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Original Article

Effect of a 6-Week Balance Training Program with Shuttle Balance on Balance, Gait Speed, and Fear of Falling in Elderlies

Zahra Mohammadian[*1], Reza Rajabi [1], Hooman Minoonejad [1], Aynaz Samadzade[1]

[1.] Department of Health and Sport Medicine, University of Tehran, Tehran, Iran

[*] **Corresponding Author:** Department of Health and Sport Medicine, University of Tehran, Tehran, Iran. **Tel**: +98(930)4354565, **Email address**: zahra.md70@gmail.com

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Introduction: Falls are considered as the major health problem in ageing and the damages caused by falls (such as fractures, disability, heavy costs on government and family, and death) are the major concern of the World Health Organization. So, determination of risk factors and specific ways to prevent falls in the elderlies are of great importance. The aim of this study was to evaluate the effect of a six-week shuttle balance exercises on balance, gait speed, and risk of falling in elderlies.

Methods: This ranomised controlled trial study was conducted with the pre-test and post-test design among the elderlies in Tehran, Iran. To conduct the study, 30 healthy men and women older adulth were randomly divided into the experimental (n = 16) and control (n = 14) groups. Members of the experimental group participated in the six-week exercise program, which was held in three 90-minute sessions per week. The intervention involved five exercises conducted in presence of the researcher. Data were collected using the valid and reliable instruments of Berg Balance Scale, Timed Up and Go Test, and the Falls Efficacy Scale Intrnational. Data were analyzed by independent t-test, paired sample t-test, and analysis of covariance at the significance level of 95% using SPSS 19.

Results: The study findings showed that balance training with shuttle balance improved the participants' balance, gait speed, and fear of falling significantly ($p < 0.05$).

Conclusion: The six-week balance exercises with shuttle balance improved the participants' walking gait and reduced the risk of falling in elders. These results highlight the beneficial effects of shuttle balance over other devices, such as more security, adjustability of height in chair arms, and possibility to enhance its exercise programs. Therefore, balance shuttle can be applied to improve balance, increase gait speed, and reduce falling risk in elderlies.

Keywords: Shuttle Balance, Balance, Gait Speed, Fear of Falling, Older Adults

Introduction

Aging is part of a biological process that involves all living creatures, including humans. Considering the decrease in the rate of premature deaths and the improvement of health in the current century, the individuals' life expectancy has prolonged (1-3). With the increase of elderly population, the prevalence of physical disabilities has also increased. Therefore, issues and problems of the elderly people should be determined to improve their health (4). Many factors can cause disability in elderlies, among which loss of mobility and reduction of balance are very important (5, 6). Balance plays a significant role in stability and walking (7). In fact, balance is essential for improving the life quality and functional autonomy, while reducing the risk of falling. Moreover, imbalance is recognized as the most important risk factor of falling and is a major public health problem among the elderly (8, 9).

Weak balance and change in walking pattern are among the important risk factors of falling (2, 3, 10).

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So, the ability to maintain a correct standing position, both in static and dynamic postures, as well as improvement of the walking patterns, even in the presence of a mild physical impairment, should be among the falling-prevention measures among the elderly (10).

Falling is associated with dangerous complications, such as hip and pelvis fractures, and is the leading cause of mortality in elderlies. In addition, falling imposes heavy costs on the government, family, and individual (11-14).

The conducted studies in this area showed that appropriate physical activities, such as balance exercises, walking, strength and endurance exercises can improve the elderlies' balance and walking and reduce their risk of falling (3, 5, 10, 15, 16). Several training interventions have been developed to improve individuals' balance, such as training at unstable levels. Hirase et al. investigated the effects of a balance exercise program over foam pads and hard surfaces on the balance of elderly people. They reported a significant improvement in the balance of the group who practiced on the foam pad (17). Martínez-Amat et al. studied the effect of a 12-week exercise program using Swiss balls on balance, walking, and risk of falling among the elderlies. Results of their study indicated a significant improvement in the participants' balance, walking, and reduced risk of falling (16).

Shuttle balance is newly developed training equipment, which is not commonly used in Iran. The main difference of shuttle balance with other training devices (e.g., shaking boards, trampolines, etc.) is its physical and mechanical benefits compared with the other unstable surfaces. It has greater security and provides adjustability of the arms' height, which gives the patients a possibility to enhance their exercise programs. It is also easily available to users. On the other hand, research over the effect of training on unstable surfaces, such as wobble board, trampoline, and foam, indicates that exercises on these levels create a situation similar to real walking conditions that individuals encounter during their daily activities. So, they have more effective results (7, 13, 12, 18-20). However, in the past studies, most of the applied equipment required an individual to take care of the elderly while using the device and the equipment did not have any protective and adjustable arms for users. Therefore, it seems that the shuttle balance has overcome shortcomings of the other equipment and can be a decent balance exercise tool for the elderly.

Due to the physical properties and structure of the shuttle balance device, it can be used to improve balance, help rehabilitation of lower limb injuries, enhance exercise performance, and prevent falls in elderlies.

Regarding the important of the issue and Lake of studies about benefits of shuttle balance exercise equipment's among older adults. This study aimed to investigate the effect of a six months training program with shuttle balance.

Methods

Study design

This randomized controlled trial which is approved in Iranian Registry of Clinical Trials (code: IRCT20190410043229N1) was carried out among the elderly men and women over the age of 60 years living in Tehran's districts, region's number five and six.

Participants

The participants included 32 elderly men and women, who entered the study based on the following criteria: having age of 60 years and above, earning a score of at least 21 in the balance test (18), needing no walking aids (21), no history of lower limb fracture in the past six months (21), and having a body mass index of less than 35 (10). Participants were randomly divided into experimental (n = 16) and control (n = 14) groups. Two participants of the control group left the study due to individual reasons.

Measurement

Timed Up and Go (TUG) Test

In order to measure gait speed of the elderly, TUG test was used. This test requires the individuals to get up from a standard armchair (with an approximate height of 46 cm for the chair and 65 cm for its arms), walk three meters, turn, and go back to the armchair. To get familiar with this test, participants performed this process once prior to the main test. The time required for TUG test was recorded in seconds using a timer. With a reliability of ICC = 0.97, this test is an appropriate test for measuring the walking speed (2, 22).

Fear of falling

To measure fear of falling, the 16-item Falls Efficacy Scale-International (FES-I) was used, which was designed by Yardley et al. (23). The items in this questionnaire have four options including "I'm never worried about falling," "I'm a little worried about falling," "I'm almost worried about falling," and "I'm totally worried about falling," with scores of 1 to 4, respectively. At the end, the total score was calculated for each individual. Higher scores indicated higher levels of falling fear. The reliability of this test was reported as 0.98 (24).

Berg Balance Scale (BBS)

This test includes 14 subtests to determine the balance level of the elderly people. Each test is scored on a five-point scale and higher scores show higher degrees of functional independence in performing the desired tasks and higher levels of balance skills. The maximum attainable score is 56 in this scale (25). Each participant received a score based on his/her performance in the 14 performance tests related to balance and mobility. The participants were also provided with some instructions about each test individually or generally, which were presented orally or practically. The participants' attempts with regard to the expected performance were very important and

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their performance was considered as the scoring criterion. To carry out this test, a timer, a ruler, an armchair, and a step with 18-20 cm height were used. The average time needed to complete the tests of this scale was considered to be from 10 to 20 minutes depending on the participants' ability. In this research, the Persian version of this test, translated and standardized by Davatgaran et al., was used. Furthermore, this test has an acceptable construct validity of 0.72 for the elderly and the reliability of each subscale is 0.98. The reliability of test is 0.99 between the sub-scales and its internal consistency is 0.96 (26).

Interventions

Shuttle balance

The shuttle balance is a tool used to carry out exercises, including a board attached to height-adjustable rods with four attachment chains in the corners (Figure 1). In this study, these adjustable rods were set at the same height (equal to the participants' gravity center) for all people. This device has three degrees of free movement and one center of rotation at the attachment points of chains to the rods. The rotation center of the shuttle balance is movable due to its structural features and adjustability of arms. Thus, different degrees of instability can be created in individuals' condition using this device (27).

To conduct the research, after selecting the participants based on the inclusion criteria and obtaining the required permissions, the study goals, importance, and procedures were explained to participants. Later, participants were asked to sign the written consent forms and to complete the demographic characteristic questionnaire. One week before execution of the training protocol, participants took the initial tests including BBS, TUG test, and completing FES-I questionnaire.

After the pretest, the participants were randomly divided into two groups. The balance exercise group participated in a six-week training program, in which participants performed a series of balance exercises designed for the shuttle balance. These participants were supposed to conduct five consecutive exercises. Each exercise set lasted 30 seconds and two minutes of rest was considered between the sets. The protocol included three sessions per week. The severity of exercises was incremented during the study period by increasing the number and time of each set.

The approximate duration of the exercise sessions increased from seven minutes in the first week to 18 minutes in the sixth week per person. The exercises included: standing on the shuttle balance, lifting the legs in turn, lifting the single leg, standing on two feet while moving the board to the left and right, standing on the board and catching the ball (Figure 2). The trainings' severity levels enhanced so that different forms of exercises were initially performed on two feet with open eyes and by holding the chair arms. In the following weeks, after the participants acquired the required skills in doing the exercises, they performed them with open eyes without holding the arms. Later, the participants were supposed to perform the exercises with closed eyes without holding the arms.

During the study period, the control group members were asked to keep their daily physical activity routines without any exercises.

After completion of the training period, all participants were tested in all the studied variables, in the same environment using the same method in the post-test.

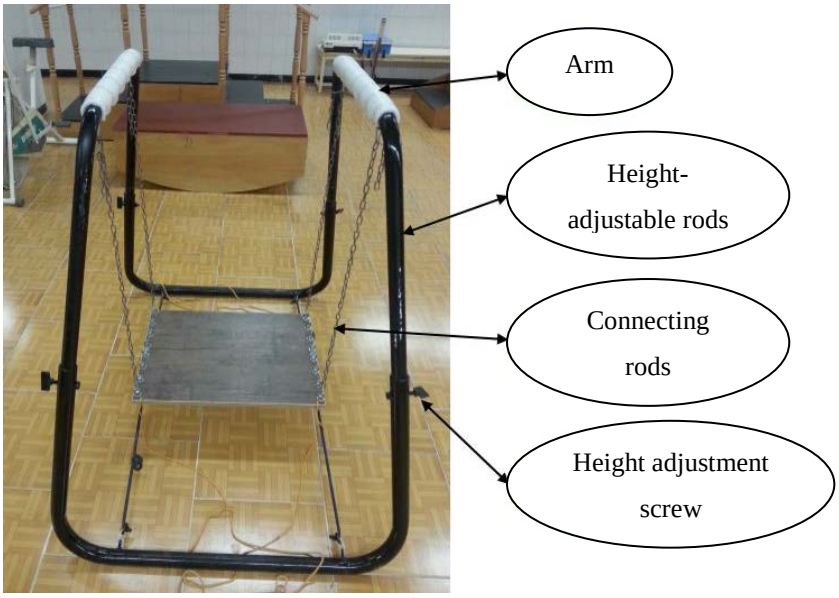

Figure 1. Constituent parts of the shuttle balance

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Figure 2. one form of the exercises

Statistical analysis

After collecting the information, the data were analyzed using descriptive and inferential statistics by SPSS version 19. To compare the pre-test and post-test within and between the groups, the paired t-test and independent t-test were run. The level of significance was set at 95 percent with alpha of < 0.05.

Ethical considerations

The research protocol was approved by the Research Ethics Committee of research center of physical education (code:IR.SSRC.REC.1398.026). In addition, after explaining the research purposes to the participants, obtaining their written informed consent, ensuring confidentiality of information and voluntarily answering the questions, the people who were willing to participate in the study were included.

Results

The demographic characteristics of the experimental and control groups are presented in table 1. The results of independent t-test showed a significant difference and the effects of confounding variables were investigated using the analysis of covariance. Independent t-test showed no significant difference between demographic characteristics of the experimental and control groups.

Table 2 shows the results of total paired t-test. According to these findings, a significant difference was observed between the pre- and post-test scores of the experimental group in balance, three-meter walking, and fear of falling tests. The results showed that the obtained scores in balance and walking speed tests improved, while the elderlies' fear of falling decreased after six weeks of balance shuttle training ($p < 0.05$). However, the findings indicated no significant difference between the pre- and post-test scores of the control group in all three variables.

To assess effect of the training program with shuttle balance on three variables of balance, walking speed, and fear of falling, covariance analysis was used to determine the difference between groups in the post-test. The results of the covariance analysis are reported in table 3, the results showed a significant difference in the post-test scores between two groups after adjusting for the effect of the pre-test (covariate). In other words, variables of balance and walking speed improved, whereas, the fear of falling decreased significantly in the experimental group ($p < 0.05$).

Table 1. Demographic characteristics of participants

Variables	Control group (n=14)	Experimental group (n=16)	p - value
Height (cm)	165.50 ± 10.00	166.43 ± 10.47	0.80
Weight (kg)	66.85 ± 15.09	65.82 ± 9.54	0.82
Age (year)	69.42 ± 5.72	70.50 ± 7.63	0.67
BMI (Kg/m^2)	24.39 ± 5.33	23.77 ± 2.69	0.68

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Table 2. Paired t-test results for three variables of balance, three-meter walking, and fear of falling in pre-post test

Variable	Group	within-group difference	t	p - value
Balance	Experimental	-6.12 ± 2.84	-8.60	0.001
	Control	-1.07 ± 2.86	-1.39	0.18
Three-meter walking	Experimental	0.97 ± 0.88	4.40	0.001
	Control	0.12 ± 0.41	1.16	0.26
Fear of falling	Experimental	6.19 ± 4.41	-0.80	0.001
	Control	-0.14 ± 0.66	5.60	0.43

Table 3. Results of the covariance analysis for three variables of balance, three-meter walking, and fear of falling

Variable	Group	Test stage (post-test)	Between group difference	f	p - value	Eta squared
Balance	Experimental	51.33 (49.90-52.75)	3.78 (1.56-6.00)	2.26	0.002	0.31
	Control	47.54 (46.10-49.08)				
Three-meter walking	Experimental	16.10(15.78-16.43)	0.41 (0.92-0.09)	2.47	0.10	0.09
	Control	16.52 (16.16-16.87)				
Fear of falling	Experimental	20.51 (19.20-21.81)	-2.40 (-4.56- -0.24)	5.23	0.03	0.16
	Control	22.91 (21.49-24.33)				

***** Mean (95% confidence interval)
†Adjusted based on the pre-test values

Discussion

The findings of this study showed that the implemented six-week exercise program significantly improved the participants' balance, walking speed, and decreased fear of falling. Extensive studies were conducted over the effect of balance exercises over unstable surfaces on balance, walking speed, and falling risk of the elderlies. However, it seems that the effect of training on shuttle balance has not ever been investigated on the balance, walking speed, and fear of falling of the elderly. Our findings are consistent with the results of studies by Martínez-Amat et al. (16), Hirase et al. (17), Nam et al. (28), Ogaya et al. (19), Hanachi and Kaviyani (12).

The results of this study indicated that participants of the experimental group had significant improvement in their balance, walking speed, and fear of falling compared to the control group. Nam et al. also found significant improvements in the static and dynamic balance as well as walking speed of the elderly. They examined the effect of training over unstable levels on the balance and walking of the healthy elderlies (28). Martínez-Amat et al. found a significant improvement in balance, walking speed, and risk of falling among the elderly following a 12-week proprioception training program (16). Hirase et al. also concluded that exercising on unstable surfaces than hard levels, resulted in faster improvement among the individuals (17).

Hanachi and Kaviyani indicated that mini-trampoline exercises had a significant effect on the dynamic balance of the elderly women in Tehran (12). Abdoli et al. investigated the effect of the type of exercise on the static and dynamic balance of the 60-75 year-old women with no history of falls. Their findings showed that the group with combinational exercises had more significant changes (21).

Despite the differences in participants, types of the training programs, and equipment used in the research, most studies on the effect of training over unstable surfaces on balance, walking speed, and falling risk in the elderly confirmed the results of the current study.

According to the results reported by the above-mentioned studies, it can be concluded that balance exercises over unstable levels increased the proprioception and lower limb muscle activity. Therefore, one of the possible reasons for improvement of the participants' balance after engaging in balance exercises over unstable surfaces can be improvement of the proprioception sense in the foot receptors and muscles' mechanoreceptors. In addition, the central and peripheral interactions of various factors are essential for maintaining balance. Environmental factors are composed of a somatosensory system that provides information about the joints' position, tension level, extension, joints' pain, muscles, ligaments, and atrial system. The central factors integrate information received from the environmental factors and provide the correct position of the body. Unstable levels not only activate the sensory systems, such as the somatosensory, atrial, and visual systems, but also affect the central nervous system. Unstable levels also affect fitness of the brain. Research results showed a significant improvement in the static and dynamic balance skills, walking speed, and fear of falling.

The acceptable mechanism for improving these factors can be so that the somatosensory receptors are heavily influenced by stability of the level; so, balance exercises activate the joints' receptors, ligaments, and tendons by unstable levels. This may be due to the activation of the somatosensory system while practicing on unstable levels. In order to prevent from failure of the somatosensory

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system, the atrium and visual systems should be strengthened. Organs that represent the largest distribution of the somatosensory receptors in the human body are hands, feet, and face. Among them, feet have the highest number of sensory receptors. Therefore, balance exercises using unstable levels can be used as a strategy to increase the effects of the somatosensory system. According to the findings of this study, it seems that six weeks of balance exercises with a shuttle balance were a practical and effective way to improve balance, walking speed, and falling risk in the elderly. This method can also be used to reduce the risk of falling in occupational therapy, rehabilitation, and everyday life of the elderly (16, 17, 28).

Conclusions

According to the findings, a significant difference was observed in the elderlies' balance, gait speed, and fear of falling scores after attending the shuttle balance exercise program. Therefore, it can be concluded that balance exercises using shuttle balance improves the elderlies' balance and speed, while it reduces their falling risk. These results highlight the beneficial effects of shuttle balance over other devices, such as more security, adjustability of height in chair arms, and possibility to enhance its exercise programs. Furthermore, the findings show that utilization of this device is cost effective with easy access and transfer. So, it can be applied to improve the elderlies' balance and gait speed, while reducing their falling risk.

Study limitations

The participants' psychological factors were not investigated, elderlies who were living in the nursing homes were not included, and participants were selected from specific regions of Tehran city.

Conflict of interest

The authors declare there is no conflict of interest.

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Authors' contribution

All authors have participated in the design and implementation of the study, analysis and interpretation of data, and to draft or modify the article. All authors have read and approved the final version of the article.

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