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Original Article

Comparable Effects of Eight-Week Water- and Land-Based Functional Training on Balance and Physical Functionality of Elderly Women

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Abstract

Background: Older adults typically engage in less physical activity due to age-related factors and health conditions. Given the specific needs associated with this stage of life, it is crucial to focus on their physical activity levels and independence. Accordingly, this study aimed to examine the impact of land-based and water-based functional exercises (LBFT/WBFT) on balance, physical performance, and fall risk among older adults.

Methods: This semi-experimental study involved 28 healthy elderly women from Tabriz city, with a mean age of 67.07 ± 6.32 years, a mean weight of 71.67 ± 11.8 kg, and a mean height of 156.32 ± 6.9 cm. Participants were recruited using a convenience sampling method and randomly assigned to one of three groups: land-based exercise training (n = 9), water-based training (n = 9), and a control group (n = 10). Physical function parameters, including strength, endurance of both upper and lower body, flexibility of the lower body and trunk-shoulders, reaction time, agility, and balance, were evaluated before and after the intervention. The selected exercises were performed over an eight-week period, twice weekly, with 3 sets of 12 repetitions each session. Statistical analysis involved paired *t* tests and ANCOVA, followed by Bonferroni post-hoc tests to assess both inter-group and intra-group differences.

Results: The results indicated that both LBFT and WBFT led to significant improvements in all assessed parameters ($P \leq 0.05$).

Conclusion: The two training modalities notably enhanced muscle strength and endurance, flexibility, and agility, which are crucial for improving balance and overall physical performance in elderly women. Therefore, both forms of functional training appear to be effective interventions for enhancing balance and physical performance while reducing fall risk in older adults.

Keywords: Functional training, Water training, Balance, Strength, Performance, Elderly

Introduction

Old age is a critical period of human life, and paying attention to the issues and needs of this stage is a social necessity. The aging process is a natural phenomenon that affects all biological and psychological aspects of a person. The increase in the elderly population is so significant that it has been referred to as a silent revolution. According to the statistics of the World Health Organization (WHO), there are almost 1 billion elderly people over the age of 65 in the world, and this number is increasing day by day.[1] Statistical reports from Iran also indicate the growth and acceleration of aging. It is predicted that an aging population explosion will occur in Iran in 2030, and 25-30% of the population will be over 50 years old.[2] Therefore, aging, the specific conditions of the elderly, and improving their mental and physical health are among the issues that require special attention.[3]

The aging process causes widespread destructive and regressive changes in the neuromuscular system, which result in muscle atrophy, decreased strength, lack of endurance, balance issues, impaired motor function, and performance loss. These changes increase the risk of falling, fear of falling, and injury and decrease physical activity, which can aggravate the process of sarcopenia.[4] Since muscle weakness, lack of flexibility, loss of muscle synergy mechanisms, and motor control problems all play a role in falling, doing a physical fitness program seems to be an effective strategy to prevent falling in older people.[3,5] Exercise training and regular physical activity in older adults can compensate for the decrease in muscle mass and moderate the disability caused by the aging process, improve bone health and balance, increase flexibility, increase life expectancy, and maintain mental ability.[6] In addition, physical fitness plays an essential role in improving people's quality of life. According to studies, physical fitness exercises are more helpful for elderly people than for younger adults. Additionally, strength and endurance in the shoulder girdle area are among the critical and essential factors in the completion of daily tasks, and reduction of osteoporosis, prevention of many

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skeletal-muscular discomforts, and also reduction of injuries caused by falls in old age are all positive effects of training in the elderly.[6,7] In this regard, functional exercises are prevalent due to their neurophysiological features. This type of exercise can improve balance and increase walking ability in the elderly.[8] According to the studies, functional exercises have resulted in greater muscle efficiency and increased neuromuscular adaptation.[9] However, some elderly may avoid exercise due to the fear of increasing joint pain, movement limitation, and possible falls.

One of the appropriate alternative methods for improving balance control is water exercise, which allows the elderly to exercise in a pain-free environment due to the physical benefits derived from the water environment.[10] Hydrostatic pressure and buoyancy allow exercise in the water environment to have several advantages over land-based exercises. First, the anti-gravity buoyancy force in the water environment acts as a resistance force. Therefore, water is a suitable environment for easy and comfortable movement of people who have problems moving on the ground.[11,12] Second, the hydrostatic pressure during immersion in water exerts an equal resistance on all active muscle groups, hence it creates a kind of training condition and also provides a strong sense of stability.[11,13] Third, because there is no static resting position in the water, the muscles are constantly active to stabilize the body's positions; therefore, it is possible that the problem of fixing the position of the person exercising in the water will allow him/her to gain more strength and flexibility and most importantly improve his/her balance.[12] Moreover, due to the higher viscosity of water, exercising in water adds more resistance; therefore, it can improve the sensory response and cause a more significant increase in body awareness.[14] For these reasons, water can be an appropriate environment for balance exercises. In the study conducted by Häfele et al, exercise in water improved the strength of lower-body muscles in the elderly.[15] In contrast, some researchers indicate that aquatic exercises have no effect on the health of the elderly.[10] In their study, de Castro et al investigated the effect of exercise in water and exercise on land on the balance of elderly women, and they did not observe a considerable change among the studied groups.[16] Therefore, it is possible that exercising in the water is not always helpful for the elderly, and despite the relatively high costs of exercising in the water, a significant change in the physical fitness factors among the elderly may not be observed. Additionally, the effectiveness of exercise methods in increasing the ability to maintain balance in the elderly has not been determined. Therefore, the aim of this study was to find a suitable way to improve balance and physical functional performance and reduce the number of falls caused by balance disorders in elderly people using water and land-based functional training (WBFT/LBFT).

Materials and Methods

This semi-experimental study included a sample of 30 healthy elderly women from Tabriz city (mean age: 67.07 ± 6.32 years, mean weight: 71.67 ± 11.8 kg, and mean height: 156.32 ± 6.9 cm). The participants were selected by the available sampling method and randomly divided into one of the three groups: land-based training (n = 9), water-based training (n = 9), and control (n = 10). The subjects were socially active and could do daily tasks individually. Exclusion criteria included inability to walk independently, blindness, inability to follow directions due to cognitive impairment, and a history of more than one fall in the past 12 months. Two subjects were identified and excluded from the study due to illness and movement problems, using a medical questionnaire and a questionnaire measuring the level of readiness for physical activity (PAR-Q). Before starting the research, a written consent form was obtained from the participants and the study protocol was approved by the Research Ethics Committee of Tabriz University of Medical Sciences (IR.TBZMED.REC.1396.654). Before the pre-test, the subjects were asked not to do exercise activities other than the research program, and the pre-test was taken in 4 sessions from 9:30 to 12. Each participant performed functional fitness tests and training programs under the supervision of a physician.

The measurement of body composition included height and weight. Height was measured in a standing position, and weight was measured with a digital scale with an accuracy of 0.05 kg. In order to assess upper extremity muscular endurance, the arm curl test was used. In the arm curl test, subjects sat on a chair and were asked to bend their elbow as far as possible in 30 seconds while holding a 1 kg dumbbell. Participants were asked to maintain their normal breathing pattern and keep their elbows close to their sides throughout the entire experiment. The score was the total number of hand weight curls through the full range of motion in 30 seconds. In order to assess lower extremity muscular endurance, we used the multiple sit-to-stand test. The chair stand test was used to assess lower body strength [17]. Each subject completed two practice repetitions and one 30-second test trial. The score was the total number of stands executed correctly within 30 seconds.[18]

Hand grip strength was measured by a hand dynamometer. The subjects were asked to perform this task 3 times with each hand, and the maximal strength obtained during the 3 trials was used for analysis. Previous research has shown that aging affects handgrip strength and lower extremity muscles similarly and that these measures are equally effective in identifying poor mobility.[19]

To measure the flexibility of the lower body, the chair sit and reach test was used. Each subject completed two practice trials and two test trials. The score was the best distance achieved between the extended fingers and the tip of the toe. The trunk rotation test was used to assess trunk and shoulder flexibility. Each subject completed two practice trials and two test trials. Participants were allowed to turn their shoulders, hips, and knees but not to move their feet. The score was recorded as the best distance achieved from the line.

Nelson's ruler test was used to measure the reaction time. To familiarize the participants with the Nelson's ruler test, they were allowed to have two practice trials. Research shows that reaction time is a reliable predictor of falls and performance decline in old age.

The 8-foot up-and-go test was used to measure coordination and agility. In this test, the subject sat on a chair (next to the wall) with his hands on his knees and his feet on the floor. With the command "go", they got up and (without running) moved as fast as possible (and safely) towards the cone placed 8 feet in front of the chair, and after turning around it, they returned to sit on the chair. Timing was stopped when the subject sat down. The best record of two trials was recorded for the participants.

In addition, the Berg balance scale was used to determine the level of balance and falling risk. This test includes 14 items (sitting to standing, standing unsupported, sitting unsupported, standing to sitting, transfers, standing with eyes closed, standing with feet together, reaching forward with outstretched arms, retrieving object from floor, turning to look behind, turning 360 degrees, placing alternate foot on stool, standing with one foot in front, and standing on one foot). The minimum score for each item was 0, and the maximum score was 4. Then, the sum of the points was calculated. The post-test was conducted according to the pre-test conditions.

Functional Training

Selected exercises (Table 1) were performed over an eight-week period, two days a week, 2-3 sets, 12 repetitions each. Participants started exercising for 30 min/d with an intensity equal to a Borg rating of perceived exertion (RPE) of 13-14. The intensity and duration were progressively enhanced during the next weeks until each subject exercised for a period of 1 h/day at an RPE of 17 for 8 weeks.

Statistical Analysis

Shapiro-Wilk test was used to check the normality of data, and paired *t*-test, as well as ANCOVA statistical method, was used to assess the inter- and intra-group differences. The Bonferroni post-hoc test was also used to determine the source of significant differences. SPSS version 24.0 was used to analyze the data at the significance level of 0.05.

Results

The mean ± standard deviation of the variables investigated in this research and the intra-group changes from the pre-test to the post-test are shown in Table 2.

The analysis of the collected data using the analysis of covariance (Table 3) showed that in the post-test stage, there was a significant difference in the variables of strength, upper body and lower body endurance, trunk rotation and hamstring flexibility, reaction time, agility, and balance. In order to determine the source of the differences, the Bonferroni test was used, the results of which are shown in Figure 1. In all variables of balance and physical functional performance, both water and land-based functional training methods have caused significant improvement compared to the control group ($P \leq 0.05$), while there was no difference between the two training groups.

Discussion

The results of this study indicated that both water and land-based functional exercises significantly enhanced strength, balance, flexibility, and endurance of the upper and lower body, along with the agility and balance of Iranian elderly women.

The most obvious finding to emerge from the analysis is that performing regular physical activity with moderate intensity, land-based or water-based exercises, can become the basis for an active lifestyle for older females. These types of exercises can be very valuable and helpful due to the improvement of fitness in this population, who need appropriate amounts of strength, balance, agility, and so on to meet their daily needs.

In the meantime, one of the essential factors of physical fitness, especially in older women, is to have an appropriate level of balance to decrease the risk of falling, which may lead to irreversible consequences for the elderly. It can be said that balance is a complex movement stage that describes the dynamics of the body in preventing falls. The ability to control the posture of the body in space is attributed to the simultaneous and complex interaction of three nervous, muscular, and skeletal systems, which are collectively called the posture control system. This posture

Table 1. Eight-Week Protocol of Water and Land-Based Functional Training

	Muscular Endurance (3*12 reps)	**Strength (3 sets*5 reps)**	**Flexibility (3 sets*12 reps)**	**Agility (3 sets*12 reps)**	**Reaction time (3 sets*10 sec)**	**Balance (3 sets*10 sec)**
WBFT	Front leg raises	Raising the arm with a weight of 0.5 kg	Stretching the hands	Walking in different directions	Reacting to the coach's movements	Pairing the legs and standing
	Arm abduction	Squat	Stretching the legs	Crossing movement of the arms and legs in response to the coach	Catching the ball	Walking in a line
LBFT	Holding hands out on top of the head up to 50 counts	Raising arms and legs with a 2 kg weight	Stretching arms	Crossing movements	Reacting to the stork movements by the coach	Stork balance standing
	Doing 50 chair squats	Bending the back	Waist flexion	Walking in different directions	Catching the ball	Raising the knees and holding

WBFT, water-based functional training; LBFT, land-based functional training.

Table 2. The Unadjusted Mean Values of the Studied Variables in the Pre-test and Post-test Phases

Variable/Group		Control	*P* Value	LBFT	*P* Value	WBFT	*P* Value
Age		64.50 ± 6.94	-	68.22 ± 4.84	-	68.77 ± 6.64	-
Height		156.35 ± 7.03	-	156.22 ± 7.96	-	156.38 ± 6.65	-
Weight	Pre	75.35 ± 15.77	0.692	70.88 ± 12.13	0.866	68.38 ± 4.32	0.809
	Post	74.2 ± 17.96		70.77 ± 11.18		68.26 ± 3.84	
Hand grip strength (kg)	Pre	14.42 ± 3.46	0.068	16.55 ± 4.18	0.064	17.00 ± 2.69	0.25
	Post	13.05 ± 4.01		18.33 ± 3.24		18.11 ± 3.98	
Arm curl test (rep. 30 s^{-1})	Pre	15.60 ± 5.81	0.096	17.44 ± 3.24	0.009**	17.55 ± 6.10	0.023*
	Post	14.40 ± 4.74		21.11 ± 3.55		22.44 ± 4.87	
Sit to stand test (rep. 30 s^{-1})	Pre	9.00 ± 3.88	0.1	8.00 ± 4.33	0.223	11.11 ± 2.75	0.01**
	Post	7.40 ± 4.16		9.88 ± 6.80		14.00 ± 4.03	
Chair sit and reach test (cm)	Pre	-1.00 ± 7.91	0.156	1.88 ± 9.15	0.112	0.11 ± 11.55	0.019*
	Post	-4.10 ± 8.69		4.88 ± 7.75		2.44 ± 8.12	
Trunk rotation test (cm)	Pre	5.5 ± 7.24	0.137	6.22 ± 3.99	0.002**	10.55 ± 6.8	0.008**
	Post	4.7 ± 7.31		12.8 ± 7.75		14.5 ± 6.82	
Reaction time (ms)	Pre	221.54 ± 18.37	0.082	197.71 ± 21.61	0.006**	200.18 ± 30.24	0.0001**
	Post	211.61 ± 46.05		160.11 ± 47.45		124.63 ± 49.03	
Balance (s)	Pre	50.00 ± 2.70	0.08	49.44 ± 5.36	0.0001**	48.88 ± 6.37	0.01**
	Post	48.20 ± 3.08		52.22 ± 4.71		52.66 ± 3.46	
Agility (s)	Pre	8.65 ± 3.00	0.08	7.88 ± 2.24	0.01**	7.50 ± 2.52	0.108
	Post	9.21 ± 2.56		6.20 ± 1.36		6.43 ± 1.29	

WBFT, water-based functional training; LBFT, land-based functional training.
* Significant difference at the 0.05 level; ** Significant difference at the 0.01 level.

Table 3. Adjusted Mean Values ± SE of the Research Variables in the Post-test, Considering the Pre-test Values of Each Variable as Covariate

Variable/Group	Control	Training	Water Training	*P* Value	SE
Hand grip strength (kg)	14.345 ± 0.767	17.804 ± 0.785	17.202 ± 0.793	0.011*	0.31
Upper body endurance (rep.min^{-1})	15.149 ± 1.001	20.729 ± 1.047	21.995 ± 1.048	0.0001**	0.51
Lower body endurance (rep.min^{-1})	7.779 ± 1.056	11.329 ± 1.138	12.139 ± 1.155	0.021*	0.28
Chair sit and reach test (cm)	-3.423 ± 2.100	4.044 ± 2.217	2.536 ± 2.206	0.05*	0.22
Trunk rotation test (cm)	6.65 ± 1.055	14.08 ± 1.099	11.07 ± 1.143	0.0001**	0.51
Reaction time (ms)	21.918 ± 2.118	14.709 ± 2.243	8.605 ± 2.186	0.001**	0.45
Balance (score)	47.830 ± 0.514	52.236 ± 0.541	53.064 ± 0.542	0.0001**	0.71
Agility (s)	8.837 ± 0.306	6.294 ± 0.320	6.762 ± 0.322	0.0001**	0.61

* Significant difference at the 0.05 level; ** Significant difference at the 0.01 level.

control system considers the integration of sensory data to detect the position of the body in space as well as the ability of the musculoskeletal system to apply the appropriate force to maintain balance and then create movement. According to this theory, musculoskeletal factors effective in regulating balance include muscle characteristics, joint range of motion, and biomechanical relationship of different parts of the body.[20]

In addition, the nervous system plays a very important role in controlling posture. Therefore, based on this theory and also the effect of functional exercises on each of these systems, it seems logical that water-based and land-based functional exercises can improve balance. In addition, since balance depends on the input of cutaneous receptors in addition to the input of proprioceptive receptors, the decrease in balance in the elderly is to some extent related to the decrease in motor ability.[21]

It seems that the improvement in balance can be attributed to the increase in muscle strength and flexibility of the lower limbs of the participants in this study. Therefore, maintaining balance in different movements and directions requires muscle strength. Keeping in mind that one of the reasons for the loss of balance performance is the placement of the body's center of gravity in the outer part of the ankle joint due to the decrease in the muscle strength of the lower limbs, the improvement of muscle strength can cause the center of gravity to transfer to an appropriate point and so balance can be improved.[7] On the other hand, exercise-induced muscle strength and endurance, balance, and agility (i.e., functional performance) can be attributed to the increased neural adaptations, such as the use of more effective neuronal units, reorganization in the sensory-physical cortex, increasing efficiency and strength of synaptic

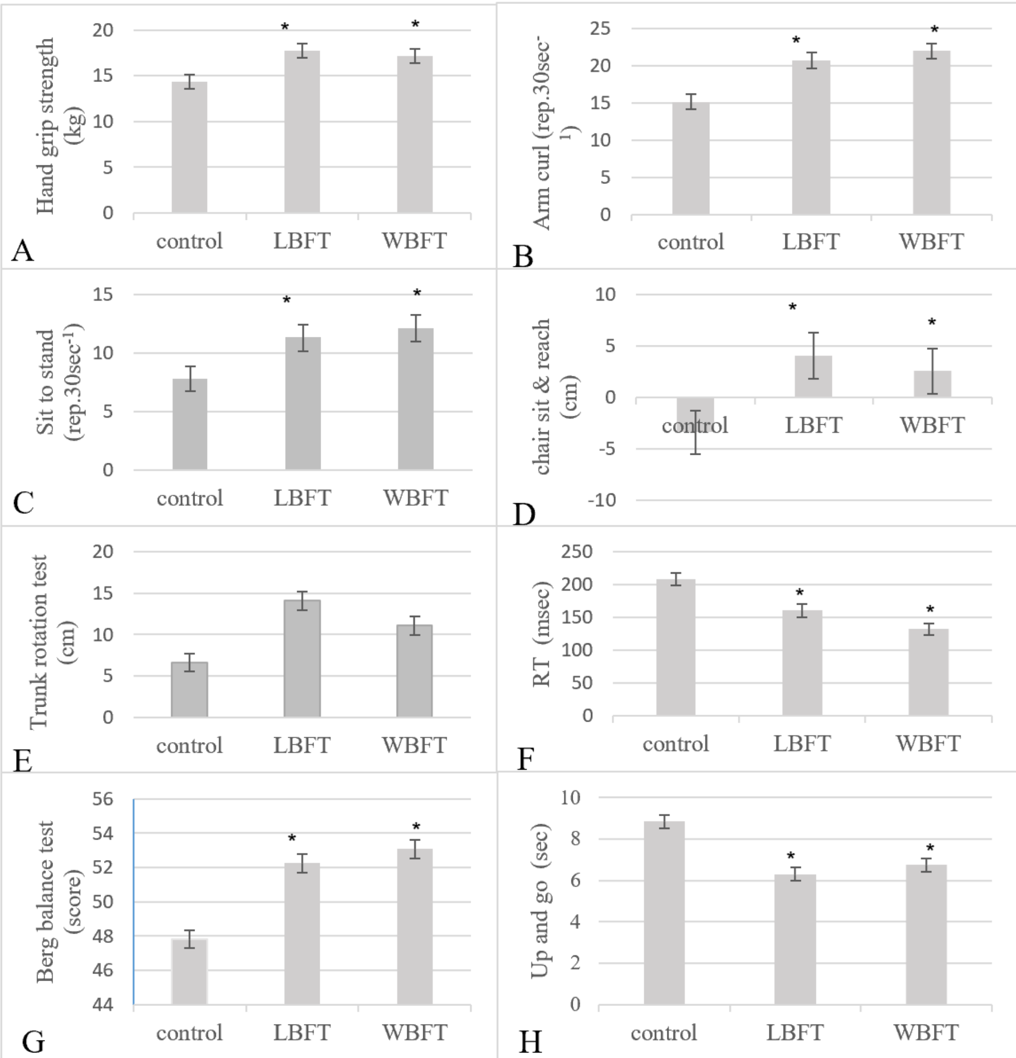

Figure 1. Performance Test Results (Mean ± SD). **A**, Hand grip strength. **B**, Upper extremity endurance (Arm Curl). **C**, Lower extremity endurance (multiple sit-to-stand). **D**, Lower body flexibility (chair sit and reach). **E**, Trunk and shoulder flexibility (Trunk rotation test). **F**, Reaction time (Nelson ruler). **G**, Balance (Berg balance test), **H**, Agility (up and go). LBFT: land-based functional training. WBFT: water-based functional training. * Significant difference with the control group at the 0.05 level

junctions, improved activation of the nervous system, reduction of inhibitory nerve reflexes, reduction of the resistance of nerve pathways to impulse transmission, and improvement and mastery in the transmission of inputs from each of the senses.[22]

The results of other studies that include decision-making challenges in exercise programs for the elderly show that these challenges and exercises can lead to better functional independence in daily activities and brain function of the elderly. As a result of reaction exercises in which the study subjects have to mimic the trainer's movements, structural and cognitive changes may occur in the brain, which will ultimately improve cognitive and physical actions in the elderly.[23] In addition, the ability to react quickly and make appropriate decisions can lead to better balance and physical performance in the elderly. Regarding the progress of the muscle strength of the elderly in the current study, the results of the timed up and go test showed that agility improved after completing the exercise protocol, and this is because of the improvement in muscle strength.

These results are in line with the results of the studies conducted by Filar-Mierzwa et al,[24] Furtado et al,[25] Stanghelle et al,[26] and Koohboomi et al.[27] As mentioned before, the improvement in balance can be attributed to the improvement of flexibility. It can be said that flexibility is known as the maximum possible range of motion in one or more joints, which is of particular importance at all ages. Joint stiffness, changes in connective tissue, and diseases such as osteoarthritis are factors that reduce flexibility, and the incidence of them increases with age. Studies have shown that appropriate exercises can regulate joint movement in the full range of motion and enhance flexibility by 20%-50% in men and women of all ages.[28] The improvement in strength and flexibility and subsequent amelioration of balance depended on the amount and appropriateness of exercise training among the elderly subjects in this study.[29] In this regard, it should be stated that the implementation of water and land-based functional training leads to an increase in strength, endurance, and flexibility in the lower limbs, which play a significant role in maintaining balance in the elderly.[10,29]

The results of this research are consistent with the results of the studies of Silva et al[10] and Costa et al.[11] The results of the study by Geraedts et al[30] are inconsistent with the present study, and the reason for this difference can be attributed to the type, duration, and intensity of the exercises, as well as the differences in age and the level of initial fitness of the subjects.

Dos Reis Caldas et al,[31] Ismail et al,[32] and de Souza Vale et al[33] reported an improvement in agility after training. Agility is the ability to quickly change the direction of the body or parts of it, which depends on a degree of strength, reaction time, speed of movement, and muscle coordination. Agility can be improved by increasing muscle strength, coordination, mobility, and walking speed.[34] Speed is one of the important aspects of walking, indicating that, from a clinical point of view, a large decrease in walking speed is an important indicator for evaluating patients' habitual problems and risk of falling.[35] Since walking speed depends on stride length and rhythm, increasing stride length and faster walking rhythm can lead to increased walking speed. However, the results of the study conducted by Blasco-Lafarga et al[36] are inconsistent with this study. This discrepancy could be attributed to the number of training sessions, the duration and intensity of the activity, and the type of training.

Conclusion

The findings of this study suggest that executive functions, which involve the interaction between perceptual and motor processes within the central nervous system, experience increasingly positive changes following a functional training program.[37] This may indicate an enhancement in functional independence among older adults. Overall, it appears that despite the prevalent advertising claims and psychological emphasis, water-based functional training (WBFT) does not have a distinct advantage over land-based functional training (LBFT). Both types of exercise can be equally beneficial for the elderly. Given the significant effects observed in this study for both training types, either form of physical activity could be recommended for older adults to help reduce the risk of falls. However, it is important to acknowledge that despite the control of many influencing factors, this study faced limitations that could restrict the generalizability of its findings to the broader elderly population. These limitations may include variables such as the quality and duration of sleep and rest among participants, psychological factors such as stress and anxiety, genetic predispositions, and individual differences in response to training.

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Competing Interests

None.

Ethical Approval

The study was approved by the Research Ethics Committee of Tabriz University of Medical Sciences (IR.TBZMED.REC.1396.654).

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