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The Effect of Eight Weeks Aquatic Balance Trainingand Core Stabilization Training on Dynamic Balance in Inactive Elder Males

HajarJahadian Sarvestani, HosseinBerenjeian Tabrizi, Ali Abbasi and Jamal Rahmanpourmoghaddam

Department of Physical Education and Sport Sciences,
Faculty of Humanities, Kazerun Branch, Islamic Azad University, Kazerun, Iran

Abstract: The purpose of the present research was to study the effect of eight weeks Aquatic balance training (ABT) and core stabilization training (CST) on dynamic balance in inactive elder males. Thirty inactive elder males voluntarily participated in this research and randomly divided into three groups of ABT, CST and control (N=10 per groups). The Y-Balance Test was used to assess dynamic balance before and after training. The training procedures were elaborated for the subjects and were performed for eight weeks, 3 sessions per week and one hour per session. One-way ANOVA was applied to determine the differences between three groups at the $\alpha \leq 0.05$. The results revealed that there were not any significant differences between three groups in pretest and between ABT and CST in posttest ($P \leq 0.05$) as well. However, there were significant differences between ABT and CST with control group ($P \leq 0.05$) in posttest. Considering the results, using both types of training are recommended for increasing dynamic balance in inactive elder males. That is because these types of training are inexpensive, yet innovative and its training intensity corresponds to the physical fitness of inactive elder males.

Key words: Dynamic Balance · Aquatic Balance Training · Core Stabilization Training · Elderly

INTRODUCTION

Balance deficit is one of the main risk factors that affect falling among adults [1-3]. Balance is one of the main elements of most physical activities and it is an important factor in the performance of sports skills [4]. Balance is a complex motor skill that describes the dynamics of body posture in preventing falling [5]. Punakallio [6] defines balance as static, the ability to maintain center of pressure (COP) within base of support (BOS) and dynamic, active movement of COP while standing, walking, or performing any other skill. Olmsted [7] and Guskiewicz [8] categorized balance from the functional aspect into static (maintaining a position with minimum movement), semi-dynamic (maintaining a position while BOS moves) and dynamic (maintaining balance while a prescribed movement is performed) [7, 8]. From biomechanical and functional perspectives, dynamic balance can be defined as the active movement of COP within BOS and maintaining the stability of BOS while performing a prescribed task [5, 9]. Most daily activities perform dynamically; thus, dynamic balance is of utmost importance in performing physical activities and sports skills.

Considering the increasing population of senior citizens around the world and the increased life expectancy in this group, diagnosis and prevention of injuries and ailments are of particular importance in improving their quality of life and independence [10]. The scientific community, especially scientists in sports and rehabilitation, are more sensitive to and careful of preventing and treating these ailments. Basically, falling due to lack of balance is a threat to the elderly which changes their quality of life and leads to increased costs of sustaining them [11]. Moreover, it might lead to physical, social and economic complications or even death [11]. Disturbance in balance is one of the driving factors in increasing the risk of falling whose improvement can prevent the incidence of falling and the complications associated with it [12]. There are various common

Corresponding Author: Hajar Jahadian Sarvestani, Department of physical Education and Sport Sciences, Faculty of Humanities, Kazerun Branch, Islamic Azad University, Kazerun, Iran. Tel: +98-9173202061.

methods for training balance and preventing falls. The effect of different training types has been the subject of many studies that have reported contradictory results [10, 13-17]. Some of these studies have reported the positive effect of strength training on improving balance and decreasing risk of falling in the elderly [16, 17]. Some others on the other hand found strength training ineffective for improving balance and decreasing the risk of falling [17].

The water environment, due to its unique nature, such as buoyancy, viscosity and hydrostatic pressure, also makes it unique to develop confidence and reduces the effect of weight bearing from the Earth's gravity and allows adults to be interested in doing exercise and physical activity without Pain [18, 19]. Recent studies have reported multiple gains from exercise in water for the adults, which they include postural oscillations reduction [20], blood lipids diminish, increased maximal oxygen uptake, strength, muscular endurance and flexibility enhancement, increase in the reaching distance [21], as well as greater independence in daily tasks [22].

Despite the application of various training programs for improving balance and decreasing falling in the elderly (e.g. strength, balance, sprint training, rehabilitation training, aquatic balance training and recently whole body vibration training, functional training and core stability training) the question remains which of these methods is more effective and more important. Considering the general view that physical activities and training has a positive effect on dynamic balance, the purpose of the present research was to study the effect of eight weeks aquatic balance training and core stabilization training on dynamic balance in inactive elder males.

MATERIALS AND METHODS

The current study was a Quasi-experimental one with pretest - posttest design on two experimental groups and one control group. Thirty inactive elder males voluntarily participated in this research and randomly divided into three groups of aquatic balance training (ABT), core stabilization training (CST) and control (N=10 per groups). The university institutional review board approved this study. All participants signed an informed consent document approved by the Institution human subjects review board. The subjects fully reported any record of joint dislocation and possible falling in a specific form. Subjects who had experienced falling over the past 12 months or had any joint dislocation, chronic arthritis, or dizziness were excluded from further study. Y-Balance Test was used to assess the dynamic balance of the subjects before and after training [23]. After performing the pre-test, the training procedures were elaborated for the subjects and were performed under the trainer’s supervision for eight weeks, 3 sessions per week and one hour per session. At the end of the training period, post-test was performed. Descriptive statistics was used to describe the personal characteristics of the subjects, One-way ANOVA was applied to determine the differences between three groups at the $\alpha \leq 0.05$. All the statistical operations were done using SPSS 16 software.

Aquatic Balance Training: The aquatic balance training group performed exercises in water with the aim of increasing the neuromuscular performance, balance and walking ability for eight weeks and three 60-minute sessions per week in accordance with previous studies done in this regard [19, 21, 24, 25]. All exercises were conducted in water with subjects’ chest high depth. Each exercise session in water was divided into three stages: adaptation with water environment, stretching exercises and static and dynamic ones for balance. Aquatic balance training was designed to improve the control of center of gravity and ability to combine sensory information, compensatory postural control and walking. All eight-week activities were progressively consolidated due to manipulated and switching hands position (i.e. cross arms to be placed on the breasts) or an increase in the difficulty of performed activities (i.e. to move with closed eyes, walking in different directions or use the insoles). Duration of each exercise session was approximately 60 minutes, each session were started with a 10-minute warm-up including walking in water, aerobic activity in water, resistance training and flexibility activities; the exercise were ended with 10-minute cool-down one, including static flexibility. The remaining time of each session (about 40 minutes) was allocated to balance and walking exercises in water. The procedures for performing select aquatic balance training are presented in table 1 [11].

Core Stability Exercises: The procedures for select core stability exercises included five types of exercise (i.e. semi sit-ups, sit-ups with rotation, lateral bridge, prone bridge and four levels of lower body strength exercises) which are presented in table 2.

Table 1: The procedures for performing select aquatic balance training

Phase	Training	Positioning	Activity	Time
1- Adaptation with water environment	Respiratory control	Semi Seated, without posterior support, with immersion to the shoulder level, shoulder at 90° flexion and with extended elbow	Slow and prolonged expiration through the mouth over the water, then with the mouth immersed and subsequently with both mouth and nose immersed	2 min
2- Stretching (each hold for 30 sec)	Hamstring	Orthostatic position with back supported against the wall	Elevation of one of the lower limbs, maintaining knee extension and ankle dorsal flexion	30 sec
	The triceps surae and iliopsoas	Orthostatic position with hands on the edge of the pool	Taking a large step forward, while maintaining the anterior knee in flexion, the posterior knee in extension and feet in contact with the bottom of the pool	30 sec
3- Static and dynamic exercises for balance	Walking in circles	Hand-in-hand with sporadic change of direction	Walking sideways, facing forwards, alternating the direction from clockwise to anticlockwise, 3 times in each kind of walk	3 min
	Walking in line	Hands supported on the waist of the individual in front	Moving in the pool making circles and changes in direction	3 min
	Walking forward	Walking forward pushing lower members vigorously	Walking with higher speed and propulsion (45 m, speed: 0.5 m/s)	4 min
	Walking backward	Standing	Walking backward (45 m, speed: 0.2 m/s)	4 min
	Side walking	Standing	Lateral walk with large steps (45 m, speed: 0.55 m/s)	4 min
	Tandem walking	Standing	Walking supporting one foot immediately in front of the other (45 m, speed: 0.20 m/s)	4 min
	walking	Walking with trunk rotation	Walking forwards hand to opposite knee in flexion, alternately (45 m, speed: 0.30 m/s)	4 min
	Walking	Walking with one-leg support pause	Walking and, at the physical therapist's command, maintaining one-leg support with the opposite knee n flexion for 10 sec (12 pause in 45 meters, speed: 0.50 m/s)	4 min
	Bilateral shoulder flexion-extension	Semi-seated position	Performing shoulder flexion and extension while keeping the elbows in extension. Starting with maximum shoulder hyperextension and going until 90° flexion (10 rep, f: 12 rep per min)	4 min
	Bilateral horizontal shoulder abduction -adduction	Semi-seated position	Starting in adduction and going until 90° of horizontal abduction (10 rep, F: 12 rep per min)	4 min
	Ankle pumping	Orthostatic position, with immersion up to the xiphoid process level	Extension of the knees associated with plantar flexion, maintaining this position for 5 s and then knee flexion associated with dorsiflexion, also maintaining this for 5 s (10 rep, F: 3 rep per min)	4 min

Table 2: The profile of select core stability exercises

First Week	Repetition	Fifth Week	Repetition
Lower Abdominal Series – Level One	2 sets with 10 repetitions	Lower Abdominal Series – Level Four	2 sets with 10 repetitions
Semi sit-ups	2 sets with 10 repetitions	Semi sit-ups	2 sets with 20 repetitions
Lateral Bridge	2 series with 10 repetitions	Lateral Bridge	2 series with 20 repetitions
Sit-Ups with Rotation	2 sets with 10 repetitions	Sit-Ups with Rotation	2 sets with 20 repetitions
		Prone Bridge	3 sets with 20 repetitions
Second Week	Repetition	Sixth Week	Repetition
Lower Abdominal Series – Level One	3 sets with 10 repetitions	Lower Abdominal Series – Level Four	3 sets with 10 repetitions
Semi Sit-Ups	3 sets with 10 repetitions	Semi sit-ups	3 sets with 20 repetitions
Lateral Bridge	3 sets with 10 repetitions	Lateral Bridge	3 sets with 20 repetitions
Sit-Ups with Rotation	3 sets with 10 repetitions	Sit-Ups with Rotation	3 sets with 20 repetitions
		Prone Bridge	2 15-second series
Third Week	Repetition	Seventh Week	Repetition
Lower Abdominal Series – Level Two	2 sets with 10 repetitions	Lower Abdominal Series – Level Five	2 sets with 10 repetitions
Semi Sit-Ups	2 sets with 15 repetitions	Semi sit-ups	2 sets with 25 repetitions
Lateral Bridge	2 sets with 15 repetitions	Lateral Bridge	2 sets with 25 repetitions
Sit-Ups with Rotation	2 sets with 15 repetitions	Sit-Ups with Rotation	2 sets with 25 repetitions
		Prone Bridge	3 15-second sets
Fourth Week	Repetition	Eights Week	Repetition
Lower Abdominal Series – Level Two	3 sets with 10 repetitions	Lower Abdominal Series – Level Five	3 sets with 10 repetitions
Semi Sit-Ups	3 series with 15 repetitions	Semi sit-ups	3 series with 25 repetitions
Lateral Bridge	3 series with 15 repetitions	Lateral Bridge	3 series with 25 repetitions
Sit-Ups with Rotation	3 series with 15 repetitions	Sit-Ups with Rotation	3 series with 25 repetitions
Prone Bridge	2 10-second series	Prone Bridge	4 15-second series

Fig. 1: Y-Balance Test procedures

Sit-ups with rotation: Sit-ups along with rotation of the waist where each elbow moves toward the contralateral knee.

Semi sit-ups: In the supine position, chin toward the chest, subject bends forward as lower part of shoulder is separated from the ground. In this position, the hands are on the chest and the soles are on the pad.

Lateral Bridge: With the body sideways against the pad, one hand is placed underneath the body and the body is separated from the ground with the help of trunk muscles.

Prone Bridge: Lying prostrate on the pad, the forearm and the palms of hands are placed beneath the body. With the help of the arm and trunk muscles, body is separated from the ground so that only the palms and toes are touching the ground.

Lower Body Exercises: These exercises involve five levels. Four of these levels were performed in eight weeks. Considering the physical condition of the subjects and the result of the previous research [26], the third level was excluded. The chief purpose of these exercises is to strengthen abdominal muscles.

Y-Balance Test Procedures: In this test, three directions (anterior, posteromedial and posterolateral) are set in a central plateau. The angles between these three directions are specified with graded bars which are fixed on the sides of the plateau in three directions and an indicator is installed on each of the bars [27]. Before starting the test, the preferred leg of the subjects is determined. If the right leg is the preferred limb, the test is performed counterclockwise and it will be performed clockwise if otherwise [27]. The subject stands with their preferred leg (single-leg) on the plateau where the three directions meet and performs reaching by moving the indicators with the other leg in a direction that the examiner randomly chooses, as long as there is no error (without moving the stance leg from the plateau, or using the reach foot as support, or falling down). Then, the subject returns to the beginning position on both legs and the extent to which they have moved the indicator is recorded as their reaching distance. Each subject performs three trials for each of the directions and finally their average was calculated, divided by leg length (in centimeters). The dynamic balance calculated as follow [27] (Figure1):

RESULTS

Table 3 presents the descriptive characteristics of the subjects and table 4 presents the data related to reaching distance of the subjects in the balance test (both pretest and posttest).

Results of one-way ANOVA revealed that there are not any significant differences in reaching distance between three groups in pretest ($P \leq 0.05$). However, there are significant differences in reaching distance between three groups in posttest. The results of Tukey post-hoc test revealed that there are significant differences in reaching distance between CST ($P = 0.002$) and ABT ($P = 0.003$) with control group in posttest, while there was not any significant differences between CST and ABT in posttest ($P \leq 0.05$).

Table 3: Descriptive characteristic of the subjects

Group	Height (Cm)	Mass (Kg)	Age (Years)
CST	168.46±8.15	73.24±10.23	57.74±3.35
ABT	172.20±6.43	70.35±8.74	55.34±4.21
Control	170.56±4.65	71.52±9.28	56.59±4.19

Table 4: Data related to the reaching distance of the subjects in Y-Balance Test

Time	Group	Y-Balance	F	P-value
Pretest	CST	70.96±6.32	10.64	0.951
	ABT	71.74±6.74		
	Control	72.54±5.47		
Posttest	CST	83.54±6.78	224.45	0.009
	ABT	81.37±5.34		
	Control	71.67±5.64		

DISCUSSION AND CONCLUSION

The purpose was to study the effect of eight weeks aquatic balance training and core stabilization training on dynamic balance in inactive elder males. The results, in accord with the findings of previous research such as Rosendahl [28], Resndende [11] and De Bruin [16], suggested the increased balance control after performing CST and ABT in inactive elder subjects [11, 16, 28]. In addition, the effect of both training types on balance control was equal and no significant difference was observed between them. In order to identifying the causes and mechanisms underlying the improvement in balance after performing exercises, one needs to point to different elements of the sensorimotor system which are responsible for maintaining balance. This system includes sensory, motor and the central processing components. The function of this system relies on the feedbacks obtained from different senses that are related to various motor behaviors, flexibility and adaptability. Thus, balance occurs based on functional motor skills that are flexible and these skills can improve through training and experience [10, 13, 14, 26, 29].

Central nervous system evaluates the feedbacks from sensory receptors around the body in order to be informed of the position and movement of the body in space. Normally, this information is transferred to the central nervous system via visual, vestibular and somatosensory senses so that CNS evaluates the position and movement of body in space with respect to gravity and the surrounding environment. In central processing regions, these feedbacks are combined and evaluated so that the importance and relationship between them is determined and proper motor responses including equilibrium responses are selected and performed with proper speed and intensity [30]. The information collected by visual, vestibular and somatosensory systems are processed in three separate levels of motor control which are the spinal cord, brain stem and higher regions such as cerebellum,basal ganglia and cortex [30]. The effectiveness of training for balance requires a response in three motor levels. At the spinal cord level, its main role is to adjust muscle reflex. The sensory data from mechanoreceptors of the joint following balance reflexes lead to a compensatory contraction around the joint and prevent extra pressure to the passive factors that inhibit the movement of the joint [31]. At the brain stem level, balance reflexes helps balance control and at higher nervous centers (cortex and cerebellum), with conscious focus and attention, the individual tries to consciously control the joint positions and body balance [31]. Control at each of these levels requires the sensory data collected from visual, vestibular and somatosensory systems. As a result, with additional training, the proper load will be applied on these senses and proprioceptors [32].

Due to physiological and sensorimotor adjustments in skill learning, functional exercises can decrease the variability in recruitment of motor units, increase the plasticity of the motor cortex, or help the elderly learn (or relearn) how to employ their muscles for optimal performance of the motor task [33].

It seems that neural adaptations achieved through these types of training remain for a long period signifying the importance of training-specificity. An important issue in designing ABT programs is to pay specific attention to the principle of training-specificity [11] that can be one of the reasons for the effectiveness of these types of training in improving the balance of the elderly. The training program used in the present research highly emphasized balance training which included exercises in water. Generally, due to the connection between the bones and limbs and the fact that the body structure is not a hard material, performing each voluntary movement will disturb balance [34]. To compensate for this internal weakness, voluntary movements perform along with feedforward postural adjustment. These automatic, involuntary movements are a source for ensuring precise, coordinated movements [34]. In fact, activation of the muscles that control this postural adjustment takes place before the activation of the voluntary muscle activity. Considering the manifest principle of specificity in ABT, this type of training may have had an effect on the activation of the muscles responsible for feedforward postural adjustment and voluntary movements for controlling balance. On the other hand, improvement in balance can be due to better distribution of attention between the motor tasks of interest. Actually, task-specific training can lead to more concentration on that motor task [35].

One of the factors that can affect the improvement of balance maintenance and strength gain through ABT is the initial level of physical activity in the elderly individual. The subjects of the present research had no pathological diseases and were functionally independent and they could walk without the need for any additional instrument (e.g. canes or walkers). None of the subjects engaged in any regular sport activity before participating in the exercises. Thus, the improvement in balance can possibly be attributed to their low level of physical fitness as well as the effect of ABT on the improvement of muscle strength, joint range of motion, neural control of movements and mental factors of the subjects [36].

The applied training program in the present research emphasized strength and stretching exercises. These exercises can improve strength in lower limb muscles and prevent the displacement of COP and as well increase muscle flexibility and decrease pains in the lower body when trying to maintain balance and finally, increase balance. The ABT were designed to improve balance and considering the relationship between physical fitness and mental health. It can be argued that performing this type of training possibly affects the improvement of neural factors involved in balance control and thus will decrease stresses due to fear, anxiety and low self-confidence, as well as depression due to withdrawal or isolation that are in turn the result of decreased activity. Performing these exercises can lead to adjustment and improvement in the sensorimotor system [37].

The possible reasons for such a relationship between the strength of core stabilizing muscles and balance control can attributed to the fact that insufficient endurance in core stabilizing muscles leads to fatigue and decreased function during functional activities. It has been documented that in healthy people, transverse abdominal muscles and multifidus muscles are activated 30 milliseconds before the movement of shoulder and 110 milliseconds before the movement of lower limbs in order to stabilize the spine [4]. Since these muscles affect the activation of lower extremity muscles, weakness of these muscles leads to delays in activation of the lower extremity muscles and incidence of injuries. Moreover, these muscles are responsible for maintaining the position of the pelvic area; when these muscles are weakened, it will lead to the loss of correct pelvic direction and as a result, the lower limbs attached to this region decrease in function due to disturbance in the length-tension relation and perturb the balance of the individual [4]. On the other hand, considering the importance of abdominal muscles in creating core stability, the correct function of these muscles is very important. The most important functional aspect of these muscles is stabilizing the spinal column, achieving optimal orientation, link between the pelvis and the spinal column and preventing extra pressure and compensatory movements of the pelvis during the movement of limbs [38]. In case of weakness in these muscles, all these issues will be disturbed and the lower extremities will be prone to injuries and it will increase postural sway.

The Effects Specific to CST Can Briefly Attributed to the Following Issues: Performing these exercises, especially with the training protocol developed in the present research, will increase strength in the waist region and abdominal muscles and will enable the elderly people to maintain proper body posture and by restoring the COP axis to its original position, it will decrease postural sway and facilitate balance maintenance. Moreover, core muscles will be effectively engaged at the beginning of activity and will play a preventive role in the imbalance of subjects by increase in strength and proper function of these muscles. Before the subject's balance exits the base of support and the individual tries to restore it, these muscles will minimize such effort through a preventive action. Strength gain in core muscles is probably accompanied by decrease in disorders but because it is not assessed in the present research, it cannot be argued with certainty. Yet, it is evident that with the decrease in body abnormalities, balance control will face less sway.

FINAL CONCLUSION

Considering the results of the present research, it seems that developing and administering physical fitness programs for the inactive elder males is effective for increasing their balance and as a result their quality of life. Considering their special conditions, both training types (ABT and CST) can be used. Further, despite the equal effect of both training types on improving balance in the inactive elder males and also considering the greater safety associated with ABT and the satisfaction of the subjects performing this training method, it is more appropriate and this type of training can be recommended to the geriatric society.

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