The effect of 8 weeks deep-aquatic exercises on static balance and lower body strength among elderly men

Ehsan Seyedjafari¹, Mansour Sahebozamani²*, Ramin Beyranvand³, Ehsan Ebrahimipoor⁴, Mahboube Razavi⁴

¹ master, Faculty of Physical Education and Sport Science, ShahidBahonar University of Kerman, Kerman, Iran, ² professor, Faculty of Physical Education and Sport Science, ShahidBahonar University of Kerman, Kerman, Iran, ³ ph.D.Faculty of Physical Education and Sport Science, ShahidBahonar University of Kerman, Kerman, Iran, ⁴ master student, Faculty of Physical Education and Sport Science, ShahidBahonar University of Kerman, Kerman, Iran

ABSTRACT:

The purpose of this study was to investigate the effect of deep aquatic exercises on lower body strength and balance among elderly men. Thirty elderly men over 65 years old were randomly divided into two equal groups including experimental and control groups. Experimental group participated in a deep aquatic exercise program that consisted of 60-minute sessions three times a week for 8 weeks while control group had no plan of exercise. Muscle strength and balance was assessed before and after the program as pre and post-test by HHD (Hand-Held Dynamometer) and BBS (Biodex Balance System) respectively. Repeated measures two-way analysis of variance (ANOVA) was performed on outcome variables (p ≥0.05). Deep aquatic exercises promoted significant increases in the elderly men's muscle strength and balance, as assessed using HHD (p< 0.001) and the BBS (p< 0.001). The present deep-aquatic exercise training for the elderly are able to improve the muscle strength and static balance.

KEY WORDS: Aquatic exercise, Balance, Strength, Elderly men, Falling

INTRODUCTION

Aging is a dynamic, progressive, biochemical, psychological and physiological process, that is associated with an incremental and accumulative reduction in the normal functioning of all critical bodily systems, specially postural balance [1,2]. Complex
Deep-aquatic exercises on static balance

balance process involves coordination of multiple sensory motor and biomechanical components [1,4]. Complex interaction between sensory motor control system and integrating motor output to muscles is required to keep balance [2]. properly maintaining and functioning balance system are essential for determining the direction and speed of movement, position of body with reference to gravity and to adjust postures automatically [1,37]. One of the major goals of balance control is the capability to sustain the body’s COM over the BOS during standing, while moving, and in reaction to imminent postural disequilibrium [5]. Maintaining posture and performing normal routine activities, required proper balance control [1]. There have usually been some important challenges related to health conditions in the elderly people including how to increase physical fitness, life expectancy [3]. Today, falling is one of the largest public health problem among elderly people due to the high morbidity, mortality or hospitalization and costs for the family and society [4,5]. The main risk factors for falling in elderly people are related to the poor control of posture, functional limitations, history of falls, ageing, muscle weakness, use of psychotropic medicines, environmental risks, visual deficits, and female gender [6,7,8,9,10,11]. Every year in the United States of America, 30 percent of non-institutionalized elderly people suffer from falling [12].

Approximately 5 percent of these causes, many kinds of fractures, especially in the hips and neck of femur [12]. Besides physical injuries and the related loss of independence, falls often entail fear of falling and elusión of physical activity, with negative effects for health, independence, and quality of life [9,10]. In the United States, the annual cost of treating fractures in elderly people caused by falling is above 10 billion dollars [13]. A number of studies, have shown that with ageing both sensory inputs and motor outputs decrease leading to alterations in the strategies used in postural control [14]. Some examples of reduced motor function with ageing include decreased muscular strength and an alteration in the coordination of agonist/antagonist muscle activation patterns, and maybe these causes falls [3].

According to Bouman et al. it has been demonstrated that by 2050, the global numbers of adults aged 80 years and older will be 268 million in less developed countries, compared with 124 million in developed countries and also life expectancy is increasing at a similar rate in less developed countries [37]. These demographic propensities will have an impact on resources to manage the resultant increase in chronic disease, treat falls-related injuries, and manage the costs of caring for older adults. One of the most important approaches to delay the morbidity associated with aging is to increase
physical activity (PA) among older people [8,37]. Therefore, it has been recognized in the literature that physical activity practiced throughout life can decrease bone and muscle loss, and reduce the risk of fractures by up to 60 percent [6,8]. In addition, physical activity promotes muscle strength, aerobic conditioning, flexibility, balance, quality of life and also reduces the risk of falls [8,15]. Since long ago, aquatic exercises have been used as a resource for treating rheumatic, orthopedic and neurological diseases; but, it has just recently become the target of scientific studies [28]. The physical proprieties of water, together with the exercises, can fulfill most of the physical objectives that are proposed in a rehabilitation program [16]. The aquatic environment is considered safe and efficient for the rehabilitation of elderly population, because water acts simultaneously on musculoskeletal disorders, balance and strength improvements [17,18].

According to the previous studies; Water makes a low-impact atmosphere permitting cases to accomplish therapeutic activities with less stress of falling [19]. Buoyancy and hydrostatic pressure made by the aquatic atmosphere supply a supportive force on joints and a reduction in gravitational force, which can facilitate postural control [20,21], and also water resistance requires the participant to apply larger force than when moving on the ground [22]. In addition, hydrostatic pressure and viscous force supply a distinct proprioceptive and sensory feedback from that felt on the ground [23], therefore affecting the postural control system and balance ability [24], and Many studies in the literature have shown improvements in muscle strength in different populations performing strength training in water [25,26].The plenty of symptoms such as pain, loss of muscle mass and strength, balance deficits, obesity, arthritic diseases and gait disorders, among others, make it difficult for elderly people to perform exercises on the ground [27]. The situation is different with exercises in an aquatic environment, where there is a reduction in joint overload and less risk of falls and lesions. In addition, floating allows participants to perform exercises and activities that cannot be done on the land [8,17]. On the other hands deep water exercises is accomplished with the help of a floatation vest that serves to hold the participant in a vertical position and assists to prevent any contact between the feet and the bottom of the pool, therefore excluding any strike [28]. This quality permits participants to perform interval aerobic and resistance activities at high loads with a decreased risk of harm [29].

Although few studies have reported the effects of aquatic exercises on balance, muscle strength and the reduction of falls, all of them
have shown benefits, for example, reduced postural oscillations, increased functional reach and greater independence in activities of daily living [27]. Given their relevance of this subject, the objective of the present study was to evaluate the effects of 8 weeks deep aquatic exercises on static balance and strength among elderly men. And it was hypothesized that there would be a significant difference between the pre-test results and post-test results after the 8 weeks of aquatic exercises in experimental group.

**METHODS**

The subjects of the study originated from a group of 30 men, over 60 years old that randomly selected from among the 200 men of this age group in Kerman (the selected group thus comprised 15 percent of the total group). They were selected based on inclusion and exclusion criteria like; age over 60 years old, independence in walking, the absence of medical contraindications for activities, use of psychotropic drugs (benzodiazepines) or participation in other physical exercises or physical therapy program. To perform the study 15 elderly men were chosen as experimental group and 15 other chosen as control group (table 1). All subjects were educated about the contents and purpose of the experiment prior to its beginning and were asked to provide written informed consent prior to participating in the experiment. Ethical clearance was obtained by the Ethics Committee of Kerman Medical University, Kerman, Iran (Ethics Committee Number: IR.KMU.REC1394.598).

All subjects underwent measurement of the lower extremities muscular strength that was measured by hand-held dynamometer (HHD) (Lafayette Model-01165 and Hoggan microFET2). According to Katoh’s study the relative reliability of isometric leg muscle strength measurements was improved by use of a belt to restrain the hand-held dynamometer. So according to the Katoh’s results we used the HHD by belt for more reliable results. For assess the postural stability of the subjects, Biodex Balance System (BBS) SD, USA (ICC ≥0.79)) was used.

|                      | N     | Age (year) | Height (cm) | Weight (kg) | body mass index (BMI) |
|----------------------|-------|------------|-------------|-------------|-----------------------|
| **Experimental group** | 15    | 65.50±3.481 | 168.10±5.215 | 70.865±7.775 | 24.781±2.483          |
| **Control group**    | 15    | 66.50±3.232 | 169.20±6.314 | 71.322±8.531 | 24.982±3.535          |
The most precise measure for assessing postural stability includes the Overall Stability Index (OSI), Anterior–Posterior Stability Index (APSI) and Medial–Lateral Stability Index (MLSI) scores. A person’s ability to maintain center of balance is emphasized by the Postural Stability Test. A lower deviation from center is more desirable than a higher score. Our aquatic exercises program were based on “Aquatic fitness professional manual book”, but for this research some of the lower extremities exercises were chosen according to the aim of the study (table2). The participants performed deep-water exercises for 8 weeks and it took place 3 days a week for 60 minutes and it focused on lower extremities muscular Strength and balance. Before taking part in any experimental trial (i.e., before baseline measurements), all subjects performed familiarization trials to become oriented with all testing procedure. To assessing isometric muscle strength, the participants were set in these position depending on the testing segment; knee extensors, and knee flexors were assessed in a seated position; ankle plantar flexors, ankle dorsi flexors in a supine position. All subjects were given 3 trial for each test and the best one was chosen. During static balance testing process participants stood on their feet without any footwear on the BBS locked platform and the platform stability level of 6 was selected. They were instructed to keep the opposite extremity off the ground in a comfortable position, maintain their arms by their sides and look straight ahead at a point on the wall approximately one meter away at eye level. The postural stability test was assessed with 3 repetitions with level 8 as difficulty of the test and given a 20-second rest between each repetition and the best one was chosen.

The SPSS 22 software (SPSS Inc., Chicago, IL) was used to analyze the data. Descriptive statistics with a mean and standard deviation (SD) were employed in the data analysis. The normality and homogeneity of the data were tested using Shapiro–Wilk’s normality test and Levene’s homogeneity test, respectively (p ≤0.05). Repeated measures two-way analysis of variance (ANOVA) was performed on outcome variables (p ≥0.05).
Table 2

Exercises of deep aquatic-based program

| Type of Exercises                                         | Duration |
|----------------------------------------------------------|----------|
| Warm-up exercises                                        |          |
| Land walking slowly                                      | 10min    |
| Stretching exercises (Gastrocnemius, Quadriceps, Hamstring, Adductors, the upper extremity muscles) | 3min     |
| Fast walking in the shallow end of the pool              | 5min     |
| Cool-down exercises                                      | 2min     |
| Warm-up exercises                                        |          |
| Fast walking in the shallow end of the pool              | 10min    |
| Stretching exercises (lower extremity)                    | 5min     |
| Main training program                                    |          |
| Cycling across the deep area of the pool                 | 10min    |
| Hip flexion and extension with extend knee               | 5min     |
| Hip abduction and adduction with extend knee              | 5min     |
| Float horizontally and hip and knee flexion and extension each leg one by one | 5min     |
| Float horizontally and hip flexion and extension with extend knee (back stroke leg kicking) | 5min     |
| Go back to the shallow part of the pool by cycling       | 5min     |
| Main training program                                    |          |
| Warm-up exercises                                        |          |
| Warm-up exercises                                        |          |
| Main training program                                    |          |
| Warm-up exercises                                        |          |
| Cool-down exercises                                      | 5min     |
| Walking slowly in the shallow end of the pool            | 3min     |
| Stretching exercises (lower extremity)                    | 2min     |

STATISTICAL RESULTS

According to the obtained results aquatic exercises promote significant increases in elderly men lower extremities strength and balance, as observed by means of the postural stability test by BBS for balance results and HHD for strength. The increase in these qualities occurred after the 8 weeks of training (Table 3). No differences were noted between control group in static balance and strength.
Table 3
Comparison of lower body strength and balance between the experimental and control groups at 8 weeks of intervention.

|                        | Variables         | Pre test  | Post test | Pre test  | Post test | Sig      | F        | Effect size |
|------------------------|-------------------|-----------|-----------|-----------|-----------|----------|----------|-------------|
| **Lower Body Strength**| Knee Extensor     | 14.99±5.03 | 23.02±6.49 | 13.69±2.28 | 14.05±2.21 | 0.001    | 80.32    | 0.755       |
|                        | muscle (Quadriceps) | 14.82±3.48 | 24.51±5.61 | 14.59±2.89 | 14.81±2.93 | 0.001    | 39.42    | 0.603       |
|                        | Knee Flexor       | 11.09±2.69 | 24.85±5.33 | 11.29±1.78 | 11.63±1.66 | 0.001    | 77.25    | 0.748       |
|                        | Muscles (Hamstring) | 14.19±1.93 | 29.63±6.51 | 12.73±2.14 | 13.04±1.99 | 0.001    | 62.97    | 0.708       |
| **Static Balance**     | APSI               | 1.98±0.53  | 1.46±0.41  | 1.94±0.48  | 1.88±0.46  | 0.002    | 12.11    | 0.318       |
|                        | MLSI               | 1.51±0.55  | 1.22±0.35  | 1.47±0.41  | 1.40±0.32  | 0.005    | 9.63     | 0.270       |
|                        | Overall            | 2.74±0.77  | 2.11±0.48  | 2.81±0.56  | 2.74±0.53  | 0.001    | 16.03    | 0.381       |

Results are reported in Tables 3. As seen, all variables including lower body strength, static balance were significantly improved in experimental group after aquatic exercises program, but there was not any significant improvement in control group as seen.
DISCUSSION

The aim of this study was to investigate if a deep aquatic exercises program would be capable for improving static balance and lower body strength. The initial hypothesis was that there would be notable difference in the lower extremities strength as a result of participating in a deep-aquatic exercise after 8 weeks in the experimental group. These findings confirmed our hypothesis that lower body strength of the older adults who have done the aquatic exercises enhanced. These results are parallel with Routh et al. and Wang et al. that aquatic exercise against water resistance could improve muscle...
strength in the lower extremities [30,36]. The greater improvements in muscle strength might be explained by the higher hydrostatic pressure and resistance, as a consequence of the viscosity and the density in water that required muscle capacity (and thus the consumption of energy) at a certain speed of movement. Water is viscous, it decelerates movement and retards falls, which prolongs the time available for regaining posture when the body gets out of balance. Floating acts as a support, which increases individuals’ confidence and reduces the fear of falling. In this way, individuals can be challenged beyond their limits of stability without being afraid of the consequences of falls that would occur on the ground [10,25]. The increased resistance to movement through the water requires additional muscle activation to overcome the resistance and produce the same movement that is more easily produced in the air [16]. According to the obtained results we observed a significant improvement in the static balance as a result of the aquatic exercise. We found deep aquatic based exercise conducted over an 8-week period were equally effective in promoting balance improvement. Yoshihiro Katsura et al. reported that after aquatic exercise training using water resistance equipment in elderly both dynamic and static balance improved as a result of simultaneous stimulation of not only the leg muscles but also the support muscles involved in spinal and pelvic movements [31]. In contrast Bento et al. stated that the water-based training was effective in improving dynamic balance, but not static balance. These results can be due to water level was kept at the level of the xiphoïd Process but in our study water depth was over 2 meter [32].

By utilizing the properties of water, balance training may be more advantageous when performed in an aquatic environment. Aquatic exercise may contribute to neuromuscular coordination, proprioception, and balance efficiency. There is speculation that an aquatic environment will increase proprioceptive input to the immersed body by providing more stability and body alignment, leading to enhancement of balance. Sensory feedback may also increase, promoting a sense of body awareness, because resistance to movement through a viscous fluid (water) is greater than resistance through air [36]. For these reasons, the aquatic environment may be an effective medium for balance training [30].

The greater improvements in static balance also might be explained by this fact that the aquatic environment provides situations of instability and maintaining and recovering balance in the presence of water turbulence may represent a valuable stimulus for increasing muscle strength in the lower limbs which could promote greater improvements in body balance reactions during the water exercise activity.
more than one person was moving in the water; this created turbulence which may have increased the variability of the factors influencing each participant's movement. These factors suggest that the water exercisers' postural control needs continually varied with the constantly changing pool environment. These changing balance requirements would cause the subjects to acquire or enhance their postural control mechanisms in order to prevent a fall. [31,33].

It has been suggested that because there is no stationary resting position in water, muscles are activated continuously to stabilize the positions of the body. The stabilization may allow a patient to gain more strength, flexibility, and more importantly, improve balance [30]. What was interesting to note is that the experimental group had more increase in the flexor and extensor muscles of the ankle joint. These results are consist with Barauce Bento’s study that stated the actions required to recover balance and to propel the body in several directions in depth require vigorous plantar flexion actions. The flexor and extensor muscles of the ankle joint are likely to be well activated to recover balance throughout the water-based sessions due to the constant perturbation caused by the water turbulence [32,35].

There are a number of limitations in the present study;

1. The method of participant selection was by volunteer and therefore subjects were not randomly selected. This could affect the generalizability of the outcomes to the intended population.

2. The motivation and willingness of each subject to participate varied, possibly leading to alterations in the true outcomes of the study.

CONCLUSION

The present study demonstrated that a 8-week program of deep-aquatic exercises results in significant improvements in lower body strength, static balance, prevention of falling and quality of life and also health cost can be decreased in elderly men compared with no intervention. So deep Aquatic exercise can be useful intervention option for elderly men.

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Deep-aquatic exercises on static balance

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