The Effect of Land and Aquatic Exercise on Balance Scores in Older Adults

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ABSTRACT

Background and Purpose: Lower body exercises are an important intervention in retraining balance. The aquatic environment has been identified as an appropriate medium to perform these exercises. The purpose of this research was to determine if aquatic exercise was more effective than land-based exercise when training balance. Study Design: The study involved a 2-group pretest-post-test design. The Berg Balance Scale (BBS) scores served as the outcome measure. Methods: Eleven subjects completed this study. Five subjects were from an assisted living facility (age 83.2 ± 8.1 years) and 6 subjects were from an outpatient facility (age 75.0 ± 3.6 years). Each group did a comparable set of lower body exercises (2 times per week for 6 weeks), but one group exercised in the pool, and the other exercised on land. The data was analyzed using a mixed model 2x2 analysis of variance. Results: There was a significant main effect of time (p < .001) but not group on BBS scores. There was no significant interaction between group and time. Conclusions: Regardless of the treatment medium, significant improvements were evidenced on the BBS between pretest and post-test. The utilization of lower body exercise, whether in water or on land, was accompanied by improved balance. Neither medium however was superior for retraining balance in the older adult.

Key Words: balance, physical therapy, aquatics

INTRODUCTION

Falls are the leading cause of fatal and nonfatal injuries among the elderly; they represent a major health and socio-economic problem that costs the people of the United States an estimated $7-10 billion per year.1 A major contributor to falls in an older person is the diminished functioning of a number of physiological systems.4 Age-related declines in muscle mass or sensorimotor systems may contribute to decreased balance and stability while walking. MacRae and colleagues5 identified muscular weakness in the hip abductor, knee extensor, knee flexor, and ankle dorsiflexor muscles as being related to an elder’s risk for falls. The literature indicates that exercises that are repetitive, of high intensity, and continuous are desirable to achieve increased strength in community dwelling elders.6

Balance, strength, and proprioception may be addressed in an aquatic environment.7 According to Campbell et al,7 activities in water are appropriate for the geriatric population. Ruoti and associates8 described the support offered by water as allowing more independent upright postures. They posited that in water there may be an increase in afferent stimulation from greater cutaneous inputs, that muscles may be more freely firing, as patients are less fearful of movement, and that activity in water may facilitate vestibular inputs.9 Exercising in water may be more appropriate than on land for those with musculoskeletal impairments. Joint loading diminishes relative to the depth of immersion.6 Then and Brody-Then6 found that being submerged to the level of the anterior superior iliac spine allows for a 54% reduction in weight bearing, thus reducing lower extremity stress. Consequently, aquatics may be a more effective balance intervention for those elders with significant joint pathology. The warm water of the pool has the potential to increase the circulation to the involved joints, relax muscles, and temporarily decrease pain.10 Exercise in water can slow the speed of falling, secondary to the properties of viscosity and density, allowing an individual with impaired balance more time to detect postural errors that might lead to a fall.11

It is of considerable importance to determine whether exercise in the aquatic environment, which has been advocated as a means of keeping physically active, has an impact on balance ability.12 Lord and colleagues13 demonstrated that water exercise can offer a means of keeping physically active for the moderately disabled elder. In their investigation, an aquatic environment was used to study neuromuscular control, strength, reaction time, improved body sway, flexibility, and joint pain. The experimental group participated in a water program designed for older individuals (mean 69.7 years), which consisted of a weekly aquatic exercise session for 9 weeks. Physical therapists and trained leaders led a standard exercise program with warm-up, conditioning, and cool down periods modified to meet the needs of this older population in the aquatic environment. The control group attended classes on current affairs and took part in activities such as painting and crafts. The subjects who participated in the aquatic therapy program improved significantly in strength and body sway when compared to the control group. However, the researchers were looking at elements contributing to balance rather than the performance of balance tasks specifically.

In addition, Simmons and Hansen14 found that water exercise was a means of improving forward reach in community dwelling elders. Their study had 4 groups. Improvements in forward reach were significant in the land and water exercising groups. These researchers noted greater compliance of a water exercise group compared with 3 other groups. Furthermore, the majority of the water group (80%) continued to exercise several months after the study. Simmons and Hansen14 demonstrated a greater increase in forward reach.
with aquatic exercise versus land exercise. Forward reach has
been shown to correlate with forward limits of stability. A
limitation of this study was that it only measured forward
reach, a single component of the Berg Balance Scale (BBS).

The BBS is an ordinal scale of balance that is well validat-
ed and reliable, it is straightforward, and requires less than 20
minutes to administer. Reliability has been established with
the elderly and stroke patients. In addition the BBS has
been shown to have strong internal consistency. Shumway-
Cook and Woollacott describe the BBS as the best predictor
of falls status amongst community dwelling older adults.
Criterion related validity of the BBS has been established by
Berg and associates in 1992 using the Barthel Index of self-
care and mobility and the Fugl Meyer. Riddle and Stratford
used the Berg as a means to study validity indexes such as
sensitivity, specificity, positive and negative predictive val-
ues, and likelihood ratios. A subject with a BBS score of 55
can be described confidently as a non-faller. The lower the
BBS score, the greater is the risk for falls. In fact a person with
a score below 40 is almost 12 times more likely to fall than a
person with a score above 40.

This study investigated the utilization of similar balance
retraining exercises in the aquatic and land-based environ-
ment. The primary purpose of this study was to compare
preintervention BBS scores to postintervention BBS scores in
a land versus aquatic environment in order to test if one
training environment is of greater benefit than the other
with this population.

METHODS
Subjects
The age of the land subjects was 83.2 ± 8.14 (73-91) years.
The age of the aquatic subjects was 75.0 ± 3.63 (68-78) years.
Subjects for the land portion of the study were recruited at an
in-service on balance and falls at an assisted living commu-
nity. In addition, flyers were posted inviting residents to come
to the in-service and recruitment meeting. The staff later
introduced to the investigators residents that were not pre-
sent for the in-service but were still interested in participat-
ing. Subjects for the aquatic portion of the study were
recruited by the use of a flyer posted at a physical therapy
office. The purpose of the flyer in the office was to heighten
the awareness of the staff regarding patients meeting the
inclusion criteria that have been discharged 6 to 12 months
previously and were in the database. Over 40 were invited
to participate by phone, of which only 6 met the inclusion crite-
ria. The rest of the potential subjects, either scored too high
on the BBS, lacked transportation, or were unable to commit
to the 6-week program. All of the aquatic participants pre-
viously received outpatient aquatic therapy for various ortho-
pedic conditions and were comfortable with exercise in the
water. These aquatic exercises were designed to address their
specific joint pathology, not balance. The New York Institute
of Technology (NYIT) Institutional Review Board approved
this study; and all subjects signed an informed consent.

Twelve subjects were recruited to participate in the
aquatic versus land study. There were 2 groups of partici-
pants, 6 participated in the water exercise, 6 on land.

Subsequently, one land participant was excluded because of
inability to attend all exercise sessions. Subjects were
assigned to the site that was familiar to them. This was done
to ensure compliance and to reduce attrition. Subjects were
informed that they were expected to attend all 12 sessions.
All subjects completed 2 sessions each week with at least
one day of rest between sessions for 6 weeks. The inclusion
criteria for the subjects included the following: subjects were
healthy elderly aged 65 and older who were independent
ambulators with or without an assistive device and indepen-
dent in activities of daily living. They were able to follow ver-
bal instruction and attained a score of 20 or better on the
Mini Mental Status Examination (MMSE). Their score on the
BBS could be no greater than 47 since scores greater than
that would be approaching the test's ceiling. The subjects
could not have any medical condition precluding increased
physical activity and all obtained medical clearance.

Exclusion criteria for the subjects included: any significant
illness within the last 6 months; receipt of physical therapy,
chiropractic, or osteopathic manipulative therapy at the time
of the study; and/or enrollment in any other formal exercise
program.

Procedures
Screening examinations were used to identify subjects
who met the inclusion criteria. The MMSE was administered
for the group participating in the aquatic exercise; the assist-
ed living facility subjects already had their MMSEs on file. The
BBS was administered at the start of the study, and again at
the end. The BBS and MMSE were administered in a quiet
treatment area at the pool site. The land exercises and BBS
testing took place at the assisted living facility's recreation
room. The investigators supervised both groups at each ses-
sion at both sites. Each session lasted 20 to 30 minutes.

The 14-item BBS was administered by one of the investiga-
tors to each participant and scored in a manner in keeping
with the operational definitions of each item. Two investiga-
tors were dedicated to each site and completed all pre- and
post-testing for their group, as well as the exercise sessions.

To establish reliability, the investigators viewed a video of
a therapist administering the BBS to a patient and graded
that patient's performance. Seven days later the investiga-
tors viewed and scored the same video. The raters were
blinded to their initial scores. The investigators were found
to have inter-rater reliability of .99 and intrarater reliability of
.98.

Exercises were comparable for both land and water and
were administered 2 times a week for 6 weeks. Subjects
exercised to their tolerance and were allowed rest periods as
needed. Subjects were instructed to report any discomfort
immediately. Land exercises were conducted indoors in an
assisted living recreation area. Water exercises were per-
formed in an indoor pool with a temperature that was 33°C
(92°F). The aquatic group used the Aquamotion, Inground Custom Therapy Pool (Longmont, Colo). The dimensions are
11' x 17'8" and 3'4" and 5' depths. Each depth has a lane within the pool of 3 feet. This allowed accommo-
dation for the variable height of the subjects.

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The subjects exercised in a water level based on their height; the water level was between their waist and nipple line. Subjects in the aquatic group worked in the pool as 2 groups of 3 in order to reduce any possible difficulty that would arise from increased turbulence of the water. As a result, 3 subjects completed the exercise activities while the other 3 simultaneously worked on the walking portion of the protocol. The pool had a shelf adjacent to its entrance, approximately 12 inches (seat depth) and 24 inches (seat height). The shelf ran the length of the pool and served as the sit to stand site. There was a spotter available in the pool while the subjects were exercising. In addition to an available spotter, the land exercisers could hold on to a stationary chair or their assistive device for stabilization if necessary.

Statistical Analysis
The study employed a 2-group pretest-post-test design using the BBS score as the dependent variable. A mixed model 2x2 ANOVA was used. The main effects studied were time (pretest vs. post-test) and group (water vs. land). Statistical significance was set at .05 level. Calculations were performed with the SPSS statistical package (version 10.5.0 Chicago, Ill).

RESULTS
There was a significant main effect (F_1,74 = 2516.57; p < .001) of time, which demonstrated there were significant differences in BBS scores between pre and post-test scores for the 2 groups. The main effect of group (difference in BBS scores between groups) was not significant (F_1,38 = 1.26; p = .290). There was no interaction effect between time and group (F_1,54 = .008; p = .932). Figure 1 displays the means and (±) SD of the pre- and post-test BBS scores of the aquatic and land groups.

DISCUSSION
This study was designed to compare the effectiveness of similar balance retraining interventions performed in a land versus aquatic environment. The results of this study demonstrated that regardless of the exercise medium, significant improvements in balance were achieved by lower body exercise. These findings conflict with the conclusions of Simmons and Hansen.11 They concluded that postural control improved greatest in the aquatic group as compared to a land group (although both groups showed improvement), when measured using forward reach. Analysis of their raw data indicates that both the aquatic and land group had end scores that were the highest possible for the BBS. Their raw data, when converted to inches from centimeters, demonstrate that forward reach for both the land and aquatic groups was in excess of 10 inches. Greater than 10 inches receives the highest score for the forward reach item in the BBS. Therefore, Simmons and Hansen would have realized a ceiling effect, if the BBS was used to score forward reach.

Our direct comparison used a balance specific comprehensive approach toward assessment of balance retraining effects of 2 interventions over 6 weeks time. The BBS functioned in this study as a multiple measure of steady state and anticipatory postural control and not a single element of measure of postural sway or functional reach. The main finding from this study was that balance ability in older adults could be improved through the use of land-based or aquatic-based therapeutic exercise. We found land- and aquatic-based exercise conducted over a 6-week period were equally effective in promoting balance improvement. This study adds to the evidence base of effective interventions for balance retraining in the community-based elderly. In today’s health care climate there is increased accountability of the rehabilitation personnel with regard to evidence-based practice, to achieve reimbursement. Lower body activity as described in either medium is effective in increasing balance outcomes as determined using the BBS. Recognizing the BBS as a sensitive predictor of falls based on the score attained, these subjects with these improvements should be at a reduced risk for falls. Therefore, with the use of the BBS, noted as a significant predictor for falls status, we can posit that balance improvements by both groups of subjects were correlated directly with a decreased propensity of future falls. Further follow up is necessary to confirm this premise.

Although exercising in water may be more appropriate than land exercises for individuals with musculoskeletal problems we found in these 2 small groups that land and water were both beneficial. Considerations of availability, cost, and maintenance of the therapeutic pool will guide the clinician in the decision making process for balance retrain-
ing in the well elderly. All subjects within the study were genuinely interested and enthusiastic in the balance training and were fully compliant to the program. Consistent participant attendance was achieved and thus played a vital role in outcomes measured.

One substantial limitation of the study was the sample size. Increasing the sample size would have increased the statistical power of our study. The lack of random assignment due to recruitment issues also may have affected our results due to the inherent differences between the groups. It is impossible to know that these results would be achieved for all community dwelling elders. Researchers of future studies might wish to extend this to larger groups. Other variables that warrant attention are the duration, intensity, and frequency of the intervention. Most of the literature reviewed used different frequencies and durations for the intervention program. Future aquatic/land-based balance studies might use a combination of 2 or more balance assessment tools such as the BBS, and a gait performance tool to substantiate any improvements in functional balance ability. A higher-level gait examination such as the Dynamic Gait Index might be considered for this independent and mobile population.19 Reassessments of participants at different intervals to determine the duration of the gains made during retraining, or when the significant gains were achieved, would be beneficial.

CONCLUSION

The results of this study demonstrated that there were no significant differences between the 2 groups in the improvement of balance. Regardless of the treatment medium, significant improvements were evidenced on the BBS post-test. Lower body exercise in either medium may be effective in retraining balance in the older adult.

REFERENCES