The Effects of Water and Land Exercise Programs on Functional Fitness Factors in Elderly Men

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Abstract

The goal of this investigation was to compare functional fitness factors following water and land exercise in elderly men. Thirty elderly men aged 63-70 were randomly selected and divided into two groups. Pre- and post-intervention tests of lower limb muscle's strength, walking ability, lower limb flexibility, static and dynamic balance were conducted. Measures included 30-second chair stand, eight-feet time up and go, chair sit-and-reach test, the Sharpened Romberg Test, Functional Reach Test (FRT), Functional Reach Right (FRR) and Functional Reach Left (FRL) Tests. Next, both groups participated in a water or land exercise program. At pre-test there was no. significant difference between the two groups' functional fitness factors (p<0.05); however, at post-test, the groups differed on their functional reach left test with the water exercise group showing better performance than the land exercise group (p<.0.05). There was also significant differences between pre- and post-test results of the water exercise group on all the tests (p<.0.05). The land exercise group showed significant differences from pre- to post-tests on muscle strength, walking ability, static balance with open and closed eyes, FRT, FRR, and FRL (p<.0.05). Although the results support the positive effects of water and land exercise on functional fitness factors for male elders, water exercise proved to be more beneficial than land exercise in improving the elders' physical capability to maintain their body balance.

Keywords: Older adult men**,** water exercise, land exercise, functional fitness factors

Introduction

Old age is a critical period in life and paying attention to the requirements and problems of elders is a social necessity [1]. Today, the goal is not to reach an older age but the final years of human life must be accompanied with physical and mental peace. Moreover, providing the means for elderly activities has been a common global concern [2].

Within the next 20 years, %10 of the Iranian population will be old. Aging is associated with many changes in different systems of the body; for example, muscles and the nervous system, which are the main parts for walking degenerate, causing a fundamental problem for older adults [3].

After the age of 65, %10 of the older adults lose their independence to do one or more daily tasks [4]. Between the ages 65-75, one out of nine, between the ages 75-85, one out of four and, from 85 upward, three out of five people face difficulty doing basic life tasks [4,5]. As a result of aging, muscles loose their strengths along with other parts of the body; reduced muscle strength is an important factor of disability and a main reason for one's ability for balance and walking properly [6]. Eight percent reduction of strength in the third decade of life begins in arms and feet muscles; in the 7^{th} and 8^{th} decades of life, reduction of isometric strength of different muscles of the body amounts to 20 to 40 percent [6].

Therefore, old age can be considered as a collection of unfavorable structural and functional changes in organs that, especially in the advanced stages of life, could be pervasive. Such changes interfere with motor skill mechanisms and reduce the adaptability of the individual with environment [7]. Loss of muscle strength in skeletal muscle system initiates from the age of 25-30 due to various factors and adversely affects the flexibility of all joints [8,9]. Reduced flexibility and muscle strength in older adults has a negative impact on their balance, posture and functional components, which, in turn, increases the risk of falling; causes breathing problems; reduces walking speed; and interferes with the elders' daily activities [10].

Older adults are usually advised to participate, three days a week, in strength activities to improve

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their strength and endurance. Also, they are advised to perform physical activities that improve their balance and flexibility. Because older adults' body readily and positively reacts to the effects of physical activities, even a limited amount of exercise can improve their health conditions [11]. There is a general agreement that muscle strength should be increased to improve joints' movability and prevent functional defect of the elderly. The most appropriate solution for muscle strengthening is following a suitable training program in a long term [12].

In older adults, falling results in minor and major wounds, medical and negative socio-economic consequences. The costs of falling in the elderly could be very high, e.g., it imposes an annual cost of about 7-to-10 billion dollars on the American economy [13,14,15]. One reason for falling in older adults is the infirmity of some physiological systems [16]. Muscle atrophy and infirmity of sensory-motor systems that are related to age increase, which leads to poor balance and stability during walking. Macrae et al. (1992) found that weakness of hip abduction muscles, extensors and flexors knee, and dorsi flexors of ankle are related to falling risk in older adults. Evidence suggests that getting involved in routine exercise with high intensity could help improve muscle strength in elders [17].

In water environments, balance, strength, and internal stimulus are influenced [18]. According to Campbell et al. (1989), doing activity in water is useful for older adults [19]. Ruoti, Morris, and Cole (1997) believed that water has a supporting role and helps the person to independently maintain his/her vertical state. They believed that water increases stimulus afferent (sensory) nerves and hence stimulating of muscle occurs more easily and more freely. Therefore, patients who exercise in water are less afraid of falling then when they exercise on land.. For those with a skeleton-muscle problem, activity in water is more suitable and useful compared with land environment. Activity in water reduces work pressure on joints [20]. Thein (1998) found out that performing physical activity in water up to anterior superior iliac spine put less strain on weight bearing joints and lower limbs (feeling up to %54 lighter)[21]. Therefore, water environment creates an effective balance for those having problems in their joints. Moreover, warm water of swimming pools increases blood circulation in involved joints, help with the relaxation of involved muscle and reduces pain [22]. Furthermore, as a result of water viscosity, activity in water causes slower movements which can reduce velocity of falling. Nonetheless, people who are just about to fall while in water a longer time to gain their control, which leads to falling [23]. This study was carried out to compare functional fitness factors (strength, flexibility of lower limb, walking ability and static and dynamic balance) in older adult men following training in aquatic and land environments.

Methodology

Design and participants

This research employed a semi-experimental design with pre- and post-tests. Thirty older adult men between 60-to-73 years old were selected. All the participants were from Mashhad. They were independent of others in doing their daily activities, and were capable of doing the study exercises (as confirmed by a physician). The criteria for exclusion from the study were neurological defects (e.g., apoplexy, Parkinson's), cardio-vascular defects, chronic impermanent disease (e.g., diabetes), severe congenital defect and limiting skeleton-muscle problems. Moreover, the participants maintained that they had no special physical training or regular walking program (e.g., at least two times per week for 30 minutes); this means that they had low mobility during the last 5 years [10].

The participants volunteered to the study and were randomly divided into two equal groups of (a) water exercise (N =15) with mean age of 65.80 years (*SD* = 4.88), height 173.33 cm (*SD* = 4.67)., and weight 71.13.kg (*SD* = 3.7); and (b) land exercise (N=15) with mean age of 66.60 years (*SD* = 4.15), high 174.20cm (*SD* =4.55), and weight 72.86kg (*SD* = 3.68).

Measurements

Measurements of the participants' lower limb strength, walking ability, lower limb flexibility, and static and dynamic balance were carried out before and after the exercise program.

Assessment of muscle strength was done using 30 second chair stand test. For this assessment, participants were required to sit on a 43cm high chair, place their hands on the opposite shoulder crossed at the wrists, and on signal rise to a full stand position and then sit down on the chair for 30 seconds; the participant's score was based on the number of times he or she could perform this task [24].

For assessing walking ability or functional test, participants should, without using their hands, stand up from a handless chair and after walking for 8 feet (2.44m) get back to their seat [24]. All participants had to walk with speed but without running. The total time was recorded as the participant's walking ability.

To measure flexibility of lower limb, participants were required to sit on the fore half of a chair. One of the participant's legs should have been in a 90° flexion state, and the other leg, being in complete extension state, had to be put on the heel such that the joint of ankle was in 90° as well. The hands with open fingers were put on each other and the participant tried to reach his or her toe by his or her hand. The distance between the mid fingers from the toe was recorded as the participant’s score for flexibility of lower limb. Normally, if the mid finger dose not reach the toe, a negative score is recorded; if the mid finger reaches the toe, zero is recorded and if the mid finger crosses over the toe, a positive score is recorded [24].

Assessment of static balance of participants was carried out as follows using the Sharpened Romberg Test. The participant was asked to stand straight with naked feet, putting one foot in front of the other and his or her arms crossed upon the chest; the score given to each individual was the time he could maintain a stable state with open and then with closed eyes [25]. Because the participants were unaware of the scoring, they were asked to repeat the task three times (in order to control for the plateau effect) before the main test; next, in a separate trial, they performed the task for another three times, for which an average score was calculated and considered as an index for their ability to maintain balance,

To assess functionality by Functional Reach Test, participants were instructed to stand, with their feet open as wide as their shoulder’s width; standing straight near a wall (but not touching it) the person was required to stretch his or her hands and body forward as far as possible but without stepping forward or falling over. The maximum difference between the participant’s standing angle and reaching angle was measured in centimeters using a checker table that was mounted on the adjacent wall. [26]. Because the participants were unaware of the test procedure and in order to increase the accuracy of the results, the test was repeated three times and the mean score was recorded as the participant’s score. To prevent fatigue, there was a 2-3 minutes rest time between the two testing trials.

Next, the two groups of water and land training participated in two separate, 8-week programs. The water training protocol took 40 min per session to complete; this included adaptation to water medium, two stretches for 30 seconds each, and the main phase or training in water that included eight walking-related practices in various states and three strength practices to fortify walking ability and the strength of the lower limb muscle. Water exercise was done in a warm water swimming pool in a medium with 10^{m} length and width and 1.30^{m} depth; the average temperature of water was $32^{\circ c}$ [10]. Participants doing land exercise had the same training as the water group but in a roofed saloon. When the training period was over, all the participants completed the post-tests, which included the same battery of measures at the pretest. Descriptive statistics were used to calculate mean and deviation of age, height and weight, and also, determine changes within and between groups; independent samples *t*-tests and paired sample *t*-tests (p<.0.05) were also calculated to compare the two groups.

Results

Demographic characteristics of the participants are presented in Table 2, separately for each group. The results of a series of independent t-tests showed that the two groups did not differ from each other on height, age, and weight. The results of a series of dependent *t*-tests (Table 3) showed that there were significant differences from pre-to post-test measurements for the water exercise group, indicating improvements on their muscle strength, walking ability, flexibility, static balance with open and closed eyes and functional test (p<.0.05). The land exercise group also showed a significant difference from pre- to post-test on muscle strength, walking ability, static balance with open and closed eyes, functional reach test and functional reach right and left tests (p<.0.05); however, there was no improvement in their flexibility (p>.0.05). Moreover, the results of a series of independent *t*-tests comparing the two groups at pre- and post-test assessments indicated group differences only at the post-test measurements (Table 4), with the water group scoring better than the land group; the only exception was for the functional reach test on which no difference was observed at the post-test.

In summary, participants in the water exercise group showed a better performance than the land exercise group on the tests of muscle strength, walking ability, flexibility, static balance with open and close eyes and functional reach test, and functional reach right tests.

Table 2. Mean and standard deviations of age, weight and height and between-subjects comparisons for water and land exercise groups at pre-test.

	Group	M	*SD*	Independent *t*-test	df	*p*-value
Age	Water exercise	65.80	4.88	-0.483	28	0.633
	Land exercise	66.60	4.15			
Weight	Water exercise	71.13	3.77	-1.27	28	0.214
	Land exercise	72.86	3.68			
Height	Water exercise	173.33	4.67	-0.515	28	0.611
	Land exercise	174.20	4.55			

Table 3. Within-subjects comparisons in muscle strength, flexibility, walk ability, static and dynamic balance tests for water and land exercise groups.

Group	Test	Pre-test (M ± *SD*)	Post-test (M ± *SD*)	Paired sample t-test	df	*P* value
Water exercise	Muscle strength	9.33±1.04	11.20±0.94	-6.820	14	0.000
	Walking ability	10.33±0.96	7.81±0.91	15.785	14	0.000
	Flexibility	-3.60±2.26	1.40±1.24	-11.754	14	0.000
	Static balance with open eyes	33.28±1.69	40.65±3.06	-9.881	14	0.000
	Static balance with close eyes	10.76±1.28	14.15±1.87	-6.532	14	0.000
	Functional reach test	23.13±2.99	27.93±2.01	-9.609	14	0.000
	Functional reach right test	20.46±2.50	24.20±1.82	-4.291	14	0.001
	Functional reach left test	21.73±3.17	27.46±4.65	-7.960	14	0.000
land exercise	Muscle strength	9.46±0.95	10.20±0.86	-4.785	14	0.000
	Walking ability	10.45±0.69	9.31±1.24	3.597	14	0.003
	Flexibility	-3.13±2.26	-2.80±2.36	-1.581	14	0.136
	Static balance with open eyes	33.44±2.21	36.76±2.45	-5.182	14	0.000
	Static balance with close eyes	10.95±1.23	12.31±1.10	-5.727	14	0.000
	Functional reach test	22.53±2.89	25.06±3.76	-4.061	14	0.001
	Functional reach right test	21.26±2.76	22.66±1.71	-2.468	14	0.027
	Functional reach left test	22.20±3.93	24.26±4.90	-3.901	14	0.002

Table 4. The difference between participant groups in muscle strength, flexibility, walk ability, static and dynamic balance tests

P value	df	Independent t-test	land exercise	Water exercise	test	
0.713	28	-3.71	9.46±0.95	9.33±1.04	Pre-test	Muscle strength
0.005	28	3.035	10.20±0.86	11.20±0.94	Post-test	
0.684	28	-0.412	10.45±0.69	10.33±0.96	Pre-test	Walking ability
0.001	28	-3.766	9.31±1.24	7.81±0.91	Post-test	
0.577	28	-0.565	-3.13±2.26	-3.60±2.26	Pre-test	Flexibility
0.000	28	6.086	-2.80±2.36	1.40±1.24	Post-test	
0.816	28	-0.234	33.44±2.21	33.28±1.69	Pre-test	Static balance with open eyes
0.001	28	3.857	36.76±2.45	40.65±3.06	Post-test	
0.682	28	-0.414	10.95±1.23	10.76±1.28	Pre-test	Static balance with close eyes
0.003	28	3.269	12.31±1.10	14.15±1.87	Post-test	
0.582	28	0.557	22.53±2.89	23.13±2.99	Pre-test	Functional reach test
0.015	28	2.597	25.06±3.76	27.93±2.01	Post-test	
0.413	28	-0.831	21.26±2.76	20.46±2.50	Pre-test	Functional reach right test
0.025	28	2.372	22.66±1.71	24.20±1.82	Post-test	
0.723	28	-0.385	22.20±3.93	21.73±3.17	Pre-test	Functional reach left test
0.078	28	1.832	24.26±4.90	27.46±4.65	Post-test	

Discussion and conclusion

For many older adults, senescence is equal to losing strength, energy and physical fitness, each leading to different problems. But it is not correct to attribute weakness, loss of energy, and having difficulty in walking long distances, going up the stairs and carrying groceries to muscle degradation that results from aging; degradation of muscle and the consequent problems are rather due to low levels of mobility. Therefore, all older adults, especially those who are weak, can easily improve their mobility and efficiency by doing regular physical training, and their ability for living an independent life [11]. The results of the present study showed a significant increase in certain functional fitness indices among elder men as a result of doing water and land exercises.

Evidence indicates the positive effects of water exercise for those who are at risk of falling or are afraid of falling [23,27,28,29]. Surface twitch of water makes movement in water slow and prevents falling–if a person loses his or her balance in water, he or she has more time to recover balance. Thus water exercise not only increases self confidence in older adults, but also it reduces falling fear. Therefore, older adults who do water exercise can continue to improve balance and stability without any fear of falling [30,31].

Physiological changes related to aging, various diseases, mental stresses and muscle problems can increase the risk of accidents among the people over 65. As a major hazard, falling is a major cause of death among them. Although older adults have considerable experience with the environment they live in, disease, muscle weakness and/or sensory-motor damage can still expose them to various hazards and problems [5,6,32]. Muscle strength and flexibility of the lower limb are among factors that play a major role in older adults' ability to walk and prevent from falling. Because the strength of knee extensors plays a major role in maintaining balance in elders [33], it is important to improve their muscle strength and hence to improve their movability through special exercise methods.

Therefore, the goal of the present study was to compare the effects of water and land exercise on muscle strength of the lower limb and walking ability in older adult men. The result of our investigation showed that water exercise improves flexibility of the lumbar vertebra and lower limb, a finding that supports Rauchbach' (1990). Rauchbach (1990) have reported considerable improvement in the flexibility of lumbar vertebra of older adults after performing a 3-month exercise [34].

Muscles of the lower limb (quadriceps group, hamstring group and tibialis anterior) plays an important role in achieving balance; these muscles can be improved through different physical training programs [33].that create practice opportunities and challenge balance mechanisms [29].

Physical fitness programs could be especially effective in preventing falling because training and physical activity increases muscle strength, flexibility and motor control [35]. Duncan et al. (1999) showed that active older adults were better than their inactive counterparts in controlling their own balance during laboratory or functional tests [26]. Even those being in a good physical condition showed a muscular activation pattern similar to those of young people when exposed to imbalance and disruption [35]. Considering the effects of water exercise on muscle strength, our results confirm those of Chu et al (2004) and Candeloro and Caromano (2008), but as far as balance is concerned, the results are different from those of Chu et al. In Chu et al.'s study, eight weeks of water exercise had no effect on the balance of people with heart disease but significantly improved their their cardiovascular fitness, walking speed, and lower limb strength [36]. Judge et al. (1993) tested the effects of 12 weeks training on body posture, balance, strength of arm extensors, hip adductors, and dorsi flexors ankle; they observed a significant increase in their participants' muscle strength and walking speed, a finding that is supported by our findings also[37]. Moreover, our findings support those of Candeloro and Caromano regarding muscle strength and flexibility.

Our findings on the effect of exercise on balance also support those of Costill (1997) [38], Resende et al. (2007) [39] and Sadeghi and Alirezayi (2008) [40], and Simmons and Hansen (1996)—these authors also compared training in water and land exercise and merely used functional tests or berg balance index to evaluate the effects of different training periods. Our findings, however, are in contrast to Arabnarmi et al (2010) findings about the better training. Arabnarmi et al. compared the effects of water and land exercises on balance, and proposed that balance in both groups (water and land exercise) significantly, and equally, improved [41].

According to Simmons and Hansen (1996), improvement of functional fitness factors in water compared to land is due to the fact that the water medium condition permits older adults to perform a wide range of activities without increasing damage or risk of falling risk. Moreover, the protective and secure medium of water makes them able to maintain a straight state independently [42]. Moreover, water provides elders with an appropriate medium for all types of balance activity and for challenging the neuromuscular system involved in balance. Furthermore, due to water viscosity the movements become slower and thus the individual has a longer time to respond and react. Therefore, water training is favorable for those having problems with their balance [43].

The older adults can benefit from physical activities aiming at increasing or maintaining muscle strength and balance. Recently, a study on the individual programs of older adults showed that the programs whose goals were to create muscle strength, balance improvement and increased walking speed, significantly reduced the probability of falling [44].

To conclude, our findings suggest that both water and land exercise programs are effective; the difference is that water exercise may have even more positive effects on some functional fitness factors. Because water provides a safer environment, and it also provides a condition for challenging the balance system, water exercise can be an effective method for improving muscle strength, walking power, flexibility and balance, and consequently for preventing falling among older adults. Therefore, exercise in water can be introduced as a training method to improve the fitness indices for older adult men with no regular sport background.

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