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Report of Health Care **Original Article**
Volume 4, Issue 3, 2018, p. 1- 13

The Effect of Eight Weeks of Core Stability and Pilates Trainings on Ankle Proprioception, Postural Control, Walking Performance, Self-efficacy and Fear of Falling in Elderly Women

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Received: 1 May 2018

Accepted: 15 August 2018

Published online: 1September 2018

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Competing interests: The authors declare that no competing interests exist.

Citation: Naderi Tehrani Z, Jalali Dehkordi Kh. The effect of eight weeks of core stability and pilates trainings on ankle proprioception, postural control, walking performance, self- efficacy and fear of falling in elderly women. Rep Health Care. 2018; 4 (3): 1- 13.

Abstract
Introduction: Incidence of falling is a common problem in the elderly, which is more likely to occur with increasing age. The purpose of this study was to compare the effect of eight weeks of core stability and Pilates trainings on ankle proprioception, postural control, walking performance, self-efficacy and fear of falling in elderly women.
Methods: 30 elderly women (age 68.13±1.14 years, weight 57.10±7.13 kg, body mass index 163±20.73 kg/m^2) were selected purposefully and then randomly divided into three experimental groups of 10 subjects: 1- core stability training, 2- Pilates training, and 3- control group. Groups 1 and 2 performed three sessions of their training protocol per week for 8 weeks; meanwhile, the control group performed their normal daily activities. Before and after the training period, the ankle proprioception, balance, walking performance and fear of falling were respectively measured using goniometer, standing stork and Y-level balance test, the elderly walking performance test, and fall efficacy scale-international-1 (FES) were measured. To analyze the findings, paired sample t-test, one-way ANOVA and Bonferroni's post hoc test were used ($p \leq 0.05$).
Results: The results of core stability and Pilates training had a significant effect on ankle proprioception, static and dynamic balance, walking performance and significant decrease in fear of falling ($P \leq 0.05$). Also, Pilates training compared to core stability training had more effect on ankle proprioception, static and dynamic balance and walking performance and decreased fear of falling ($P \leq 0.05$).
Conclusion: It seems that Pilates and core stability trainings can be used in the medical centers as a complementary rehabilitation method in order to improve the ankle proprioception, balance, walking performance and decreasing the fall of elderly women.
Keywords: Aging, Balance, Walking Performance, Fear of Falling, Training

Introduction

The phenomenon of aging is one of the inevitable events that occur in human society. Due to the progress of the society towards industrialization and the dramatic increase in health and medical facilities in developed and developing countries, the life span of the community has increased, so that it is expected for the elderly community to reach over one billion and 900 million by 2050. According to reports, currently around 6% (almost four and a half million) of the total population of Iran are over 60 years old, and this figure is projected to reach 26 % (almost 26 million) by 2050 (1) .Among elderly problems we can mention disturbances in balance, falling, failure in walking performance and postural control and decreased ability to perform daily activities (2). Age- related changes may occur in sensory systems, using sensory strategies, in the structure of the central and peripheral nervous system, in the musculoskeletal system, or in making modifications to the stature. These age- related changes, as the subsystem involved in elderly postural control, lead to weaker postural control (3). Damaging any of these sensory resources leads to more difficult balance control and the likely risk of losing balance and falling. Past research has shown that the degree of participation of these systems in posture control is the function of age-related decline. Therefore, the effects of aging on sensory-motor systems involved in postural control lead to a reduction in the ability of people to balance in old age (4). Decreased balance and postural control in the elderly, which occurs after some diseases or through the aging process, can lead to adverse effects such as falling. Two- thirds of the elderly who fall out usually have a disturbance of balance (5). The incisence of falling leads to a variety of physical, psychological, and social disabilities, reduced performance and independence in daily life activities, and fears of fall and eventually death, which can lead to direct and indirect costs (6). The role proprioception in balance is of great importance. The ankle proprioception affects the balance of the body. Reduction in the ankle joint proprioception can have a negative effect on the balance and reduce it (7). In the studies on the relationship between the above two factors, it was found that a reduction in the ankle joint proprioception increases the likelihood of a person falling out, and there is a significant relationship between posture instability and the possibility of ankle sprain. Therefore, in individuals with decreased ankle joint proprioception and decreased control of this joint, it can lead to failure in joint stability and posture stability (8). Strengthening the effective factors in maintaining balance, such as joint proprioception, can be effective as a major strategy in the treatment and prevention of equilibrium problems. Also, falling is the most common cause of injuries and the most serious problem for the elderly, which is known to be the sixth cause of death in the elderly (9). Past studies have shown that the underlying factors for falling elderly include: previous fall, lower lumbar muscles weakness, imbalance, walking pattern disorder, muscle weakness, high age, female gender, and psychological factors such as fear of fall. Smee *et al.* in their research reported strong correlation between gender and fear of falling (10). Walking as a basic skill, which includes certain parameters such as length of gaits and walking speed, may be used to measure the risk of falling and even the death of the elderly (11). Most of the research done in the field of walking in the elderly is to reduce the number of falling during walking. Many age- related changes that occur in the musculoskeletal system are the result of a physical activity that results in impaired fractures in the elderly (12). Performing regular physical activity improves fitness, balance, muscle strength and improves mental performance. Participation in regular sport activities is considered as an effective way in terms of health, cost and appropriateness for the improvement and preservation of the physical health of the elderly (13). Pilates is one of the sporting techniques that has attracted the attention of sports and rehabilitation specialists in the last decade and is now widely being spread. Pilates exercise is a cognitive and motor training program that can be used as a complementary therapy (14). Also, core stability trainings lead to strength, the development of core stability and the core body stability, as well as the ability of the individual to maintain the core mass body above the reliance surface, and alternatively the develop the balance. In recent years, such exercises have positively and effectively been applied at the levels of rehabilitation (15). In recent studies, the positive effects of Pilates training on dynamic balance, static balance, walking speed, and depression in the elderly women have been reported (16). Marcus *et al*. (2017) observed that exercises such as core stability training can reduce the incidence of risk of falling in the elderly (17). Mokhtari *et al*. (2013) also stated that core stability trainings are effective in improving the dynamic balance of elderly people (18). Nevertheless, to determine the effectiveness of these exercises on elderly people, especially Iranian elderly, more research is needed. In addition, regarding the importance and role of balance and postural control, and also given that the risk of falling in aging is increasing, performing exercises that improve these factors is considered necessary. Therefore, in this research, it is aimed to examine the effect of a period of Pilates training and core stability on the ankle proprioception, postural control, walking performance and fear of falling in elderly women.

Methods

As a semi- experimental research to be done in the field, the present study was applied in terms of using the obtained results, which used three groups of pre-test and post-test with the control group. The sample consisted of 30 elderly women (age 68.13 ± 1.14 years, weight 57.10 ± 7.13 kg, body mass index 20.73 ± 1.63 kg / m^2), who were selected purposefully out of 70 volunteers. After completing the medical questionnaire and obtaining consent, the subjects were randomly divided into three groups of 10: 1- core stability training 2- Pilates training, and 3- control group. The criteria for inclusion in the research included: female gender, age range of 60-75, lack of regular participation in sports activities in the last year, ability to walk independently, and no need to auxiliary tools in walking. Exclusion criteria included the presence of orthopedic and neurological problems that prevent the participation in trainings, severe deformity especially in the lower limbs, severe joint problems (including severe arthrosis or arthritis), acute problems with vision and hearing, and absence from trainings for more than two sessions. All subjects were first matched according to demographic characteristics (Table 1). The subjects at a meeting learned how to do trainings and implement them. The goniometer was used to measure the ankle proprioception. The intra-rater coefficient of correlation was 0.97 and the inter-rater coefficient of correlation was 0.87 in the research. This device is designed to measure the ankle proprioception.Testing was performed the way that the person would sit on a chair so that a 90-degree angle of thigh and knee was maintained, and the height of the chair was such that the soles of the individual could not reach the ground. Then the person's foot was positioned with the goniometer in such a way that the eyes of the person were closed. Then the individual foot was inactively taken to the midrange. This angle was 10 degrees for dorsiflexion, 20 degrees for plantar flexion, 15 degrees for inversion and 10 degrees for eversion. Afterwards, the person was asked to actively re-create the desired angle with his closed eye; the test was performed three times, and the mean of three times of the angle of reconstruction determined the individual's score in each of the states. Standing stork test was used to test the static balance; this test included a steady state in which a subject without a shoe stopped on a flat surface, and held hands on the hip joint. Then, the non-supporting foot (top leg) was placed adjacent to the knee of the supporting foot (non-top foot). The subject practiced this position for a while. He then raised his heel to establish balance on his toes. When the subject tried to lift the heel on the ground, the timer started to work. The length of time that the subject could maintain this state was calculated as his score and the timer stopped with the error. Errors in this test included removing hands from the thighs, swinging the supporting foot in any direction, separating the non-supporting foot from the knee and touching the ground with the heel of the supporting foot. Y test was used to measure dynamic balance. Since this test has a significant relationship with the length of leg, in order to carry out this test and normalize the data, before starting the measurement process, the actual length of the leg from the anterior superior Iliac soine to the internal ankle joint was measured in the supine sleeping state on the ground using the strip meter. The test was performed in three directions: anterior, posterior-internal and posterior-external, and the subject was placed on one leg (instability leg) in the center of Y and maintaining the balance on the supporting foot tried to do the access with the other leg. The subject knocked the farthest point possible with the toe in each of the designated directions without error. The distance from the contact point to the center is an access distance measured in cm. In order to minimize the learning effects, each subject practiced the test 6 times with 15 second rest interval in each of the three directions. After 5 minutes of rest, the subject performed the main test in the main directions. In the event of an error, if the leg place in the center was moving or the individual's balance was disturbed, the subject was asked to repeat the test. In order to obtain the balance score in each direction, the following formula was separately used:

Score = Mean of access distance (cm)÷ Length of the leg (cm) × 100

Evaluation of walking performance was conducted to assess moving performance. This test consists of 10 factors: 1. Level of walking 2. Change in walking speed 3. Walking with vertical head swing 4. Walking with horizontal head swing 5. Walking and swaying the pelvis 6. Walking so that there is a block in the middle of the road 7. Walking with a low level of reliance 8. Walking with closed eyes 9. Moving backward 10. Climbing the stairs, and scoring it comprised 3 = Normal; 2 = Mild disorder; 1 = Moderate disorder; and 0 = Severe disorder.

Subjects had to complete 10 items at a distance of 6 meters in length and 30 cm in width according to the instructions. The validity and intra-group reliability of test is reported to be 79 %. To measure the fear of falling, fall efficacy scale-international form was used which has 16 items that was developed and validated by Yardley *et al.* (2005). Fall efficacy scale-international is a scale of 16 questions. Questions 1 through 10 are the main fall efficacy items and 6 items were added to it which include: walking on the slippery surface, meeting friends and acquaintances, going out in group, walking on a non-level place, rising and falling down and going out to attend the ceremony. Each question measures the level of concern or fear of falling during each activity on a scale of 4 points. The items in this questionnaire have 4 options: "Very little worried", "A little worried", "Much worried", "Too much worried" (score 1 to 4). Getting a higher score on this scale means having more fear of falling. The results of Pearson correlation (0.70) indicate the positive time reliability and Cronbach's alpha (0.98) showed a very optimal internal reliability of this scale. Therefore, it can be concluded that these questionnaire was valid and reliable instruments for Iranian population. The training protocol for the participants in Pilates and core stability experimental groups consisted of 8 weeks, with a frequency of three sessions per week, and the duration of each session varied from 45 to 60 minutes. The training time was adjusted so that the subjects spent the first 10-15 minutes of each session for special warm-up activities, which included stretching, relaxation and walking. Then, for 30 minutes, they performed the main Pilates and stability trainings, and eventually they spent the ending 5- 10 minutes for cooling (Table 1 and 2). Levene' s test was used to test the homogeneity of variances in the pre-test. Kolmogorov-Smirnov test was used to ensure the distribution of the variables was normal. After showing the normality of data, data were analyzed. To compare the mean of pre-test and post-test within-groups paired sample t-test was used, and to compare between-groups, one-way analysis of variance (pretest, post-test difference) and in case of significant results, Bonferroni' s post hoc test were used. All data analysis was performed using SPSS software version 22 and at a significance level of p≤0.05.

Results

The demographic characteristics of the participants in the study, such as age, height, weight, and BMI, are presented in Table 3. The results of paired sample t-test indicated that the ankle proprioception in the core stability training group (P = 0.01) and Pilates (P = 0.01) in the post test was significantly decreased compared to the pretest. There was no significant difference in the pre-test and post-test of ankle proprioception in the control group (P = 0.5). Static balance in the core stability training group (P = 0.01) and Pilates (P = 0.01) in the post-test was significantly increased compared to the pre-test. There was no significant difference in pretest and post-test of static balance in the control group (P = 0.6).Dynamic balance in the anterior direction was significantly increased in the control group in the core stability (P = 0.03) and Pilates (P = 0.04) in the post- test compared to pre-test. There was no significant difference between the pre- test and the post- test of dynamic balance in the anterior direction in the control group (P = 0.30). Dynamic balance in the posterior direction in the core training group (P = 0.01), Pilates (P = 0.04)) was significantly increased in the post-test compared to pre- test. There was no significant difference in the pre- test and post-test of dynamic balance in the posterior internal direction in the control group (P = 0.50). Dynamic balance in posterior external direction was in the core stability training group (P = 0.01), Pilates (P =0.02) was significantly increased in the post-test compared to the pre- test. There was no significant difference in the pre- test and post-test of dynamic balance in the posterior external direction in the control group (P = 0.60). Walking performance in the core stability training group (P = 0.01), Pilates (P = 0.01) was significantly decreased in the post-test compared to pre- test. There was no significant difference in the pre-test and post-test of walking performance in the control group (P = 0.50). Self-efficacy of fear of falling in the core stability training group (P = 0.04), Pilates (P = 0.03) in posttest Significantly decreased compared to the pre-test. There was no significant difference in pre-test and post-test of self-efficacy of fear of falling in the control group (P = 0.6). The results of one-way ANOVA showed that there is a significant difference in the proprioception (p = 0.01), static balance (p = 0.01), dynamic balance in the anterior direction (p = 0.001), dynamic balance in the posterior external direction (P = 0.01), dynamic balance in posterior internal direction (p = 0.02), walking performance (p = 0.01) and self-efficacy of fear of falling (p = 0.01) in the three groups of research. The results of the post hoc test in Table 5 showed that dynamic balance in the anterior direction in the Pilates exercise group and core stability decreased significantly compared to the control group (p = 0.001); and in the Pilates training group significantly decreased compared to the core stability training group (p = 0.001).Dynamic balance in the posterior internal part of the Pilates training group, and the core stability decreased significantly compared to the control group (p = 0.001); in the Pilates training group compared to the core stability training group significantly decreased (p=0.001). Dynamic balance in the posterior external part of the Pilates training group, and core stability decreased significantly compared to the control group (p = 0.001), and in the Pilates training group, compared to the core stability training group (p = 0.001) significantly decreased (p = 0.001). The results of the post hoc test in Table 5 showed that the walking performance in the Pilates training group and core stability was significantly decreased compared to the control group (p = 0.001). In the Pilates training group, there was a significant decrease compared to the core stability training group (p = 0.001).The results of the post hoc test in Table 5 showed that the self-efficacy of fear of falling in the Pilates training group and core stability decreased significantly compared to the control group (p = 0.001); also in the Pilates training group significantly decreased compared to the core stability training group (p = 0.001).

Table 1. Core stability group trainings

Training	Week	1	2	3	4	5	6	7	8
Move one hundred	Set	2	2	2	2	3	3	3	3
	Repetition	8	8	10	10	12	12	13	13
The opposite hand and foot	Set	2	2	2	2	3	3	3	3
	Repetition	8	8	10	10	12	12	13	13
Bridging	Set	2	2	2	2	3	3	3	3
	Repetition	8	8	10	10	12	12	13	13
Bridging with one foot	Set	2	2	2	2	3	3	3	3
	Repetition	8	8	10	10	12	12	13	13
Move the cat	Set	2	2	2	2	3	3	3	3
	Repetition	8	8	10	10	12	12	13	13
The opposite hand and foot	Set	2	2	2	2	3	3	3	3
	Repetition	8	8	10	10	12	12	13	13

Table 2. Pilates group trainings

Hundred	Week	1	2	3	4	5	6	7	8
One leg stretch	Set	2	2	2	2	3	3	3	3
	Repetition	8	8	10	10	12	12	13	13
Clam	Set	2	2	2	2	3	3	3	3
	Repetition	8	8	10	10	12	12	13	13
Shoulder Bridge	Set	2	2	2	2	3	3	3	3
	Repetition	8	8	10	10	12	12	13	13
Hip Twist	Set	2	2	2	2	3	3	3	3
	Repetition	8	8	10	10	12	12	13	13
One leg kick Scissors	Set	2	2	2	2	3	3	3	3
	Repetition	8	8	10	10	12	12	13	13
One leg kick	Set	2	2	2	2	3	3	3	3
	Repetition	8	8	10	10	12	12	13	13
Side Kick	Set	2	2	2	2	3	3	3	3
	Repetition	8	8	10	10	12	12	13	13
One leg circle	Set	2	2	2	2	3	3	3	3
	Repetition	8	8	10	10	12	12	13	13

Table 3. Demographic characteristics of the subjects in the pre-test

Group / Variable	Core stability training	Pilates	Control
Age (year)	68.13±1.4	71.31±3.12	69.11±3.16
Height (cm)	166±1.12	172.14±1.06	174±2.14
Weight (kg)	57.10±7.3	56.13±7.46	54.11±6.54
Body Mass Index (kg/m^2)	20.73±1.63	18.98±1.06	17.88±2.21

Table 4. Results of one-way ANOVA and t-test to examine changes in measured variables in three research groups

Variable	Group	Time	Mean ± Standard deviation	Paired sample t- test	One- way ANOVA
Deep ankle proprioception (Degree)	Core stability training	Pre-test	0. 51±0.12	P=0.01 *	P=0.01 *
		Post-test	0.46±0.11		
	Pilates training	Pre-test	0. 49±0.13	P=0.01 *	
		Post-test	0. 44±0.10		
	Control	Pre-test	0. 49±0.12	P=0.53	
		Post-test	0. 49±0.14		
Static balance (Second)	Core stability training	Pre-test	4.12±0.11	P=0.01 *	P=0.01 *
		Post-test	7.46±0.12		
	Pilates training	Pre-test	4.52±0.64	P=0.01 *	
		Post-test	8.82±0.32		
	Control	Pre-test	3.94±0.89	P=0.64	
		Post-test	3.88±0.65		
Dynamic balance in the anterior direction	Core stability training	Pre-test	37. 02±0.16	P=0.03 *	p=0.001 *
		Post-test	40.07±0.14		
	Pilates training	Pre-test	36. 23±2.12	P=0.04 *	
		Post-test	41.14±2.2		
	Control	Pre-test	36.95±1.11	P=0.36	
		Post-test	36.63±1.62		
Dynamic balance In the posterior internal direction	Core stability training	Pre-test	39.15±2.4	P=0.01 *	P=0.01 *
		Post-test	43.01±0.14		
	Pilates training	Pre-test	41.23±2.1	P=0.04 *	
		Post-test	47.14±2.2		
	Control	Pre-test	41.82±2.24	P=0.51	
		Post-test	41.17±2.03		
Dynamic balance In the posterior external direction	Core stability training	Pre-test	34.15±1.17	P=0.01 *	P=0.02 *
		Post-test	37.19±2.05		
	Pilates training	Pre-test	34.88±2.08	P=0.02 *	
		Post-test	38.22±2.11		
	Control	Pre-test	37.33±1.2	P=0.62	
		Post-test	37.88±1.23		
Walking performance	Core stability training	Pre-test	14.29±3.12	P=0.01 *	P=0.01 *
		Post-test	17.11±1.6		
	Pilates training	Pre-test	15.37±2.82	P=0.01 *	
		Post-test	19.24±4.31		
	Control	Pre-test	15.21±1.62	P=0.51	
		Post-test	15.02±2.07		
Self-efficacy of fear of falling	Core stability training	Pre-test	31.01±2.18	P=0.04 *	P=0.01*
		Post-test	29.04±1.12		
	Pilates training	Pre-test	30.34±1.13	P=0.03 *	
		Post-test	26.01±1.63		
	Control	Pre-test	31.14±3.88	P=0.68	
		Post-test	31.36±3.9		

* Significant difference at P≤0.05

Table 5. Results of Bonferroni's post-hoc test to compare changes in measured variables among three groups of research

Variable	Group	Pilates	Control
Deep ankle proprioception	Core stability training	M=0.02 p=0.001 *	M=0.03, p=0.001 *
	Pilates training	------------	M=0.05, p=0.001 *
Static balance	Core stability training	M=1.36 p=0.001 *	M=3.58, p=0.001 *
	Pilates training	------------	M=4.94, p=0.001 *
Dynamic balance in the anterior direction	Core stability training	M=1.07 p=0.001 *	M=3.44, p=0.001 *
	Pilates training	------------	M=4.53, p=0.001 *
Dynamic balance in the posterior internal direction	Core stability training	M=4.13 p=0.001 *	M=1.84, p=0.001 *
	Pilates training	------------	M=5.97, p=0.001 *
Dynamic balance In the posterior external direction	Core stability training	M=1.03 p=0.001 *	M=0.69, p=0.001 *
	Pilates training	------------	M=0.34, p=0.001 *
Walking performance	Core stability training	M=2.13 p=0.001 *	M=2.09, p=0.001 *
	Pilates training	------------	M=4.22, p=0.001 *
Self-efficacy of fear of falling	Core stability training	M=3.3 p=0.001 *	M=2.64, p=0.001 *
	Pilates training	------------	M=5.67, p=0.001 *

* Significant difference at $P \leq 0.05$

Discussion

The results of this study showed that 8 weeks of core stability and Pilates trainings increased deep ankle proprioception, postural control and walking performance and decreased fear of falling in elderly women. The results of this study were consistent with the results of Rahmani *et al*. (2015), Kelly *et al*. (2007)), Newell *et al*. (2012), Mokhtari *et al.* (2011), and Fernando *et al.* (2007) (19, 20, 21, 18, 8). On the other hand, the findings of this study are not consistent with the results of Bird *et al*. (2012), Khajeh Nemat *et al*. (2014) and Chang *et al*. (2004) (22- 24). This discrepancy can be related to the implementation of the training protocol and its duration, and the subjects' gender and age. Kelly et al. (2007) attempting to investigate the effects of eight weeks of sensory-balance trainings on the position and movement of the deep ankle proprioception in the elderly showed that these trainings increased the deep ankle proprioception (20). Performing regular exercise can be a useful strategy to maintain deep ankle proprioception and prevent falling in the elderly (8). There is evidence that Pilates leads to a morphological adaptation of a major of mechanical receptors involved in the deep ankle proprioception of muscle spindle. Pilates trainings can make the muscle spindle adapt at a macro level. The intrafusal muscle fibers may exhibit metabolic changes, and at higher macro levels, the delay in the stretch reflex response decreases and the range increases (19). Perhaps this mechanism has been effective in improving the deep ankle proprioception in the elderly. The cause of the effectiveness of trainings on the core stability group has been attributed to the stability created by these trainings, which provides a better direction for distal joints in the elderly. It can also be said that the precise, timely and synchronized evoking of the body's central area for proper and timely movement of the lower and upper extremities in the elderly leads to improved proper movement patterns and ultimately improves the deep ankle proprioception and ultimately improves balance (24). Another study by Chang *et al.* (2004), which aimed to compare and investigate the impacts of Tai Chi, swimming and running on the deep ankle and joint proprioception in the elderly, indicated that the falling-prevention program should be multifactorial to effective on both the risk of falling and the amount of it (24). Sadeghi *et al.* (2015) examined the effect of eight weeks of the sole reflexology massage on the balance and profusion error of the ankle deep proprioception in the elderly men. The results indicated that massage increased the ankle deep proprioception (25). The results of this study showed that 8-weeks of core stability training and Pilates improved balance in the elderly women. Rahmani *et al*. (2015), in one study showed that Pilates trainings can improve the balance and response time in the elderly (19). Newell *et al*. (2012) also examined the effect of eight weeks of Pilates trainings (one session per week and a total of 8 sessions) on walking and the dynamic balance of the elderly, and stated that these trainings significantly improved the mean of walking speed, the static and dynamic balance of the foot-stepping cycle and the length of gait (21). The results of the research by Rodriguez *et al.* (2013) showed that 8-weeks of Pilates trainings significantly improved the dynamic balance in the elderly (26). The improvement of balance by Pilates trainings can be studied based on the theory of systems. According to the theory of systems, the ability to control in space is due to the synchronous and complex interaction of the nervous musculoskeletal system, which is generally called the postural control system. Based on this system, postural control to maintain balance, and consequently to create movement requires the integration of sensory data, to determine the position of the body in space, as well as the ability of the muscular system to maintain balance (21).

Therefore, it seems logical that Pilates trainings will improve the postural control in the elderly. Another argument can be said to be concerned with the nerve compatibility. Because physical training makes adaptation in the brain and spinal cord, due to which the individual's ability to invoke motor units increases, and it facilitates contraction and increases the muscle's ability to generate force, and as a result, the balance increases and controls the postural control is maintained (19). Several studies have probed age- related muscle changes (26). In these studies, it has been shown that aging is accompanied by increased atrophy and muscle weakness of the lower limbs over the upper limbs. There is also an inverse relation between the aging and size (mass) of the muscles of the central part of the body (abdomen and back) (27). The core stability or trunk stability trainings will stabilize the body and ensure balance of the body when moving the limbs. Strengthening the main muscles involved in this stability (transverse abdominal muscles, polyphidosis and pelvic floor) maintains a greater balance and stability of the trunk in the everyday activities. Also, core stability trainings lead to improved activity prediction and thus reduce disturbance in the displacement and vacillation of the center of gravity. In a study, Khajeh Nemat *et al.* (2014) investigated the effects of strength training and Pilates on static and dynamic balance in healthy elderly men. The results of this study showed that strength training and Pilates did not have an effect on the balance in the elderly (23). The results of this study showed that 8 weeks of core stability and Pilates improved walking performance in elderly women. Elderly changes negatively affects balance and walking, such as loss of strength, muscle mass, and bone density, re-distribution of body mass, respiratory capacity damage, selective atrophy of central nervous system components that control balance and walking, and decline in the peripheral sensory function. In addition, increasing the use of medication in the elderly may also have a negative effect on walking (25). Many studies have reported that aging and individual walking speed, affect length and width of gaits, because the decrease in walking related factors in the elderly is accompanied by an increase in the rate of falling of these people (28). In a research, Kasukawa *et al.* (2010), divided 56 elderly women into four groups of rhythmic movements, strength training, aquatic training and normal walking, considering the particular physical activity that they performed at least six months before the study, and compared them with one control group that did not perform any physical activity. The researchers found that, performing rhythmic movements could have a positive effect on balance and muscle strength, increase the number of factors associated with walking, reducing cognitive decline and reduce the risk of falling (29). Newwell *et al.* (2012) studied changes in balance and walking parameters in the elderly following eight weeks of supervised Pilates programs. In this study, observation of walking parameters including variability between gaits and postural vacillations in an elderly group during eight weeks of Pilates classes was investigated. The results of the research have shown significant improvement in the length of gait (21). However, according to the findings of the present research and the results of previous studies, it seems that well-designed exercise and training programs for the elderly can have an effective impact on the speed of walking by increasing the strength and endurance of muscles, increasing bone density, and improving the flexibility of the joints. Also, walking speed of the elderly is affected by the length of the gait, the range of motion of joints involved in walking, followed by the time and the ratio of dual reliance (21). The core stability trainings strengthen the muscles and, as a result, improve balance and postural control. In addition, from the anatomical point of view, the center of the body is the area in which the center of gravity is located and the movements come from there. Therefore, it seems that strengthening of the muscles of this area as a result of the core stability training protocol improves the nervous-muscular system, reduces the center of gravity displacement beyond the level of reliance and reduces its fluctuations, and thereby improves walking performance and ultimately decreases the rate of falling (19). A large part of the core stability and Pilates trainings are focused on movements to enhance balance, power and flexibility. Therefore, the improvement of balance and physical flexibility in experimental groups seems obvious. Reducing strength, flexibility, and muscular endurance all contribute to changing patterns of stepping and are potential factors for falling, which in this regard a selected program can compensate for such a decline (27). The results of the present study showed that 8 weeks of core stability and Pilates training improved the fear of falling in elderly women. Incidence of falling may directly and indirectly affect the movement performance of the elderly. On the other hand, as falling may have consequences like physical injury, fracture, hospitalization, disability, use of auxiliary equipment, etc., it may directly affect the performance of the elderly. In addition, falling yields to complications such as fear of falling back, avoiding self- imposed activities, limiting mobility, psychological decline, etc., which can indirectly reduce the physical performance of the elderly (30). Hosseini *et al.* (2010) in assessing the effects of selected sports programs on the balance and fear of falling old women concluded that conducting an exercise program had a significant effect on the elderly's balance (31). Irez (2014) conducted a study entitled " the effects of different exercises on balance, fear and risk of falling among adults aged 65 and over”. In this study, after 14 weeks of Pilates training, there was a significant difference in interventional and control groups after intervention in muscle strength, dynamic balance, flexibility, fear of falling and risk of fall parameters (32). Because osteoporosis is a major health problem around the world, and falling causes a hip fracture and upper limbs, which require care and treatment, therefore the prevention or reduction of the risk of falling in the elderly will contribute significantly to the health and quality of life of the elderly, resulting in a significant reduction in the use of health care resources. The core stability trainings program, improves the invocation and control of the central part of the body, and results in the better manifestation of the use of organs in the elderly (31). Proximal stability for performing distal movements improves the motion patterns and reduces the incidence of falling in the elderly. In the case of Pilates trainings, the role of stabilizing, moving, and contracting muscles is constantly being replaced. This change in the role of muscles can be effective in improving muscle strength, and hence Pilates trainings can increase muscle strength and prevent falling (30). One of the limitations of this study was controlling the subjects' daily activities. It is recommended that future researchers carry out an analogous study using advanced isokinetic devices.

Conclusion

Based on the findings of the present study, Pilates and core stability trainings increased the deep ankle proprioception, static and dynamic balance and reduced fear of falling. Pilates training had the greatest increase in the deep ankle proprioception, static and dynamic balance, and reduced fear of falling. Finally, the results of this study showed that Pilates and core stability trainings could be used in the medical centers as a complementary rehabilitation method in order to improve the deep ankle proprioception factors, balance, walking performance and decrease the fall of elderly women.

Ethical issues

Not applicable.

Authors' contributions

All authors equally contributed to the writing and revision of this paper.

Acknowledgments

We would like to appreciate all those who have collaborated in this study.

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