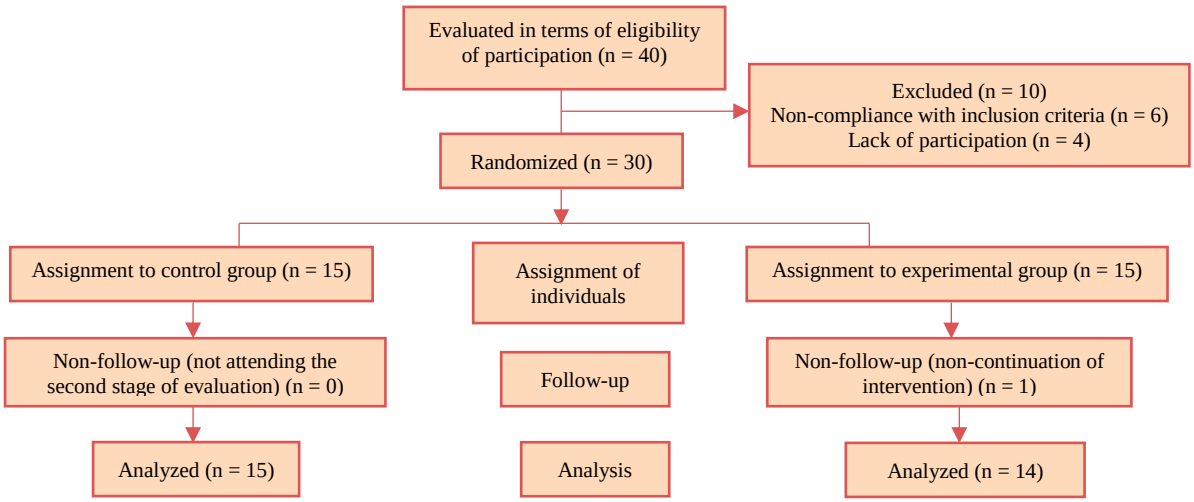

Figure 1. CONSORT process flow

The core of the body is considered as a box where the muscles around the spine and gluteal muscles in the back, the pelvic floor muscles and the pelvic girdle muscles in the floor, the abdominal muscles in the front, and the diaphragm in the ceiling, are located (17).

The spinal mobility and the strength of the body's core muscles are essential for daily activities. In fact, there is a close relationship between the movement of the pelvic girdle and the spine with daily activities such as stair climbing and sitting and getting up in the elderly (33). The core stability muscle exercises increase neural adaptations, including more efficient neural patterns, faster activation of the nervous system, and better coordination of motor and neural units (34).

Perhaps one of the main differences between other exercises, such as Pilates, and core stability muscle exercises is that it strengthens the muscles of the center of the body, as a center of transmission of force between the lower and upper limbs during daily activities (35). It has been found that older people with a history of falls and mild cognitive problems have large fluctuations in posture while walking (36).

The abdominal muscles, including the rectus abdominis, transverse abdominal, external oblique, and internal oblique muscles, all contract together to provide stability to the spine, and hence a stronger support surface for lower extremity movements (37). The large and strong muscles of the central part of the body, like a strong rope, keep the trunk stable and maintain control and balance. The role of the trunk muscle function is very important when the subject is standing on one leg. The pelvic floor muscles engage before any movement to perform the torso movement to help the person maintain balance (38). Additionally, during lower limb movements such as walking and rotation, the multifidus and transverse abdominal muscles help maintain dynamic balance while walking by providing support for the spine and improving the transfer of upper limb forces to the lower limb and reducing postural fluctuations (39). In the present study, an improvement of walking speed in the experimental group was confirmed by the 10-m walking test and TUG test records. Therefore, it can be concluded that by strengthening the body core muscles and reducing torso oscillations and reducing balance disorders, the present training protocol was effective on improving the dynamic balance and gait of these individuals. Considering the improvement of the results of the static balance test with eyes closed in the experimental group, it may be concluded that when visual data is removed as an important factor in maintaining balance, the improvement of proprioceptive, somatosensory, and spatial perception data due to participation in exercise program is suggested that leads to increased balance in the elderly. Therefore, it can be said that these exercises may have also been effective in the proprioception.

Limitations

In the present study, it was not possible to compare different exercises on different factors such as motor-proprioceptive analysis of lower extremities. Besides, there was no follow-up of the effect of training after the end of the training period due to the unavailability of participants.

Recommendations

It is necessary to conduct a study that examines the effect of the intervention used in the present study

with a follow-up period. It is necessary to evaluate the effect of these interventions on cognitive status in future studies. Furthermore, in other studies, it is suggested that three-dimensional analysis be used to evaluate pelvic kinematics in the elderly with a history of falls.

Conclusion

Given the findings of the present study, it can be concluded that strengthening the muscles in the central part of the body may lead to improved balance and gait in the elderly with a history of falls and cognitive problems during daily activities of life. These exercises can be used along with other programs to prepare, rehabilitate, and improve performance in individuals.

Acknowledgments

The authors would like to appreciate Sarai Mahalla of Tehran Municipality, the Vice Chancellor for Research, School of Physical Education and Sports Sciences, Kharazmi University, Tehran, Iran, and all the elderly people who participated in the implementation of this research project.

Authors' Contribution

Hassan Sadeghi: study design and ideation, study support, executive, and scientific services, providing study equipment and samples, data collection, analysis and interpretation of results, specialized statistical services, manuscript preparation, specialized evaluation of manuscript in terms of scientific concepts, final approval of the manuscript to be submitted to the journal office, responsibility of maintaining the integrity of the study process from the beginning to the publication, and responding to the referees' comments, Seyed Sadredin Shojaedin: study design and ideation, attracting financial resources for the study, study support, executive, and scientific services, analysis and interpretation of results, manuscript preparation, specialized evaluation of manuscript in terms of scientific concepts, final approval of the manuscript to be submitted to the journal office, responsibility of maintaining the integrity of the study process from the beginning to the publication, and responding to the referees' comments; Elham Alijanpour: study design and ideation, providing study equipment and samples, data collection, manuscript preparation, specialized evaluation of manuscript in terms of scientific concepts, final approval of the manuscript to be submitted to the journal office, responsibility of maintaining the integrity of the study process from the beginning to the publication, and responding to the referees' comments; Ali Abbasi: study design and ideation, providing study equipment and samples, data collection, analysis and interpretation of results, specialized statistical services, manuscript preparation, specialized evaluation of manuscript in terms of scientific concepts, final approval of the manuscript to be submitted to the journal office, responsibility of maintaining the integrity of the study process from the beginning to the publication, and responding to the referees' comments.

Funding

The present study was approved by the research ethics committee of the Institute of Physical Education and Sports Sciences under the number IR.SSRC.REC.1399.047. In addition, it has been registered and approved on the IRCT system under the number IRCT20180627040251N3.

Conflict of Interest

The authors and the results of this study are not in conflict of interest.

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