ARTICLES

A Randomized Clinical Trial of Aquatic versus Land Exercise to Improve Balance, Function, and Quality of Life in Older Women with Osteoporosis

C.M. Arnold, A.J. Busch, C.L. Schachter, E.L. Harrison, W.P. Olszynski

ABSTRACT

Purpose: Despite the decreased gravitational loading that is experienced in an aquatic environment, little research has been conducted on this exercise medium for women with osteoporosis (OP). Aquatic exercise (AE) may improve function and balance, thus ultimately decreasing fall risk and the potential for hip fractures in this high-risk population.

Method: A total of 68 women with OP, aged 60 years or older, were recruited into a randomized clinical trial evaluating the impact of AE, land exercise (LE), and no exercise (NE) on balance, functional mobility, and quality of life (QOL).

Results: Only one balance measure (backward tandem walk) significantly improved with AE compared to LE, but this did not translate into a greater improvement in self-report function. There were no significant differences between the exercise interventions and NE, except for in ratings of global change, where participants in the AE group were three times more likely to report improvement than those in the NE group.

Conclusion: There were no differences in balance, function, or QOL in women with OP who followed an AE or LE programme compared to those in an NE control group. However, the significant differences in backward tandem walk between the AE and LE groups and self-reported global change between the AE and NE groups warrant further investigation. Significant improvements in balance and global change suggest that AE is a viable alternative for older women with OP who have difficulty exercising on land.

Key Words: accidental falls, exercise, hydrotherapy, osteoporosis, risk factors

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RÉSUMÉ

Objet : Malgré la diminution de la pesanteur qui règne en milieu aquatique ce moyen d'exercice a suscité peu d'attention dans la recherche pour les femmes atteintes d'ostéoporose (OP). L'exercice aquatique peut améliorer la fonction et l'équilibre, diminuant ainsi, finalement, le risque de chutes et la possibilité de subir une fracture de la hanche parmi la population à risque élevé. Nous avons comparé les effets de l'exercice aquatique (EA), de l'exercice terrestre (ET) et de l'absence d'exercice (AE) sur l'équilibre, la fonction et la qualité de vie (QdV).

Méthodologie : Soixante-huit femmes, de 60 ans ou plus, atteintes d'OP ont participé à un essai clinique aléatoire évaluant l'impact des programmes d'exercice sur l'équilibre, la mobilité fonctionnelle et la QdV.

Résultats : Seulement une mesure d'équilibre (marche en tandem) a connu une amélioration marquée dans le cadre de l'EA en comparaison de l'ET, par contre cette amélioration ne s'est pas avérée au niveau d'auto-évaluation de fonction par rapport à l'ET. Il n'y a pas eu de différences importantes entre les interventions d'exercice et l'AE, sauf pour l'évaluation du changement global, c.-à-d., les participantes à l'EA étaient trois fois plus aptes à signaler une amélioration que celles de l'AE.

Conclusion : Il n'y avait pas de différences dans l'équilibre, la fonction ou la QdV à la suite d'un programme d'exercices aquatiques ou terrestres en comparaison d'un groupe témoin de femmes atteintes d'OP. Cependant, les différences importantes dans l'équilibre à la marche en tandem entre l'EA et l'ET et le changement global entre l'EA et l'AE méritent une enquête plus approfondie. L'évaluation du changement global suggère que l'EA est une option viable pour les aînées atteintes d'OP qui éprouvent de la difficulté à faire des exercices au sol.

Mots clés : chute accidentelle, exercice, facteurs de risque, hydrothérapie, ostéoporose

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C.M. Arnold, BScPT, MSc, PhD candidate: School of Physical Therapy, University of Saskatchewan, Canada.

A.J. Busch, BPT, MSc, PhD: School of Physical Therapy, University of Saskatchewan, Canada.

C.L. Schachter, DipPT, BA, MHK, PhD: School of Physical Therapy, University of Saskatchewan, Canada.

E.L. Harrison, DipPT, BPT, MSc, PhD: School of Physical Therapy, University of Saskatchewan, Canada.

W.P. Olszynski, CCD, FRCP(C), MD, PhD: Saskatoon Osteoporosis Centre, Saskatoon, Saskatchewan, Canada.

Address for correspondence: C.M. Arnold, Associate Professor, School of Physical Therapy, University of Saskatchewan, 210–1121 College Drive, Saskatoon, Saskatchewan, Canada S7N 0W3; Tel: 306-966-6588; Fax: 306-966-6575; E-mail: cathy.arnold@usask.ca.

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BACKGROUND

The greatest public health concern related to osteoporosis (OP) is the increased risk of fracture and accompanying high rates of mortality and morbidity.[1] Of particular concern is hip fracture, for which women have a one in six lifetime risk.[1–3] In all, 80–90% of hip fractures in older adults are related to falls, and each year one in three community-living adults over the age of 65 years falls.[4,5] Among hip fracture patients, 50–70% will not return to their previous functional status and many are admitted to long-term care; approximately 25% will die within the first year post-fracture.[6] In older adults with OP, exercise contributes to a decreased fracture risk by maintaining or improving bone density and improving balance, leading to a decreased risk of falling.[1] The optimal type, duration, and frequency of such exercise have not yet been established.[7,8]

Exercise programmes for women with OP are designed to address fall risk factors and promote mechanical loading through weight-bearing and resistance exercise. Both agility (balance) and strengthening programmes have been found to improve strength, balance, and reaction time in older women with OP;[9,10] however, the impact of other types of exercise programmes in which older adults typically engage, such as aquatic exercise (AE), have received little attention in this population.

AE has been defined as ''vertical exercise in the water with the participant submerged to chest or shoulder depth.''[11(p.2)] The benefits of AE include decreased stress on weight-bearing joints due to the buoyancy of the water, increased mobility due to diminished gravitational pull, the ability to use varying levels of resistance for strengthening, increased sensory feedback, and promotion of lymphatic return.[11] AE has not typically been recommended for individuals with OP as the gravitational loading effect on bone is diminished. However, the additional benefits of the support and comfort of the water have led some experts to recommend AE for individuals with more severe OP as a well-tolerated exercise medium in which to improve function and balance, which are important in decreasing fall risk.[12]

Few studies have evaluated the effect of AE on balance in the elderly. In the 1990s, a study of healthy older adults reported significant improvements in balance, as measured by the functional reach test, in aquatic exercisers as compared with land exercisers and controls.[13] A more recent study reported improved balance in women with OP following an aquatic intervention compared with a no-exercise control group.[14] Furthermore, a review article on the effects of hydrotherapy for older adults cited improvements in pain, function, self-efficacy, mobility, strength, and balance following AE compared with no exercise (NE).[15] This provides support for further examination of the effects of AE on balance, function, and QOL in more vulnerable populations.

People with OP are at higher risk of fracture due to falling. Consequently, improving balance and functional ability should be a high priority for exercise interventions. The purpose of this study was to compare the affects of AE, LE, and NE on balance, function, and QOL in postmenopausal women with OP. Our hypotheses were that: (1) AE would result in greater improvements in balance, function, and QOL compared with LE, and (2) both LE and AE would result in greater improvements in balance, function, and QOL compared with NE. This study included comprehensive testing of function and balance, not previously examined in women with established OP, and the evaluation of an exercise programme (AE) that has received little attention in the literature.

METHOD

Study Design

Approval for the study was received from the University of Saskatchewan's Biomedical Ethics Review Board. A diagram describing the study design and flow of participants throughout the study is depicted in Figure 1. Following screening for eligibility (described below), participants were randomly assigned to AE or LE using a lottery method of drawing numbers from a hat; numbers were drawn by an individual who was not involved in the study. Once the intervention quota was full, subsequent eligible participants were placed in a waiting-list (NE) control group. All participants were tested prior to and after the intervention or wait-list control period. The participants in the wait-list control group were subsequently randomly assigned to AE or LE after the control period (using the same lottery method), and were retested again following the intervention. This approach resulted in a true randomized comparison of LE and AE and a quasi-experimental design comparing NE with AE and LE.[16]

All physical testing was performed by one licensed physical therapist with 30 years' experience in practice and specialized skills in geriatric care. The physical therapist was blinded to group assignment.

Two research assistants who were not blinded to group assignment administered interview-based questionnaires. Outcome variables were measured before and after the intervention (or control phase). Participants who were initially in the control phase were evaluated three times during the study versus two times for those who were initially assigned to LE or AE. Informed consent was obtained from all participants prior to their entering the study.

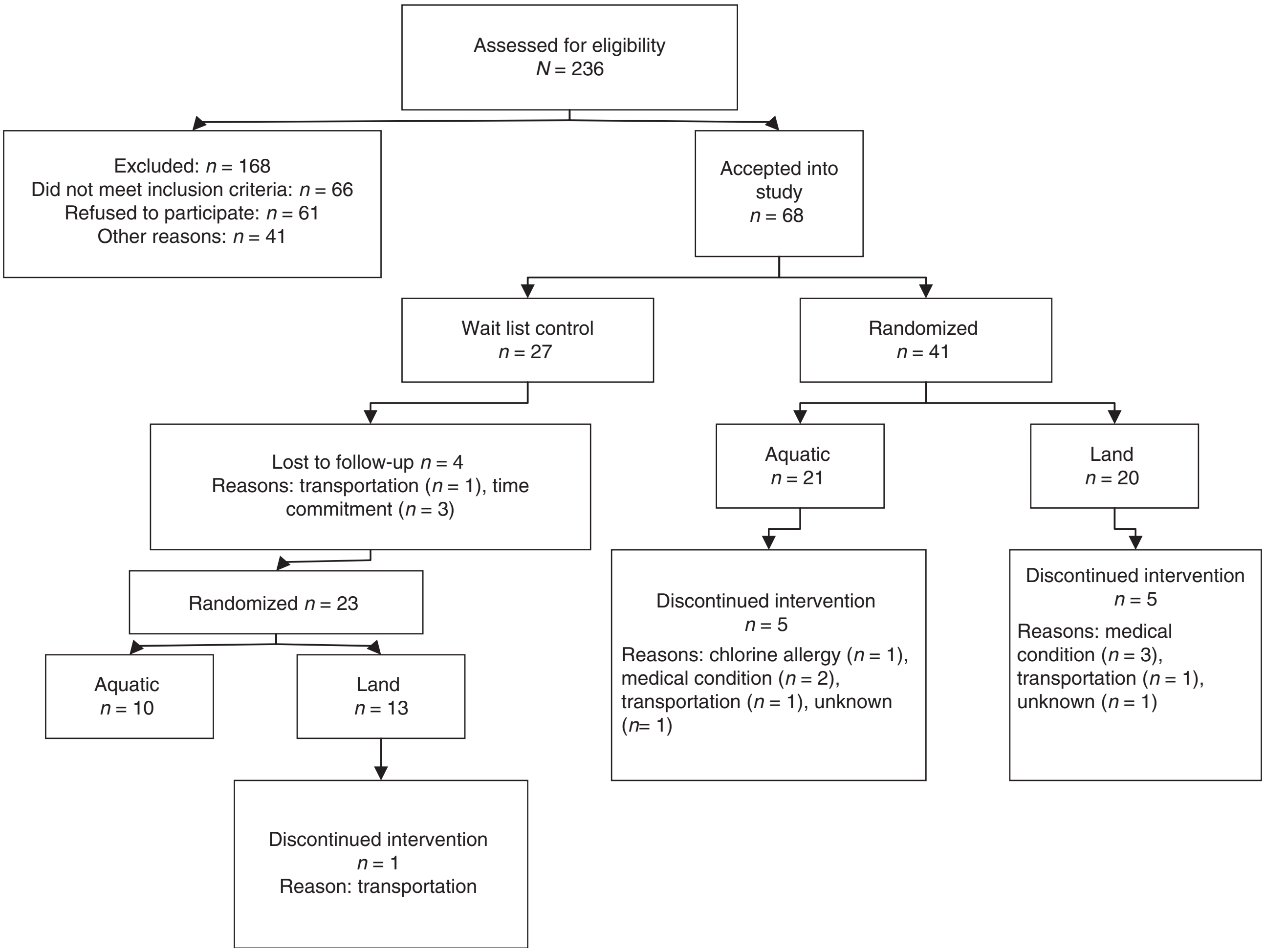

Figure 1 Flow diagram of participants' progress through the phases of the randomized trial

Participants

Participants were recruited by advertisements at physicians' offices and in local newspapers and through public poster displays, and were screened by telephone interview to verify that they met the inclusion criteria. The inclusion criteria were: (1) female, ambulatory, age greater than 60 years, and at least 5 years postmenopause, (2) diagnosis of OP, confirmed by a physician using dual-energy X-ray absorptiometry in the past 5 years (femoral neck and/or lumbar spine, level L1–L4, with a t-score of 2.5 SD or more below the mean for a healthy 30-year-old female), and (3) approval from their family physician to participate in an exercise programme.

Exclusion criteria were: (1) the presence of a neurological or medical condition resulting in extremely limited activities of daily living, (2) any condition that would jeopardize the subject's safety during moderate-intensity exercise or contraindicate AE (i.e., ischemic heart disease, uncontrolled hypotension or hypertension, uncontrolled epilepsy, dementia, extreme fear of water), (3) uncontrolled thyroid dysfunction, (4) a documented vertebral or lower-extremity fracture in the past 3 months, and (5) regular participation in an exercise programme in the past 2 months (i.e., aerobic training at least three times per week or strength training at least two times per week).

Subject Characteristics

Medical history, physical activity level, history of fracture, presence of joint pain, demographic information, calcium and vitamin D intake (food frequency questionnaire),[17] height, weight, and posture were assessed at study entry for all participants, and again following the control period for those in the NE group (prior to re-assignment to intervention).

Posture was assessed using the index of kyphosis, following a standardized protocol with the flexicurve ruler.[18,19] The index of kyphosis represents the ratio of the height of the thoracic curve divided by the spinal length. In addition to being a common physical measurement of spinal change associated with OP, the index of kyphosis is associated with detriments in balance and a history of falls specific to the female OP population.[20,21] The modified Baecke physical activity questionnaire for older adults, which exhibits good test–retest reliability,[22] was used to measure the level of physical activity.

Outcome Measures

The outcome measures were divided into primary and secondary outcomes. The primary outcome of interest was balance, and the measures used were the Berg balance scale, functional reach test, and backward tandem walk. Secondary outcomes were physical and self-report functional status, measured by chair stands, self-paced walk, a functional disability questionnaire, and a quality-of-life questionnaire.

Primary Outcome Measures

The Berg balance scale[23] consists of 14 functional items, each rated from 0 to 4, to give a total score of 0–56 with a higher score indicating better balance. The test has excellent retest and interrater reliability (intraclass correlation coefficient [ICC] = 0.98)[24,25] and has been correlated with other tests of balance and mobility.[25] The Berg balance scale has been shown to: (1) discriminate between people with different levels of standing balance at a point in time, (2) detect changes in balance over time, and (3) predict falls.[25–27] Shumway-Cook et al.[27] reported that the Berg balance scale was the best independent predictor of fall risk in a community-dwelling older adult sample, with a one-point drop in score associated with a 3–4% increase in fall risk in the 54–56 total score range, and up to a 10% increase in fall risk in the mid ranges of 46–54.

The functional reach test is a balance measure of the ability to reach forward without moving the feet. The distance reached is measured in cm using the mean of three trials.[28] Test–retest reliability is good (ICC = 0.81), and the test has been found to be predictive of falls in neurologically intact older adults.[28]

A backward tandem walk (walking toe-to-heel backwards on an 8-foot-long line) was scored by taking the mean number of errors (stepping off the line) during two tests; this has been found to be a sensitive test for detecting balance changes following an exercise intervention in community-dwelling older adults.[29] Test–retest reliability has been examined in a pilot study of 20 older men and women (ICC = 0.92).[30]

Secondary Outcome Measures

Secondary outcomes were chosen to evaluate function and QOL changes using measures of physical functional status as well as self-report measures designed specifically for the OP population.

The functional assessment system (FAS) consists of several lower-extremity functional tests that can be scored separately, and has been shown to have excellent interrater reliability.[31] The sit-to-stand test (chair stands) and the self-paced walk from the FAS were used as independent measures of physical function. For chair stands, the height of the sitting surface was adjusted using a bench designed for this study. The height of the bench was set at approximately 45° of hip flexion for each participant, and the same bench height was used for both pre- and post-intervention testing. The number of times the participant rose from sitting to standing in 1 minute was recorded. For the self-paced walk, the participant walks at their usual pace for 15 m. The time and number of steps recorded for the last 10 m and velocity (m/sec) for their usual pace were used in this study.

The functional abilities domain of the OP functional disability questionnaire (OFDQ), a self-report function scale, was used to measure functional ability. Reliability of this domain is good ($r = 0.87$), and the scale discriminates between healthy and OP patients.[32]

The OP QOL questionnaire (OQLQ) is an interview-administered questionnaire with good intrarater reliability (ICC = 0.80–0.89)[33] that has been correlated with other pain and disability questionnaires.[34] OQLQ consists of five domains: activities of daily living, emotion, leisure, physical activity, and social. For each domain, scores range from 1 to 7 with higher scores indicating a better QOL. A mean score for each domain is calculated and each domain can be independently evaluated, in addition to a total OQLQ score using an overall mean value. Of particular interest in this study was the OQLQ-emotion domain, which includes general questions regarding fear of falling and fracture.

A rating of global change was used to evaluate the impact of the exercise programmes on participants' perceptions of health, which reflect a broader analysis of functional decline and future exercise behaviour. Ratings of global change have been used in both intervention and methodological studies.[35–38] A single question was used post-intervention, which asked participants how they felt in terms of their general well-being and health compared with pre-intervention using a seven-point scale: very much worse, worse, somewhat worse, the same, somewhat better, better, or very much better.

Interventions

Both the AE and LE programmes were taught by licensed physical therapists with at least one assistant. Interventions were standardized for time, frequency, and duration, with each lasting for 50 minutes, 3 times per week, for 20 weeks. The size of the groups for both AE and LE interventions ranged from 10 to 17 participants. LE was conducted in a community gym with wall mirrors, music, floor mats, assorted weights, and other exercise equipment. AE was conducted at a community pool in the same facility. The pool had a zero-level entry (sloped, no stairs required). Water depth varied from shoulder to waist for most individuals; the water was kept at a comfortable temperature for older adults (average 30°C).

The AE group used music, paddleboards, small weights, and flotation devices. Most exercises were performed in a vertical position in chest-deep water, using the water to provide resistance to upper-body, trunk, and lower-body movements. Approximately 5 minutes were spent with participants in a horizontal position, floating with pool noodles to work on trunk-stability activities.

Both the AE and LE programmes were carefully designed to include a variety of exercises that addressed the key components related to risk factors for falls: gait activities; postural correction; upper- and lower-extremity mobility and stretching; trunk stabilization; resistance exercise for the trunk and upper and lower extremities; and balance activities. The general format was approximately 15 minutes of warm up and general mobility, followed by 20 minutes of weight-resisted activities (upper extremity, trunk, and lower extremity), 10 minutes of balance practise, and 5 minutes of cool down. Copies of the exercise programme guidelines are available on request.

Although functional activities were included in both programmes, activities such as walking in water involve different joint movements and muscle functions due to buoyancy. Since activities such as chair stands and learning to get up from and down to the floor are not feasible in an AE, water activities focused instead on resistance exercises for lower-extremity muscles such as the quadriceps and hip extensors.

Individual participants were given progressions and modifications appropriate to their level of function. Participants in both the AE and LE groups were instructed to exercise at an intensity that was moderate to somewhat hard (i.e., 12–14 on the 20-point Borg perceived exertion scale).[39] The exertion guideline was used primarily for safety; periodic checks by the physical therapist indicated that no participant worked beyond this level of exertion. Repetitions for resistance exercises were based on individual ability, but the general approach was to gradually increase repetitions (from 5–10 to 20–25) before adding resistance (weights of 0.5–1 kg). The exercise programmes were similar to others designed for individuals with OP.[10] The AE and LE groups exercised in different rooms at different times in the same facility, and were not in contact with one another during the intervention period.

The physical therapist instructing the classes completed daily reports, recording all exercise progressions, adverse effects experienced by participants, and modifications made to the programme. The first author met with all instructors regularly to ensure consistency in programme delivery. In addition, the first author and another researcher who was not directly involved in the study reviewed daily and weekly reports at the end of the study period. All reported adverse effects were recorded and categorized; weekly progressions and exercise modifications (i.e., type, order, or duration of exercise) made during each programme were also recorded. Attendance rates were calculated from the daily attendance records, and reasons for dropping out were reviewed and categorized by another researcher who was not directly involved in the study. Participants who dropped out of the study were interviewed by telephone by a research assistant regarding their reasons for dropping out.

Control Group

The control group was a wait-list control. Participants were tested and retested within a 20-week time frame, the same as for the intervention programme. During this period, group members met once per month (five times in total) in a different facility to where the interventions took place. While a research assistant acted as the group leader, the meetings were purely social in nature. Participants received no formal educational instruction during the meetings and were asked not to change their activity level or to participate in any new exercise programmes for the 20-week period.

Data Analysis

Data Cleaning

Data cleaning methods were used for diagnosing outliers, defined as points greater than 3 SD above or below the mean.[40] Five outlier data points (<1% of all data points) met this criterion, likely due to measurement error. These outliers were replaced using last observation carried forward. To avoid list-wise deletion of cases from the multiple analysis of variance (MANOVA), group mean values were substituted if both pre- and post-intervention scores for one of the seven designated outcome variables were missing. Whenever possible, individuals who dropped out during the study period were retested at the time of dropout; the last observation was carried forward for those who were unable to undergo or who declined retesting.

Baseline Comparisons

To evaluate between-group equivalency at study entry, we used one-way ANOVA to compare age, body mass index, nutritional intake, physical activity level, posture, and the results of the primary and secondary outcome measures. Comparisons of baseline values for participants who completed the study versus those who dropped out were made using an independent t-test or Mann–Whitney U test.

Inferential Analyses

Between-group differences in outcome variables meeting mathematical assumptions were examined using two multiple analyses of covariance (MANCOVAs), two separate analyses for the primary and secondary outcome measures comparing post-intervention scores, using baseline values and the index of kyphosis at baseline as covariates. Index of kyphosis was chosen as a covariate based on a previous study of this population in which a more kyphotic posture was significantly related to fall history.[21] We used Roy's largest root to obtain the *F*-statistic. Mathematical assumptions were examined using q-norm and symmetry plots and Box's M (homogeneity of variance). The primary outcome measures included the Berg balance scale, functional reach test, and backward tandem walk.

The Berg balance scale total score demonstrated a ceiling effect and did not meet the assumptions of ANOVA. It was therefore evaluated using the Kruskal–Wallis test to compare change scores among the three groups. The functional reach test and backward tandem walk were included in the primary MANCOVA analysis.

The secondary MANCOVA analysis included the following outcomes: chair stands, gait velocity, OFDQ, OQLQ-emotion, and rating of global change. The total OQLQ score was not included in the MANCOVA analysis due to high collinearity with the emotion domain. The seven-point rating of global change was collapsed to create a dichotomous score of ''better'' versus ''worse or the same.'' We determined that this scoring was more reflective of perception of improvement, as ratings of ''somewhat improved'' and ''improved'' would both be clinically relevant outcomes. The relationship of group involvement to ratings of global change as ''better'' or not was evaluated using binary logistic regression with the NE group as the reference. Odds ratios were calculated to estimate the strength of the relationship. Intercooled Stata 7.0 for Windows (StataCorp LP, College Station, TX) was used for analysis of mathematical assumptions and SPSS 15.0 for Windows (SPSS Inc., Chicago, IL) was used for all other analyses. An intention-to-treat analysis was used.

Sample Size

Based on data from a pilot study[41] that evaluated outcome measures from a sample of OP women involved in an exercise programme, 32 participants per group was determined to be sufficient to detect a moderate effect (effect size = 0.70) with a power of 80%[42] in the functional reach test, one of the primary measures used to assess balance. Using a wait-list control design where control subjects were subsequently randomized into one of the two interventions resulted in a total required sample size of 64 participants.

RESULTS

Subject Demographics and Baseline Comparisons

Figure 1 shows the participants in the study, including reasons for exclusion and dropouts. All 68 participants were randomly assigned to intervention either immediately upon entry into the study or after a 20-week waiting (control) period. The 68 participants were postmenopausal (mean, minimum, maximum: 21 years, 7 years, 45 years since menopause) and had been diagnosed with OP for a mean of 5 years (minimum, maximum: 1 year, 17 years). In all, 69% of the participants were married and 73% lived in the community with another adult. An education level of grade 9 or above was reported by 70% of the participants, with 32% achieving grade 12 or higher. Thirty percent of the sample had experienced a fall within the last 6 months, similar to findings from other studies of the community-dwelling elderly population.[43] Nine subjects in each of the AE and LE groups and eight subjects in the NE group had reported one or more falls in the last 6 months. Fifty percent of participants reported a previous fracture and 60% experienced joint pain. Approximately 25% were taking hormone replacement therapy and 60% were being treated with bisphosphonates for OP.

The demographic data for all participants are provided in Table 1. Baseline and post-intervention scores for the primary and secondary outcome measures are shown in Tables 2 and 3. One-way ANOVAs demonstrated no significant differences in baseline characteristics between the AE, LE, and NE groups. In addition, there were no significant differences in the baseline

Table 1 Comparison of Baseline Demographic Factors for the AE, LE and NE Groups

Variable	*AE* *n = 31* *Mean (SD)*	*LE* *n = 33* *Mean (SD)*	*NE* *n = 27* *Mean (SD)*
Age (years)	68.6 (5.4)	69.1 (6.3)	67.7 (6.3)
Duration of osteoporosis diagnosis (years)	4.1 (3.0)	5.2 (3.4)	5.0 (2.8)
Body mass index (kg/m^2)	24.3 (2.8)	26.2 (4.5)	25.2 (3.6)
Calcium intake (mg/day)	1635.7 (620.7)	1499.7 (604.7)	1904.3 (538.0)
Vitamin D intake (IU/day)	532.5 (244.4)	567.7 (279.9)	617.2 (272.4)
Modified Baecke questionnaire	5.7 (4.8)	5.0 (4.1)	5.8 (3.9)
Osteoporosis quality of life questionnaire-total (/7)	6.1 (0.8)	6.1 (0.9)	6.1 (0.7)
Kyphosis (%)	14.3 (4.2)	13.9 (5.0)	12.9 (4.1)

AE = aquatic exercise; LE = land exercise; NE = no exercise (wait-list control); OQLQ = Osteoporosis Quality of Life Questionnaire

Table 2 Pre- and Post-test Score Values, Effect Sizes and Results of Post-hoc Univariate Tests for Differences among AE, LE and NE Groups for Primary Outcome Measures (adjusted using pre-test values for functional reach, tandem walk and index of kyphosis as co-covariates)

Outcome Measure	*AE Pre-int. Score (SD) Post-int. Score (SD)*	*LE Pre-int. Score (SD) Post-int. Score (SD)*	*NE Pre-int. Score (SD) Post-int. Score (SD)*	$F_{2,85}$	*Univariate Results** *p*	*Effect Size* (η^2)	*Observed Power*
Functional reach test (cm)	37.7 (6.6) 39.0 (4.9)	37.6 (6.3) 39.6 (5.5)	38.3 (6.3) 40.8 (5.5)	1.16	0.32	0.03	0.25
Backward tandem walk (errors)	3.1 (2.2) 2.5 (1.8)	3.4 (2.3) 3.5 (2.4)	3.3 (2.3) 2.9 (2.4)	4.91*	0.010	0.10	0.79

*$p < 0.05$; least significant difference post-hoc tests found significant differences between the AE and LE groups (greater improvement with AE than with LE), but no significant differences between AE and NE or LE and NE

AE = aquatic exercise; LE = land exercise; NE = no exercise (wait-list control)

Table 3 Pre- and Post-test Score Values, Effect Sizes and Results of Post-hoc Univariate Tests for Differences Between the AE, LE and NE for Secondary Outcome Measures (using pre-test values and index of kyphosis as co-variates)

Outcome Measure	*AE Pre-int. Score (SD) Post-int. Score (SD)*	*LE Pre-int. Score (SD) Post-int. Score (SD)*	*NE Pre-int. Score (SD) Post-int. Score (SD)*	$F_{2,83}$	*Univariate Results* *p*	*Effect Size* (η^2)	*Observed Power*
OFDQ (/104)	94.0 (7.2) 92.0 (9.4)	92.7 (8.7) 94.3 (7.9)	94.6 (6.0) 94.9 (5.9)	4.20*	0.018	0.09	0.72
OQLQ-emotion (/7)	5.8 (1.2) 6.0 (1.1)	5.9 (1.1) 6.0 (1.3)	5.9 (1.1) 6.1 (1.0)	0.18	0.84	0.00	0.08
Chair stands (#)	31.7 (10.5) 34.5 (10.5)	26.9 (8.8) 29.9 (8.4)	29.8(9.0) 31.9 (11.3)	0.54	0.59	0.01	0.14
Self-paced walk velocity (m/sec)	1.3 (0.3) 1.3 (0.3)	1.3 (0.3) 1.3 (0.3)	1.3 (0.3) 1.4 (0.2)	0.20	0.82	0.01	0.08

*$p < 0.05$; least significant difference post-hoc tests found significant differences between the AE and LE groups (greater improvement with LE than with AE), but no significant differences between AE and NE or LE and NE.

AE = aquatic exercise; LE = land exercise; NE = no exercise (wait-list control); OFDQ = Osteoporosis Functional Disability Questionnaire; OQLQ = Osteoporosis Quality of Life Questionnaire

characteristics of individuals who completed the study compared with those who dropped out.

Adherence/Feasibility

Similar numbers of women dropped out of each study group: five from the AE group, six from the LE group, and four from the NE group. Reasons for dropping out are shown in Figure 1. Attendance rates for each of the two exercise groups were similar at 69% for AE and 67% for LE; when participants who dropped out were eliminated, mean attendance rates for both interventions were identical at 78%.

A post-hoc analysis comparing AE and LE change scores of the primary and secondary outcomes, using adherence (percentage of sessions attended) as a covariate, determined that adherence did not affect the results. No discrepancies in the method of instruction (type, order, or duration of exercise) or modifications in programme delivery were found based on daily and weekly reports recorded by the physical therapists. Although progressions were based on individual capabilities, there appeared to be no differences between classes in the application of progression guidelines by the instructors.

The primary adverse effect reported for LE was joint pain. Fifty-two percent of LE participants reported aggravation of pain in any joint during the programme compared with 29% of AE participants. Although most participants who experienced an increase in joint pain remained in the LE programme, progressions were delayed or some sessions missed due to joint pain. This did not occur to the same extent in the AE programme. However, reports of general muscle cramping and stiffness were much more common in the AE group (25% compared with 3% in the LE group). In general, participants attributed cramping to cool water temperature.

Outcome Measures

Tables 2 and 3 summarize pre- and post-intervention scores, and also provide the effect sizes and univariate results following the primary and secondary analysis of outcome measures using MANCOVA. Results of MANCOVA for the primary outcome measures of the functional reach test and backward tandem walk were significant (full factorial multivariate test, $F_{2,85} = 5.50$, $p = 0.006$). Univariate analysis revealed a significant improvement in the backward tandem walk for AE compared with LE participants, but this difference was not significant when compared with NE. Berg balance scale

Table 4 Comparison of Number of Participants Reporting Improvement in the Rating of Global Change Versus Those Who Did Not in AE, LE and NE groups.

Group	*Better n (%)*	*Same or worse n (%)*
AE	20 (65)	11 (36)
LE	20 (61)	13 (39)
NE	10 (37)	17 (63)

AE = aquatic exercise; LE = land exercise; NE = no exercise (wait-list control)

Table 5 Odds Ratios (ORs) and Confidence Intervals (CIs) for AE-NE and LE-NE Comparisons for Participants' Ratings of Global Change Using Binary Logistic Regression

Group	*β*	*SE*	*Wald*	*p-value*	*OR*	*95% CI*
AE	1.1	0.55	4.3	0.036	3.1	1.1–9.0
LE	1.0	0.40	1.8	0.07	2.6	0.92–7.5

AE = aquatic exercise; LE = land exercise; NE = no exercise (wait-list control)

change scores were analyzed separately using a Kruskal–Wallis nonparametric test, which found no significant differences between the three groups.

MANCOVA of secondary outcomes was significant for between-group comparisons (full factorial multivariate test, $F_{4,81} = 2.50$, $p = 0.049$), with a significant univariate improvement in OFDQ score for the LE group compared with the AE group, but not significantly different when compared with the NE group. Using binary logistic regression to compare ratings of global change for AE with NE and LE with NE, participants in the AE group were found to be three times as likely to report an improvement as those in the NE group, a significant relationship. A similar but non-significant relationship was found for the LE group, with an odds ratio of 2.6 compared with NE (see Tables 4 and 5).

DISCUSSION

This study evaluated an exercise programme that has received little attention as an intervention for women with OP. AE may be a useful alternative to LE for women with OP who have difficulty exercising on land due to fear of falls, poor balance, pain, or lack of motivation. Little is known about the impact of AE on outcomes linked to OP and fall risk, such as balance and functional status.

The first purpose of this study was to consider differences in balance, function, and QOL outcomes following AE and LE programmes in older women with OP. Although AE was not consistently found to result in greater improvements, we did find balance (as measured by the backward tandem walk) to be significantly improved with AE as compared with LE; however, this did not translate into a greater improvement in self-reported function (as measured by OFDQ). The second purpose was to determine differences in those who underwent AE or LE compared with NE. Our results did not support the hypothesis that AE or LE would result in improved balance or function compared with NE in a sample of older women with OP. The only significant finding was an improvement in self-rating of global change for participants in the AE programme compared with those in the NE group.

The limitations of this study may help to explain some of the non-significant findings. The design of a wait-list, nonequivalent control group that was re-assigned to intervention diminished the internal validity of the study, as the control group was not independent. There may be less variability in the data due to the same participants serving as both control and intervention. However this design was cost-effective and was used due to difficulties with recruiting adequate numbers to conduct a true randomized controlled trial of three groups.

The outcomes chosen required a variety of methods with which to evaluate balance and functional change, some general to the older adult population and some more specific to the OP population. We found a ceiling effect for the Berg balance scale. Because most of the population sample was in a ''low fall risk'' category for these measures, little room was available for improvement. For other measures, such as chair stands and OQLQ-emotion, post-hoc analysis of power indicated that larger samples (60–100 people) would be needed to detect a significant difference for the change scores we observed. We hope that this information will assist researchers in better selecting responsive, appropriate measures and appropriate sample sizes for future studies.

As there were no significant differences for the primary function and balance measures in the AE and LE groups compared with the NE group, differences between the groups should be interpreted with caution; however, there were some interesting observations. The improvement in balance for the AE group, as measured by the backward tandem walk, might be explained by the ability of individuals to perform activities such as a tandem stand or walk in water without the fear of falling onto a hard surface. Perhaps individuals can practise these activities at a more advanced level in this medium. Buoyancy and the psychological comfort of water may assist individuals with poorer balance to practise with more confidence. A recent randomized controlled trial provides additional support for the hypothesis that AE can improve balance as compared with NE.[14] Furthermore, in comparing the affects of 5 weeks of LE, AE, and NE on balance as measured by the functional reach test in healthy older adults, Simmons and Hansen found balance after AE training to be significantly better than in the other two groups.[13] Although we did not find a significant change in the functional reach test in this study, our participants had a higher mean baseline score than participants in the Simmons et al. study. Further study is needed to determine the affect of AE on balance.

LE was found to be of greater benefit than AE in improving patients' self-reported ability to perform functional activities at home. LE may have more applicability to functional tasks used in day-to-day living. For example, chair-stand movements, rising from the floor, and climbing steps were all practised during the LE class, but are difficult to simulate in the water. Practising daily functional tasks on land may result in greater improvements in daily function. A previous study reported that older adults in a 2-week, land-based training programme improved their ability to rise from the floor compared to those who received no training.[44] It is possible that the ability to perform activities in water does not translate into the ability to perform the same activities on land. Considering this, AE might benefit from the addition of a land-based component to facilitate improvements in specific functional activities.

The women in this study were not involved in regular structured exercise programmes at study entry. For many, it was their first experience with group exercise and for some their first experience in water. Despite the possible anxiety and fear related to a new experience, the dropout rate was low and adherence was good for both groups. A variety of perceived positive consequences of exercise such as improved health, socialization, and body awareness might have contributed to the participants' positive ratings of global change. Of note was the significant improvement of ratings of global change in the AE group compared with the NE group. A review of the literature has noted the impact of AE on improving pain, function, and self-efficacy.[21] An individual's expectation of outcome has been found to be one of the most important predictors of exercise behaviour in older women, and had a significant affect on perception of barriers to exercise.[45] Improvement in self-efficacy has also been reported to have an affect on increasing the duration and intensity of exercise performed,[46] and feelings of health improvement following exercise can have a profound affect, lasting as long as 2 years, on behaviour change toward exercise.[47] For some women with OP, involvement in an exercise medium that results in positive feelings of health may be one of the most important influences on continued exercise involvement and, thus, a reduction in fall and fracture risk.

From the reports of adverse effects recorded by the exercise instructors, fewer AE participants experienced joint pain as compared with those in the LE programme. This may be due to decreased ground-reaction forces and the therapeutic affect of water's thermal and sensory input on joint pain. Our results support the use of AE as a promising alternative method of gaining the health benefits of exercise. However, further research is needed before it can be recommended as a viable alternative for improving balance and function.

CONCLUSION

Exercise programmes designed to improve balance and function should target older women with OP in order to reduce the risk of falling and fracture. Because many older adults have joint pain or other age-related medical conditions, land-based group exercise programmes may not be suitable and may exacerbate joint pain or other complications. AE may be an excellent alternative to LE for individuals who lack confidence, have a high risk of falling, or have joint pain that limits their ability to practise centre-of-gravity shifts beyond the limits of their base of support. Further studies of AE and LE for the OP population should evaluate the affect of interventions on the risk factors for falling, and investigate the bone loading that occurs with partial submersion resistance exercise in AE programmes.

KEY MESSAGES

What Is Already Known on This Subject

Although several studies have suggested that exercise programmes designed to improve balance and strength on land can decrease the fall risk in older adults, there is limited evidence for the efficacy of AE. For older women with OP, controversy remains regarding the potential benefits of improved balance, strength, and QOL versus the limitation of decreased gravitational loading with AE.

What This Study Adds

Our study suggests that AE warrants further investigation as a viable alternative to LE for older women with OP to improve balance, function, and QOL. When additional impairments such as joint pain, fear of falling, or decreased balance make exercising on land difficult, AE may provide equal to or possibly greater benefits than LE. Because we failed to find significant differences between LE or AE interventions and an NE control group, conclusions regarding the potential benefits of AE should be interpreted with caution until further studies are completed.

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