

## The Effect of Aquatic Exercise and Education on Lowering Fall Risk in Older Adults With Hip Osteoarthritis

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**Objective:** To evaluate the effect of aquatic exercise and education on fall risk factors in older adults with hip osteoarthritis (OA). **Method:** Seventy-nine adults, 65 years of age or older with hip OA and at least 1 fall risk factor, were randomly assigned to 1 of 3 groups: aquatics and education (AE; aquatic exercise twice a wk with once-a-wk group education), aquatics only (A; 2 wk aquatic exercise) and control (C; usual activity). Balance, falls efficacy, dual-task function, functional performance (chair stands), and walking performance were measured pre- and postintervention or control period. **Results:** There was a significant improvement in fall risk factors (full-factorial MANCOVA, baseline values as covariates;  $p = .038$ ); AE improved in falls efficacy compared with C and in functional performance compared with A and C. **Conclusion:** The combination of aquatic exercise and education was effective in improving fall risk factors in older adults with arthritis.

**Keywords:** hydrotherapy, accidental falls, arthritis, pain, self-efficacy

One out of three adults over the age of 65 years and one out of two over the age of 80 falls annually (American Geriatrics Society, British Geriatrics Society, & American Academy of Orthopaedic Surgeons Panel on Falls Prevention, 2001), accounting for 77% of all injury-related hospital admissions of the elderly (Stokes & Lindsay, 1996). Decreasing fall risk is best achieved through comprehensive strategies including education and exercise; however, the ideal type and combination of these programs are not clear (Chang et al., 2004; Gillespie et al., 2005; Weatherall, 2004).

Older adults with hip osteoarthritis (OA) are at a higher risk of falls because of lower limb weakness, slower gait, decreased mobility, and pain (Leveille et al., 2002; Varela-Burstein & Miller, 2003). Because of greater fear of falls (Varela-Burstein & Miller, 2003), they may also be reluctant or unable to participate in standard fall-prevention programs. Despite limited evidence, aquatic exercise has been promoted as an effective exercise program for individuals with lower extremity OA to decrease pain and improve physical function and self-efficacy (Ahern, Nicholls, Simionato, Clark, & Bond, 1995; Belza, Topolski, Kinne, Patrick, & Ramsey, 2002; Geytenbeek, 2002). However, no studies have compared the effects

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of aquatic exercise alone and aquatic exercise combined with education on fall risk in the OA population. This combination program, with the goal to promote the transfer of knowledge related to exercise performance to enhance confidence in day-to-day tasks, may result in greater gains in physical status related to fall risk and improve falls efficacy.

The purpose of this study was to determine the effect of aquatic exercise and aquatic exercise combined with an education program on fall risk factors in community-dwelling older adults with hip OA. The hypothesis was that a combined aquatics and education program would result in greater improvement in fall risk factors than either an aquatics-only group or a control.

## Methods

### Testing Protocol

Recruitment strategies have been described previously (Arnold & Faulkner, 2007). Informed consent was obtained before testing, and the institution's ethics review board granted approval for the study. Refer to Figure 1 for the flowchart of participants throughout the study. Eighty-four participants met the following eligibility criteria: age 65 years or older, presence of hip pain 6 months or longer, diagnosed with hip OA and presenting with 1 fall risk factor, a timed up-and-go test (TUG; Podsiadlo & Richardson, 1991) score of 10 s or more, or a history of at least one fall in the past 12 months. Eighty-three participants were randomly assigned to one of three groups—aquatics and education (AE), aquatics (A), or control (C)—after stratification based on any previous surgical history for the hips and TUG scores 14 s or longer. Exclusion criteria were any joint surgery within the last 6 months, current participation in a group exercise program incorporating balance training or aquatics twice a week or more, and the presence of any medical or neurological condition that significantly affected independence in mobility. Random assignment was conducted by an individual not involved in the research project using a computer-generated program (Urbaniak & Plous, 2008). Participants were blinded to group assignment until after baseline testing, when they were given a sealed opaque envelope revealing their group assignment.

The fall risk factors measured were classified into five main constructs: balance, walking performance, functional performance, falls efficacy, and dual-task function. There were primary and secondary measures chosen to represent these constructs. The primary measures are reported here; secondary measures did not add any additional information and have been described in a previous publication (Arnold & Faulkner, 2009). Other measures were used to monitor physical activity level and the impact of arthritis pain on daily function. Testing was conducted by two experienced physical therapists blinded to group assignment and a research assistant.

### Fall-Risk Measures

**Balance.** The Berg Balance Scale (Berg, Wood, Williams, & Gayton, 1989) evaluates balance during common daily living tasks, with the modified version (BBSm; Rose, 2003) consisting of the last nine more challenging tasks, which have been considered more appropriate for community-dwelling older adults.

A standard protocol was followed (Berg et al., 1989), with a physical therapist rating ability to perform each functional task on a scale of 1–4 for a maximum score of 36. This scale has excellent inter- and intrarater reliability, is correlated with other functional and balance tests, and has been shown to predict falls in the elderly (Lajoie & Gallagher, 2004).

**Walking Performance.** The 6-min walk is a test used to measure walking speed and endurance. A standard protocol was followed, with the total distance recorded (Rikli & Jones, 2001). This test has high test–retest reliability ( $ICC = .95$ ) and has been correlated with other balance and function measures (Steffen, Hacker, & Mollinger, 2002).

**Functional Performance.** The 30-s chair stand is a reliable and valid measure of lower body strength, endurance, general mobility, and balance (Jones, Rikli, & Beam, 1999) that discriminates between active and inactive older adults (Miotto, Chodzko-Zajko, Reich, & Supler, 1999). The number of complete movements from sitting to standing with arms crossed during 30 s was recorded.

**Falls Efficacy.** The Activities and Balance Confidence (ABC) questionnaire has demonstrated excellent internal consistency (Cronbach's  $\alpha = .96$  and test–retest reliability  $r = .92$ ; Powell & Myers, 1995) and has been found to discriminate higher versus lower functional status (Myers, Fletcher, Myers, & Sherck, 1998). It is a self-report questionnaire that has been used extensively for community-dwelling elderly, asking respondents to rate their confidence in completing 16 common tasks without losing balance.

**Dual-Task Function.** The TUG (Podsiadlo & Richardson, 1991) measures the ability to stand up from a chair, walk 3 m, return, and sit down. Variations of the TUG measure dual-task function or the ability to successfully complete a second task performed simultaneously with the TUG. We used the TUG<sub>cog</sub> (Shumway-Cook, Brauer, & Woollacott, 2000) combining a cognitive subtraction task while performing the standard test, which has been found to negatively affect balance (Shumway-Cook, Woollacott, Kerns, & Baldwin et al., 1997). The protocol for the standard TUG is described elsewhere (Arnold & Faulkner, 2007). For the TUG<sub>cog</sub>, the total time was recorded while the participant performed the standard TUG and counted backward by 2s.

## Secondary Measures

The Arthritis Impact Measurement Scale (AIMS-2) is a self-report questionnaire designed to measure the impact of arthritis on daily function. Reliability and validity of the tool have been documented, and it is recommended as one of the better tools for use in those with arthritis (Swinkels, Dijkstra, & Bouter, 2005). The three-component model (physical, affect, and symptoms) was used. This questionnaire was added to monitor the impact of arthritis pain on daily function, but it is not a known fall risk measure. The Physical Activity Scale for the Elderly (PASE) has been validated and is a reliable tool to measure activity levels in the community-dwelling elderly (Dinger, Oman, Taylor, Vesely, & Able, 2004). It can be used to distinguish between different mobility levels and several environmental factors that may affect level of mobility (Chad et al., 2005).

In addition, height was measured as stretch stature in centimeters, and weight was recorded using a standard scale in kilograms. Body-mass index was calculated as  $\text{kg}/\text{m}^2$ . A medical history and demographic questionnaire was administered to determine history of OA, location of hip pain, type of residence, a list of medications, and a checklist of medical conditions.

## Interventions

**A.** Participants in the A group exercised twice a week for 11 weeks at a community pool with zero entry access and variable depth. Most participants exercised at chest depth. Each exercise session lasted 45 min, and the goals were to improve mobility, strength, and balance. The exercise protocol consisted of warm-up exercises (variations of walking in the water and stretching the upper and lower body), lower and upper extremity strengthening exercises (using floats, noodles, sponges, and paddles for added resistance), trunk-control exercises (abdominal strengthening in floating positions, trunk control in standing positions), posture practice and balance exercises (mobility games, variations in walking and standing balance activities), and cooldown (gentle stretch and breathing). Further information regarding the exercise program can be obtained from the first author. The instructors were experienced aquatic fitness instructors. Both instructors were given a training session and a written manual of program goals and sample exercises. The research coordinator met with them on a weekly basis. In addition, the instructors filled out weekly status reports documenting attendance, any adverse effects reported, progressions made in the program, and any modifications made.

**AE.** Participants in the AE group received the same aquatic exercise program twice a week for 11 weeks, led by the same instructors but held at a different time than A. In addition, participants received a 30-min educational session preceding the aquatic class (once a week) for 11 weeks. The educational session was held in the recreational facility where the pool was located, in a multipurpose room with mats, mirrors, and space to walk for 4 of the 11 sessions and a common meeting space with tables and chairs just outside the pool area for the other 7 sessions. The education sessions were conducted by a physical therapist with 20 years of experience working with elderly adults. The goals of the education session were to increase the transfer of exercises learned in the pool to the ability to successfully perform activities of daily living, increase knowledge of individual fall risk factors and fall-prevention strategies, and improve confidence in the ability to avoid a fall and recover from a fall at home and in the community. Participants in this group received a booklet with information for each education session and had the opportunity to set individual goals regarding exercise and fall-prevention strategies. The delivery and goals of the program were based on self-efficacy theory (Bandura, 1997) and addressed determinants of self-efficacy such as mastery experience, verbal persuasion, and the relationship of physiological and affective states. In 4 of the 11 sessions, participants practiced functional tasks such as sit-to-stand, walking, dual-task walking, and getting up and down from the floor. The purpose of this practice was to reinforce the transition of the exercises in water to improving functional tasks on land and also to increase confidence related to fall risk. This additional practice added approximately

1.5 hr of “physical” practice of balance-related activities to this group’s mastery experience. The rest of the educational content focused on knowledge building, group discussion, sharing goals and solutions, and positive reinforcement from the group leader. This cognitive-behavioral approach was designed to help persuade individuals to change behaviors and adopt positive fall-prevention strategies, to motivate them to participate in exercise, and to increase their understanding that physiological changes associated with exercise such as fatigue or muscle soreness are not signs of failure or dysfunction. Attendance was recorded for both exercise and educational sessions. Further details regarding the education and exercise program can be obtained by contacting the first author.

**C.** The C participants continued with their usual activities and were asked to not begin an exercise program during the control period, which lasted the same length of time, 11 weeks, as the interventions. They were told they would be offered either the A or AE class after 11 weeks. Adherence was encouraged by a phone call from the study coordinator every 2 weeks.

## Research Diaries

All three groups were given a diary to take home to record falls, near falls, any new medications, new conditions, therapy, or illness. The diary was returned at posttesting and reviewed with the participant. The contents of the diaries were not evaluated as outcome measures but were tracked for descriptive purposes and to monitor potential confounding factors.

## Consistency of Program Delivery

In total, three sets of 11-week sessions were run. Independent reviews of the standardization of the program were conducted by three individuals not directly involved in the program. They observed for consistency of delivery, progression of exercise, and type, frequency, and duration of exercise to address goals between the two aquatic sessions, and one observer also evaluated consistency between the instructors. There were no discrepancies observed in delivery of the program.

## Statistical Analyses

**Power Calculation.** The primary balance measure, the BBSm, was used to determine sample-size calculations. When the sample size was 25 per group there was an 80% chance of finding significant difference in the BBSm of 7% (2 points) between groups at the 95% confidence level, given a common standard deviation of 2.2. A 2-point decline in the Berg can result in increased fall risk ranging from 10% to 100% depending where on the scale the baseline score is, which is certainly a clinically relevant change related to fall risk (Shumway-Cook, Baldwin, Pollisar, & Gruber, 1997).

**Data Cleaning.** Data were cleaned by a standard protocol before statistical analyses (Tabachnick & Fidell, 2007). Group means were substituted for missing values, or, when possible, the case mean was used for variables when there were missing data points. Missing data were distributed equally across variables and accounted for less than 5%. Normalcy of the data was evaluated using pairwise

plots for nonlinearity and heteroscedasticity and tests for skewness and kurtosis. For variables that significantly deviated from normalcy, transformations were performed. If the transformation corrected the skewness or kurtosis to less than twice the value of the standard error, the transformation was retained. The following variables were transformed: 6-min walk (reflect sqrt), BBSm (reflect sqrt), and TUG<sub>cog</sub> (log10). Extreme outliers (defined as >3 interquartile ranges from the outer boundaries of the box plot,  $n = 5$ ) were converted to 1 unit above or below the next highest or lowest value in the distribution. This procedure reduced the impact of the outlier on the data distribution while still conserving its placement in the distribution (Tabachnick & Fidell, 2007). Although converted data were used in all analyses, unconverted means are reported to avoid confusion in interpretation. Participants who dropped out of the study were retested at the time they left the study when possible; otherwise, last observation carried forward was used.

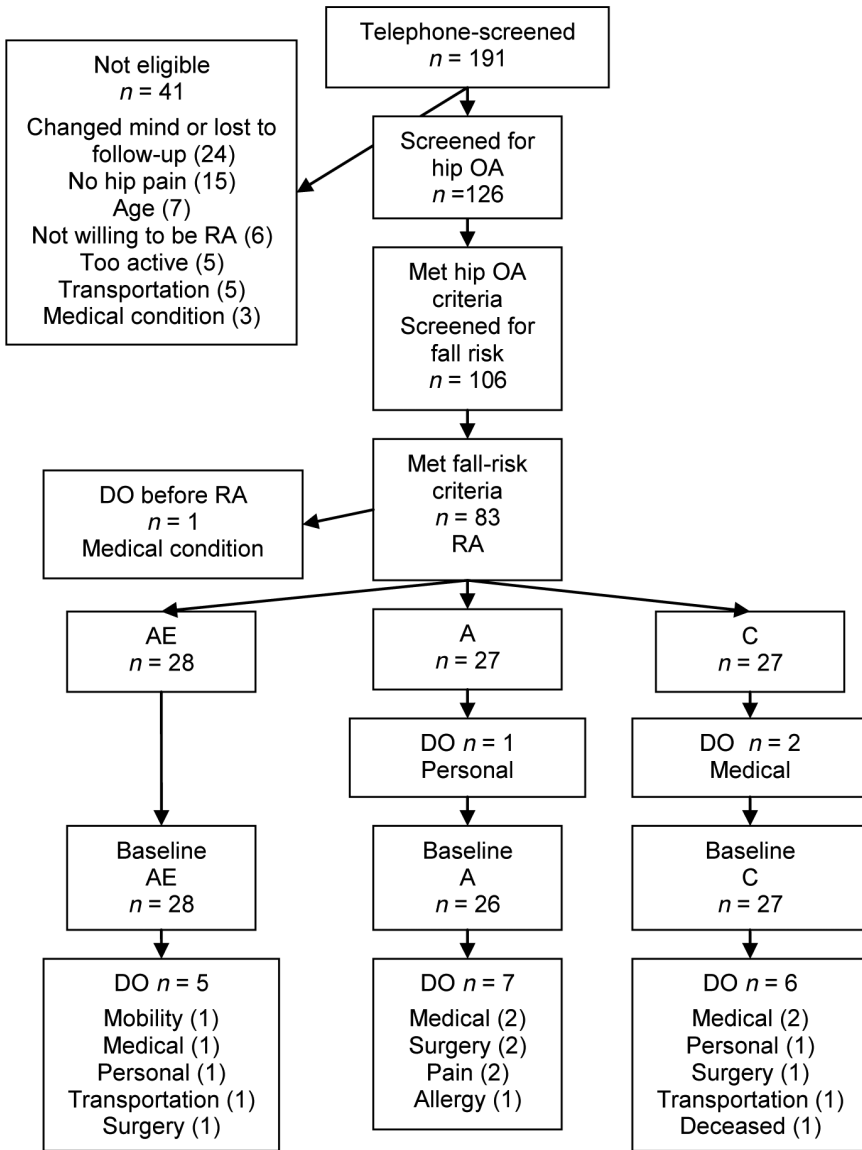
**Inferential Analysis.** Between-groups differences in fall risk variables were examined using a general linear multivariate analysis (MANCOVA) using baseline values as covariates. If the MANCOVA was significant (Roy's largest root), univariate between-groups results were reported and pairwise post hoc analysis was conducted using least significant difference. A more liberal post hoc test was chosen because this study is the first randomized controlled trial in this population; thus we wanted to err on the side of a Type I error. General linear-model univariate analysis of posttest PASE and AIMS-2 scores with pretest scores entered as covariates was used to evaluate any changes in these two potentially confounding factors. One-way ANOVA was used to compare between-groups differences at baseline. A  $p$  value of .05 was used for all tests, and all analyses were conducted using SPSS version 14.0.

## Results

### Participants

Refer to Figure 1 for a flowchart of study participants. Only one moderate adverse effect occurred in A, a fall resulting in spinal pain but no fracture, as a result of slipping on a wet surface while entering the pool. To avoid occurrence of another fall-related incident, the following processes were instigated: A maintenance worker dried the change-room floor as much as possible before and immediately after the aquatic class, and the instructors reinforced to all participants the importance of due care, use of aquatic shoes, and use of handrails when moving from change room to pool. No further falls occurred after these strategies were implemented. Minor adverse effects such as muscle soreness or increased joint pain were reported rarely (four or five times over the three sets of 11 weeks) and resolved quickly.

A demographic profile of the three groups is reported in Table 1. Baseline and posttest values are reported in Table 2. There was no significant difference in physical activity level among the three groups as measured by the PASE at baseline (one-way ANOVA;  $p = .73$ ) or at posttest, using a general linear-model univariate analysis of posttest PASE with pretest scores as covariates ( $p = .37$ ). There was also no significant difference in the impact of arthritis on daily living activities (AIMS-2,



**Figure 1** — Participant flowchart. OA = osteoarthritis; RA = randomly assigned; DO = dropped out; AE = aquatics and education; A = aquatics; C = control.

**Table 1** Baseline Demographic Description for AE, A, and C

Baseline variable	AE, <i>n</i> = 28	A, <i>n</i> = 26	C, <i>n</i> = 25
Frequency data, <i>n</i> (%)			
female	20 (71)	20 (77)	16 (64)
fell in past year	14 (50)	16 (62)	9 (36)
frequent near falls in past year	9 (32)	8 (31)	6 (24)
used a walking aid	10 (36)	9 (35)	14 (56)
previous hip-joint replacement	6 (21)	4 (15)	6 (24)
unilateral hip involvement	18 (64)	16 (62)	14 (56)
Ratio data <i>M</i> ( <i>SD</i> )			
age (years)	73.2 (4.8)	74.4 (7.5)	75.8 (6.2)
number of comorbidities	2.3 (1.2)	1.9 (1.4)	2.2 (1.1)
number of prescription medications	2.9 (2.6)	2.9 (2.5)	3.2 (2.8)
length of hip pain (years)	7.5 (7.8)	8.6 (11.4)	6.6 (6.8)
Body-mass index (kg/m <sup>2</sup> )	29.2 (5.2)	30.4 (4.50)	30.0 (5.7)
PASE score	96.6 (32.7)	106.9 (50.4)	101.4 (47.3)
AIMS-2 score	10.1 (2.4)	10.4 (3.2)	10.8 (3.3)

Note. AE = aquatics and education; A = aquatics only; C = control; PASE = Physical Activity Scale for the Elderly; AIMS-2 = Arthritis Impact Measurement Scale.

three-component model) between the three groups at baseline or at posttest, using a general linear-model univariate analysis of posttest AIMS-2 with pretest scores as covariates ( $p = .19$ ). There were no significant differences in baseline scores between the three groups for the fall risk factors.

There were significant differences between dropouts and completers for fall history, as well as several fall risk factors: 6-min walk, PASE, number of prescription medications, age, BBSm, and TUG; dropouts were older and less active with decreased performance in balance and functional tests. Because of the concern that eliminating dropouts from the analysis might bias the results, intention-to-treat analysis was used with a post hoc analysis of completers only. The mean percentage of class attendance for AE was 74% and for A was 65% (including dropouts), a nonsignificant difference ( $p = .29$ ) using an independent  $t$  test. Attendance increased to 81% and 82% for AE and A, respectively, if dropouts were excluded. Outcomes The MANCOVA for change in fall risk factors for the intention-to-treat analysis was significant,  $F(5, 68) = 2.5, p = .038$ . Subsequent post hoc comparisons showed a significant difference between groups for the ABC, in which AE improved compared with C (12% difference), and in physical performance, in which AE significantly improved in number of chair stands compared with both A and C (a 12% difference, Table 2). Similar trends were noted for TUG<sub>cog</sub> and the 6-min walk, in which AE improved more than both A and C.

In a secondary post hoc analysis of completers only (attended at least 50% of the exercise and education sessions and excluding dropouts,  $n = 23, 19,$  and  $19$  for AE, A, and C, respectively), differences in primary fall risk variables remained significant even with the reduced sample size. Not only did chair stands remain significantly different for AE than for A and C, but also the improvement in the ABC was now significantly greater for AE than for both A and C, with a 15% and 16% difference in change scores, respectively.



**Table 2 Pre- and Posttest Scores, Change in Scores, *M* (*SD*), Effect Sizes, and Results of Post Hoc Univariate Tests for Between-Groups Differences Among AE, A, and C for Primary Outcome Measures, Intention-to-Treat Analysis**

Outcome measure	AE, <i>n</i> = 28	A, <i>n</i> = 26	C, <i>n</i> = 25	Univariate Results			
				<i>F</i> (2, 71)	<i>p</i>	Effect size ( $\eta^2$ )	Observed power
BBSm (/36)				2.2	.121	.06	.43
pre score	30.4 (3.8)	29.3 (5.2)	31.1 (2.7)				
post score	31.4 (3.2)	30.5 (5.1)	30.9 (3.8)				
change	1.0 (3.5)	1.2 (2.3)	0.2 (2.3)				
% change <sup>a</sup>	3.3	4.1	0.6				
6-min walk (m)				2.3	.110	.06	.45
pre score	355.2 (93.9)	357.4 (118.1)	352.3 (111.3)				
post score	398.5 (89.3)	371.9 (136.9)	352.6 (123.5)				
change	43.3 (63.8)	14.5 (70.3)	0.3 (70.7)				
% change <sup>a</sup>	12.2	4.1	0.0				
Chair stands				4.1	.022*	.10	.70
pre score	7.6 (3.0)	6.9 (4.3)	7.5 (3.0)				
post score	9.1 (2.8)	7.5 (3.9)	8.1 (2.6)				
change	1.5 (2.0)	0.6 (1.7)	0.6 (1.7)				
% change <sup>a</sup>	19.7	8.7	8.7				

(continued)

Table 2 (continued)

Outcome measure	AE, n = 28	A, n = 26	C, n = 25	F(2, 71)	p	Univariate Results	
						Effect size (eta <sup>2</sup> )	Observed power
ABC (/100)				3.2	.047*	.08	.60
pre score	69.2 (19.9)	70.4 (21.9)	65.3 (18.1)				
post score	75.0 (15.2)	69.6 (24.4)	62.9 (20.8)				
change	5.8 (12.4)	0.8 (21.1)	2.4 (10.7)				
% change <sup>a</sup>	8.4	1.1	3.7				
TUG <sub>og</sub> (s)				2.6	.084	.07	.50
pre score	14.9 (5.6)	15.8 (9.1)	14.3 (6.7)				
post score	12.6 (3.9)	15.1 (9.5)	14.5 (7.1)				
change	-2.3 (5.1)	-0.7 (3.1)	0.2 (4.3)				
% change <sup>a</sup>	15.4	4.4	-1.3				

Note. AE = aquatics and education; A = aquatics only; C = control; BBSm = Berg Balance Scale modified; ABC = Activities Balance and Confidence Scale; TUG<sub>og</sub> = timed up-and-go test, dual-task cognitive. Primary outcome measures adjusted using pretest values as covariates.

<sup>a</sup>Positive change indicates improvement, negative sign indicates decline.

\* $p < .05$ , where post hoc tests (least significant difference) found AE significantly improved in number of chair stands more than A ( $p = .014$ ) and C ( $p = .023$ ), and AE significantly improved in ABC compared with C ( $p = .015$ ).

## Discussion

This study was unique in combining fall-prevention education with aquatic exercise for older adults with hip OA. Our hypothesis was supported in that the combination of aquatic exercise and education resulted in improvement in functional performance, as well as falls efficacy, suggesting that this type of combined program had an impact on improving both physical and psychological status related to falls. Although not all primary fall risk factors were significantly improved in the AE program, the finding of improvement in falls efficacy and chair stands supports the hypothesis that there were advantages to this type of program delivery. In addition, the similar trends noted for the other outcomes measured warrant further investigation of the benefit of this type of program delivery.

The finding that aquatic exercise on its own was not effective in decreasing fall risk compared with C suggests that short-term aquatic exercise has some limitations in improving functional ability. Although other studies have found improvement in strength, walking distance, and physical function after 6 weeks of aquatic exercise for individuals with lower extremity OA, these gains are not significantly different than with home exercise or other land-based programs (Foley, Halbert, Hewitt, & Crotty, 2003; Green, McKenna, Redfern, & Chamberlain, 1993). In a comprehensive review, Bartels et al. (2007) concluded that there are limited short-term gains from aquatic exercise in function and quality of life, with no evidence of effect on walking ability, pain, or stiffness for both hip and knee OA. Our study indicates that the addition of a 30-min educational session once a week easily administered at the pool site was enough to reinforce transfer of learning to a land environment and result in significant gains in physical function.

The addition of the education program significantly improved falls efficacy compared with C and when just completers were measured. This resulted in a greater improvement in falls efficacy than in A, as well. The educational program used in this study was developed based on self-efficacy theory (Bandura, 1997), which emphasizes that building self-efficacy and diminishing fear of an event (in this case falls) requires a process of education, knowledge building, and building confidence in movements during which falls may occur. Other educational programs based on self-efficacy theory have been used for individuals with arthritis to successfully achieve improved sense of well-being, improved coping skills, diminished pain, and improved perceived function (Marks, 2001). Ours is the first study to examine this in the context of fall prevention for this population.

Results could be linked to three of the determinants of self-efficacy: mastery experience, verbal persuasion, and physiological and affective states (Bandura, 1997). Mastery experience, one of the most influential sources of efficacy information in a group setting, was developed by learning strategies to prevent falls and consistently applying these strategies to day-to-day tasks, which included information sharing, as well as practice sessions. The group facilitator reinforced the purpose and connection of exercise to improvement in daily tasks, providing a source of verbal persuasion, with social persuasion from the other members of the group adding further influence. Combining an educational program with exercise may also provide a connection between physiological and affective states. Individuals with arthritis may interpret physiological responses from exercise such as increased muscle soreness, joint pain, breathing harder, and fatigue as signs of

inefficacy, harm, or failure. If this state further arouses affective responses such as stress, anxiety, or fear, falls efficacy also might diminish. Consistent education and feedback on reasons for arousal states and a supportive environment may help individuals remain motivated to continue with exercise and thus make physical gains in mobility tasks. Of concern was the decline in falls efficacy for C. This reinforces the importance of addressing falls efficacy in this population, in that progressive declines in confidence may occur quite rapidly without intervention. Adherence may also be an important component in realizing gains in fall risk factors for older adults with lower extremity arthritis; the analysis of only completers found an even greater improvement in falls efficacy for the AE group than for either A or C. In a previous study of aquatic exercise for adults with OA (Belza et al., 2002), improvements in physical function were significantly greater in adherers than nonadherers. The addition of the educational component in this study may have helped reinforce adherence. There was greater attendance for AE than for A, if dropouts were also included in the analysis, but similar attendance rates for completers only. Targeted education added to an exercise program may help keep participants engaged, and thus they are more likely to complete the program. Adherence may affect fall-risk improvement with exercise and an education intervention and warrants further investigation with longer follow-up.

An interesting result was that chair stands improved significantly in AE but not in A, even though both groups undertook the same aquatic balance and strengthening activities. It is possible that the improvement in chair stands was a result of the improvement in falls efficacy. Despite findings in previous studies of independent relationships of falls efficacy to function and balance tests (Kressig et al., 2001; Liu-Ambrose et al., 2006), there does not appear to be a direct causal association of falls efficacy's improving actual physical performance. Martin Ginis, Latimer, Brawley, Jung, and Hicks (2006) found that the combination of a weight training and education program improved self-efficacy and perceived performance of eight basic functional activities in older adults compared with a weight-training-only group, but there was no significant difference in actual performance of these tasks. Results from another study found no correlation of an improvement in ABC after a 13-week agility- or resistance-training program to a comprehensive fall risk score, gait speed, or physical activity level in women with osteoporosis (Liu-Ambrose et al., 2006). Another study of aquatic exercise combined with a self-management educational program for women with osteoporosis found an improvement in physical function and quality of life but not falls efficacy (Devereux, Robertson, & Briffa, 2005). However, the authors of that study point out the concern of a ceiling effect for this sample of women with higher levels of self-efficacy. The relationship of falls efficacy to other physical improvements related to fall risk needs to be investigated further in larger prospective studies comparing low- and high-falls-efficacy groups.

A second explanation for the improvement in chair stands for AE is the specificity of practice and learning that occurred in the education program. One of the problems with aquatic exercise is that it is difficult to mimic day-to-day tasks such as sit-to-stand. This may result in limited carryover in the ability to do the task on land even though the aquatic exercise focuses on strengthening muscles used for the functional task. In terms of total "dose" of exercise comparing the two groups, the AE group did have approximately 1.5 hr of additional functional practice of

activities related to fall risk on land compared with A. Because the educational component included both physical practice and group education, it is not clear if one or the other or the combination of both contributed to the improvement in chair stands observed. In previous research by one of the authors, aquatic exercise was shown to not improve day-to-day function, whereas land exercise did, in a population of older women with osteoporosis (Arnold, Busch, Schachter, Harrison, & Olszynski, 2008). If the purpose of the program is to improve functional independence in daily tasks without losing balance, designing exercise to optimize functional specificity is imperative. Others have reported that a functional training program focusing on movement control was more advantageous in improving number of chair stands than a strength-training regimen, although there were gains in both interventions for lower body isometric strength as measured by handheld dynamometry (Krebs, Scarborough, & McGibbon, 2007). Results from meta-analyses indicate that exercise programs to reduce the risk of falls should include functional balance components (daily tasks that challenge balance; Province et al., 1995) and be multidimensional in including education and environmental modifications to address the complexity of fall risk (Chang et al., 2004; Gillespie et al., 2005; Weatherall, 2004).

The sample used in this study consisted of older men and women with a clinical diagnosis of hip OA with at least one fall risk factor. It is possible that participants already identified fall risk as a priority and were ready to accept education and active involvement in a group process; this may have affected the improvement seen in falls efficacy. A second limitation of this study was that the control group continued with physical activity as usual with no social interaction. It is difficult to know whether it was the social context of the education group that improved falls efficacy or the content included in the program. Furthermore, a study designed with the addition of a fourth group that included education only would have helped delineate the impact of the educational program without the addition of exercise and physical practice on decreasing fall risk. In support of an effect beyond socialization, other studies have found no improvement in falls efficacy or other fall risk factors with a sham control group that included social interaction (Li et al., 2005; Liu-Ambrose et al., 2004). Other methodological limitations included one of the researchers' assisting with testing not being blinded, although all primary outcomes were evaluated by blinded evaluators, and a smaller sample size, resulting in diminished power to compare differences in subgroup analyses. Larger sample sizes may have yielded significant differences for these outcomes (BBSm, TUG<sub>cog</sub>, and 6-min walk). Finally, the conclusions from this study are focused on indices of fall risk—the actual decrease in number of falls or fall rates with the intervention is not known.

In conclusion, this study found that aquatic exercise combined with a group educational program can improve falls efficacy and functional performance. Aquatic exercise on its own was not enough to improve these fall risk factors for older adults with hip OA. This could be because of the limited ability to practice daily functional tasks in the water. The addition of an educational program to a community exercise class increases participant time demands, costs of the program, and health-professional involvement. Targeting this type of delivery to older adults at higher risk of falls, such as those with pain and mobility restrictions, may be the best use of resources.

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## References

- Ahern, M., Nicholls, E., Simionato, E., Clark, M., & Bond, M. (1995). Clinical and psychological effects of hydrotherapy in rheumatic diseases. *Clinical Rehabilitation, 9*, 204–212.
- American Geriatrics Society, British Geriatrics Society, & American Academy of Orthopaedic Surgeons Panel on Falls Prevention. (2001). Guideline for the prevention of falls in older persons. *Journal of the American Geriatrics Society, 49*, 664–672.
- Arnold, C.M., Busch, A.J., Schachter, C.L., Harrison, E.L., & Olszynski, W. (2008). A randomized clinical trial of aquatic versus land exercise to reduce fall risk in older women with osteoporosis. *Physiotherapy Canada. Physiotherapie Canada, 60*, 296–307.
- Arnold, C.M., & Faulkner, R.A. (2007). The history of falls and the association of the timed up and go test to falls and near-falls in older adults with hip osteoarthritis. *BMC Geriatrics, 7*, 17–25.
- Arnold, C.M., & Faulkner, R.A. (2009). Does falls-efficacy predict balance performance in older adults with hip osteoarthritis? *Journal of Gerontological Nursing, 35*, 45–52.
- Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York, NY: W.H Freeman.
- Bartels, E.M., Lund, H., Hagen, K.B., Dagfinrud, H., Christensen, R., & Neskiold-Samsøe, B. (2007). Aquatic exercise for the treatment of knee and hip osteoarthritis. *Cochrane Database of Systematic Reviews (Online : Update Software)*, CD005523.
- Belza, B., Topolski, T., Kinne, S., Patrick, D.L., & Ramsey, S.D. (2002). Does adherence make a difference? Results from a community-based aquatic exercise program. *Nursing Research, 51*, 285–291.
- Berg, K., Wood, D.S., Williams, J.I., & Gayton, D. (1989). Measuring balance in the elderly: Preliminary development of an instrument. *Physiotherapy Canada. Physiotherapie Canada, 41*, 304–311.
- Chad, K.E., Reeder, B.A., Harrison, E.L., Ashworth, N.L., Sheppard, S.M., Schultz, S.L., . . . Lawson, J.A. (2005). Profile of physical activity levels in community-dwelling older adults. *Medicine and Science in Sports and Exercise, 37*, 1774–1784.
- Chang, J.T., Morton, S.C., Rubenstein, L.Z., Mojica, W.A., Maglione, M., Suttrop, M.J., . . . Shekelle, P.G. (2004). Interventions for the prevention of falls in older adults: Systematic review and meta-analysis of randomised clinical trials. *British Medical Journal, 328*, 680–683.
- Devereux, K., Robertson, D., & Briffa, N.K. (2005). Effects of a water-based program on women 65 years and over: A randomised controlled trial. *The Australian Journal of Physiotherapy, 51*, 102–108.
- Dinger, M.K., Oman, R.F., Taylor, E.L., Vesely, S.K., & Able, J. (2004). Stability and convergent validity of the Physical Activity Scale for the Elderly (PASE). *Journal of Sports Medicine and Physical Fitness, 44*, 186–192.
- Foley, A., Halbert, J., Hewitt, T., & Crotty, M. (2003). Does hydrotherapy improve strength and physical function in patients with osteoarthritis—A randomised controlled trial comparing a gym based and a hydrotherapy based strengthening programme. *Annals of the Rheumatic Diseases, 62*, 1162–1167.
- Geytenbeek, J. (2002). Evidence for effective hydrotherapy. *Physiotherapy, 88*, 514–529.

- Gillespie, L.D., Gillespie, W.J., Robertson, M.C., Lamb, S.E., Cumming, R.G., & Rowe, B.H. (2005). Interventions for preventing falls in elderly people. *Cochrane Database of Systematic Reviews (Online : Update Software)*, CD000340.
- Green, J., McKenna, F., Redfern, E.J., & Chamberlain, M.A. (1993). Home exercises are as effective as outpatient hydrotherapy for osteoarthritis of the hip. *British Journal of Rheumatology*, *32*, 812–815.
- Jones, C.J., Rikli, R.E., & Beam, W.C. (1999). A 30-s chair-stand test as a measure of lower body strength in community-residing older adults. *Research Quarterly for Exercise and Sport*, *70*, 113–119.
- Krebs, D.E., Scarborough, D.M., & McGibbon, C.A. (2007). Functional vs. strength training in disabled elderly outpatients. *American Journal of Physical Medicine and Rehabilitation*, *86*, 93–103.
- Kressig, R.W., Wolf, S.L., Sattin, R.W., O'Grady, M., Greenspan, A., Curns, A., & Kutner, M. (2001). Associations of demographic, functional, and behavioral characteristics with activity-related fear of falling among older adults transitioning to frailty. *Journal of the American Geriatrics Society*, *49*, 1456–1462.
- Lajoie, Y., & Gallagher, S.P. (2004). Predicting falls within the elderly community: Comparison of postural sway, reaction time, the Berg Balance Scale and the Activities-specific Balance Confidence (ABC) scale for comparing fallers and non-fallers. *Archives of Gerontology and Geriatrics*, *38*, 11–26.
- Leveille, S.G., Bean, J., Bandeen-Roche, K., Jones, R., Hochberg, M., & Guralnik, J.M. (2002). Musculoskeletal pain and risk for falls in older disabled women living in the community. *Journal of the American Geriatrics Society*, *50*, 671–678.
- Li, F., Harmer, P., Fisher, K.J., McAuley, E., Chaumeton, N., Eckstrom, E., & Wilson, N.L. (2005). Tai Chi and fall reductions in older adults: A randomized controlled trial. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences*, *60*, 187–194.
- Liu-Ambrose, T., Khan, K.M., Donaldson, M.G., Eng, J.J., Lord, S.R., & McKay, H.A. (2006). Falls-related self-efficacy is independently associated with balance and mobility in older women with low bone mass. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences*, *61*, 832–838.
- Liu-Ambrose, T., Khan, K.M., Eng, J.J., Janssen, P.A., Lord, S.R., & McKay, H.A. (2004). Resistance and agility training reduce fall risk in women aged 75 to 85 with low bone mass: A 6-month randomized, controlled trial. *Journal of the American Geriatrics Society*, *52*, 657–665.
- Marks, R. (2001). Efficacy theory and its utility in arthritis rehabilitation: Review and recommendations. *Disability and Rehabilitation*, *23*, 271–280.
- Martin Ginis, K.A., Latimer, A.E., Brawley, L.R., Jung, M.E., & Hicks, A.L. (2006). Weight training to activities of daily living: Helping older adults make a connection. *Medicine and Science in Sports and Exercise*, *38*, 116–121.
- Miotto, J.M., Chodzko-Zajko, W.J., Reich, J.L., & Supler, M.M. (1999). Reliability and validity of the Fullerton Functional Fitness Test: An independent replication study. *Journal of Aging and Physical Activity*, *7*(4), 339–353.
- Myers, A.M., Fletcher, P.C., Myers, A.H., & Sherk, W. (1998). Discriminative and evaluative properties of the Activities-specific Balance Confidence (ABC) Scale. *Journals of Gerontology, Series A*, M287–M294.
- Podsiadlo, D., & Richardson, S. (1991). The timed “up & go”: A test of basic functional mobility for frail elderly persons. *Journal of the American Geriatrics Society*, *39*, 142–148.
- Powell, L.E., & Myers, A.M. (1995). The Activities-specific Balance Confidence (ABC) Scale. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences*, *50A*, M28–M34.

- Province, M.A., Hadley, E.C., Hornbrook, M.C., Lipsitz, L.A., Miller, J.P., Mulrow, C.D., . . . Wolf, S.L. (1995). The effects of exercise on falls in elderly patients. A preplanned meta-analysis of the FICSIT Trials. Frailty and Injuries: Cooperative Studies of Intervention Techniques. *Journal of the American Medical Association*, 273, 1341–1347.
- Rikli, R.E., & Jones, C.J. (2001). *Senior fitness test manual*. Champaign, IL: Human Kinetics.
- Rose, D.J. (2003). *Fallproof! A comprehensive balance and mobility training program*. Champaign, IL: Human Kinetics.
- Shumway-Cook, A., Baldwin, M., Pollisar, N., & Gruber, W. (1997). Predicting the probability of falls in community-dwelling older adults. *Physical Therapy*, 77, 812–819.
- Shumway-Cook, A., Brauer, S., & Woollacott, M. (2000). Predicting the probability for falls in community-dwelling older adults using the timed up & go test. *Physical Therapy*, 80, 896–903.
- Shumway-Cook, A., Woollacott, M., Kerns, K.A., & Baldwin, M. (1997). The effects of two types of cognitive tasks on postural stability in older adults with and without a history of falls. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences*, 52, M232–M240.
- Steffen, T.M., Hacker, T.A., & Mollinger, L. (2002). Age- and gender-related test performance in community-dwelling elderly people: Six-minute walk test, Berg Balance Scale, timed up & go test, and gait speeds. *Physical Therapy*, 82, 128–137.
- Stokes, J., & Lindsay, J. (1996). Major causes of death and hospitalization in Canadian seniors. *Chronic Diseases in Canada*, 17, 63–73.
- Swinkels, R.A., Dijkstra, P.U., & Bouter, L.M. (2005). Reliability, validity and responsiveness of instruments to assess disabilities in personal care in patients with rheumatic disorders. A systematic review. *Clinical and Experimental Rheumatology*, 23, 71–79.
- Tabachnick, B., & Fidell, L. (2007). *Using multivariate statistics* (5th ed.) Boston, MA: Pearson Education.
- Urbaniak, G., & Plous, S. (2008). *The research randomizer. Social psychology network*. Retrieved from <http://www.randomizer.org>
- Varela-Burstein, E., & Miller, P.A. (2003). Is chronic pain a risk factor for falls among community dwelling elders? *Topics in Geriatric Rehabilitation*, 19, 145–159.
- Weatherall, M. (2004). Prevention of falls and fall-related fractures in community-dwelling older adults: A meta-analysis of estimates of effectiveness based on recent guidelines. *Internal Medicine Journal*, 34, 102–108.



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