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The effect of ten weeks strength training and aquatic balance training on dynamic balance in inactive elder males

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ABSTRACT

The purpose of the present research was to study the effect of ten weeks Strength training (ST) and Aquatic balance training (ABT) on dynamic balance in inactive elder males. Thirty inactive elder males voluntarily participated in this research and randomly divided into three groups of ABT, ST 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 ten 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 ST in posttest ($P \leq 0.05$) as well. However, there were significant differences between ABT and ST 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.

Keywords: Dynamic balance, Strength training, Aquatic balance 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 (2004) 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 [6]. Olmsted (2004) and Guskiewicz (1996) categorize 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. Falling due to lack of balance is a threat to the elderly that 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 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].

It has been documented that strength training leads to increased strength, weight, power, and quality of skeletal muscles [18, 19]. This type of training can also improve endurance performance; it can play a contributory role in reducing blood pressure, insulin resistance, and abdominal fat as well as increasing resting metabolism in elderly men, and it can improve the performance of those afflicted with osteoarthritis. Nevertheless, some researches did not find significant differences in these parameters in elder subjects. For instance, Liu-Ambrose et al (2004) examined the effect of two types of agility and resistance training on decrease in falling in elder women with low osteon density. They found that both training methods reduced the falling risk in elder females [20]. Buchner et al. (1997) examined the effects of strength, endurance, and combined training on gait, balance, physical fitness, and falling in elder subjects. They found that short time strength training did not direct effect on walking and balance in subjects [21].

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 [22, 23]. Recent studies have reported multiple gains from exercise in water for the adults, which they include postural oscillations reduction [24], blood lipids diminish, increased maximal oxygen uptake, strength, muscular endurance and flexibility enhancement, increase in the reaching distance [25], as well as greater independence in daily tasks [26].

Despite the application of various training programs for improving balance and decreasing falling in the elderly (e.g. strength, balance, sprint training, rehabilitation training, core stability training, and recently whole body vibration training, functional training, and aquatic balance 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 ten weeks strength training and aquatic balance training on dynamic balance in inactive elder males.

MATERIALS AND METHODS

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 strength training (ST), aquatic balance training (ABT)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 [27]. After performing the pre-test, the training procedures were elaborated for the subjects and were performed under the trainer's supervision for ten 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.

Strength Training Program

Before beginning the program, the maximum strength of the subjects was recorded in movements other than those in the program. The intensity of the exercises increased from the first to the eighth week based on the following table. After the eighth week the intensity of the program decreased (table 1) [28].

Table 1: The training protocol of the strength-training group

Sets × Repetitions	Rest between Sets (min)	Resistance	Week
Maximum Repetition **3×7**	1	Performing all the repetitions in each set technically just before adding to the weights	1 and 2
Maximum Repetition **3×9**	1		3-5
Maximum Repetition **3×11**	1		6-8
Maximum Repetition **3×9**	1		9
Maximum Repetition **3×7**	1		10

Aquatic balance training

The ABT group performed exercises in water with the aim of increasing the neuromuscular performance, balance and walking ability for ten weeks, 3 sessions per week, and one hour per session in accordance with previous studies done in this regard [10, 23, 25, 29, 30]. 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. ABT was designed to improve the control of center of gravity and ability to combine sensory information, compensatory postural control, and walking.

All ten-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.

Table 2: 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

The procedures for performing select aquatic balance training are presented in table 2 [10, 11].

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 that are fixed on the sides of the plateau in three directions and an indicator is installed on each of the bars [31].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 [31]. 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 [31] (figure1):

$$Y = \frac{Anterior + Posteromedial + Postrolateral}{3} \times 100$$

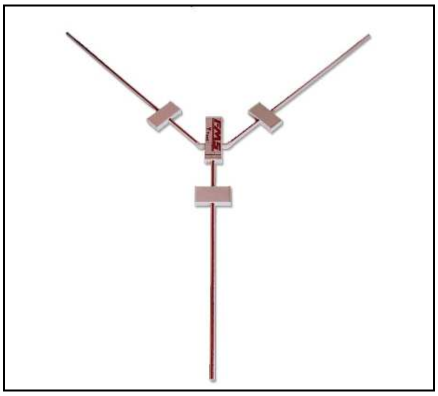

Figure 1: Y-Balance Test procedures

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).

Table 3: Descriptive characteristic of the subjects

Group	Height (Cm)	Mass (Kg)	Age (Years)
ST	168.34±6.85	72.44±8.73	55.54±6.65
ABT	172.34±6.83	71.95±7.54	58.74±5.41
Control	170.46±5.65	73.77±6.48	587.59±3.39

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

Time	Group	Y-Balance	F	P-value
Pretest	ST	73.55±4.82	8.25	0.355
	ABT	71.63±7.44		
	Control	72.54±6.57		
Posttest	ST	80.44±6.78	332.47	0.004
	ABT	81.67±5.34		
	Control	72.67±7.64		

Results of one-way ANOVA revealed that there are not any significant differences in reaching distance between three groups in pretest (P □ 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 ST (P = 0.007)and ABT (P =

0.002)with control group in posttest, while there was not any significant differences between ST and ABT in posttest (P 0.05).

DISCUSSION

The purpose was to study the effect of ten weeks strength training and aquatic balance training on dynamic balance in inactive elder males. The results, in accord with the findings of previous research, suggested the increased balance control after performing FT and ABT in inactive elder subjects[10, 11, 20]. 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, 32, 33].

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 [34]. 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 [34]. 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 [35]. 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 [35]. 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 [36].

Due to physiological and sensorimotor adjustments in skill learning, ST and ABT 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 [37]. 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 STand ABT programs is to pay specific attention to the principle of training-specificity [16] 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. 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 [38]. To compensate for this internal weakness, voluntary movements perform along with feed forward postural adjustment. These automatic, involuntary movements are a source for ensuring precise, coordinated movements [38]. 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 functional exercises, this type of training may have had an effect on the activation of the muscles responsible for feed forward 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 [39].

One of the factors that can affect the improvement of balance maintenance and strength gain through ABT and ST 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 and ST on the improvement of muscle strength, joint range of motion, neural control of movements, and mental factors of the subjects [40].

The applied training program in the present research emphasized on strength 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. 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 [41].

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 ST) 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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