International Journal of Aquatic Research and Education

Volume 10
Number 1 *First IJARE Online Open Access Issue!*

Article 1

12-28-2016

Aquatic Exercise for Better Living on Land: Impact of Shallow-Water Exercise on Older Japanese Women for Performance of Activities of Daily Living (ADL)

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Recommended Citation

Sanders, Mary E.; Islam, Mohammod M.; Naruse, Aiko; Takeshima, Nobuo; and Rogers, Michael E. (2016) "Aquatic Exercise for Better Living on Land: Impact of Shallow-Water Exercise on Older Japanese Women for Performance of Activities of Daily Living (ADL)," *International Journal of Aquatic Research and Education*: Vol. 10 : No. 1 , Article 1.
DOI: https://doi.org/10.25035/ijare.10.01.01
Available at: https://scholarworks.bgsu.edu/ijare/vol10/iss1/1

Abstract

Twenty-six Japanese women (70.5 yr) self-selected water exercise (WEX) (n=13), or control (CON) (n=13) for 12 weeks. WEX was performed 60-minutes/day, 3 days/week with warm-up, cool-down stretch, ADL exercises, and cardiovascular/muscular endurance in 30°C water at a xiphoid level depth. CON continued their current activity/nutrition patterns. Compared to CON, WEX improved ($p<.05$) functional fitness and balance measures including arm curl (22%), chair stand (21%), 8-feet up & go (13%), chair sit/reach (50%), and 12-min walk (15%). No significant changes in sway velocity (SV) or limits of stability (LOS) were seen for either group. This shallow water exercise improved land-based ADL for older women but not balance. ADL tasks associated with balance did improve which may have indicated enhanced motor control.

Keywords: aquatic exercise, activities of daily living (ADL), functional exercise, balance, older adults

Introduction

Regular exercise plays important an important role for maintaining or improving physical fitness and health. The American College of Sports Medicine (ACSM) recommends a combination of activities including cardiorespiratory, resistance, flexibility, and neuromotor exercises that are in addition to activities of daily living (ACSM, 2014, 2011).

The benefits of exercise on health and functional capacity for older adults can help to minimize the development and progression of chronic disease and disabling conditions.(ACSM, 2009). Emerging studies support the benefits of regular exercise for healthy cognitive functioning by older adults (ACSM, 2009). Regular physical activity delays decline and helps to maintain function, resulting in long-term benefits (Booth, 2003). Regular exercise recommendations for older adults include aerobic exercise, muscular strength/endurance, flexibility and neuromotor exercises (American College of Sports Medicine, 2011; U.S. Dept of Health and Human Services, 1996). Neuromotor training or functional fitness training includes a combination of balance, coordination, gait, agility and proprioceptive exercises (ACSM, 2011).

Functional activities or activities of daily living (ADL) can be defined as tasks that a person performs to be mobile and care for his or her daily needs. These activities can include moving up and down from a chair, dressing, bathing, cooking, cleaning, carrying, lifting, yard work, shopping, athletic activities and working (Sanders and Maloney-Hills, 1998). Functional exercise can be defined as those exercises designed to most closely simulate the individual's identified functional activities. The most fundamental principle taught to physical education teachers is *learning is specific to the task* (Grabiner et al., 2014; Takeshima et al., 2007; Sanders & Maloney-Hills, 1998). Functionally targeted exercise should therefore include specific functional patterns such as: push and pull, rise and lower, rotation, locomotion and full movement combinations using these skills (King & Stanforth, 2013).

Aging is associated with dramatic declines in activities of daily living (ADL) and function that can lead to physical impairment, disability and loss of independence (Spirduso, 2005; Forrest et al., 2006; DiPietro, 1996). Several studies have found that physical exercise improves functional fitness in healthy older adults (Lee et al., 2011; Takeshima et al., 2013; Narita et al., 2015; Rogers et al., in press) as well as frail older adults (Takahashi et al., 2011; Takahashi et al., 2012; Takahashi et al., 2014).

Commonly, most older adult exercise programs are conducted on land. Older adults may have chronic or age-related conditions that limit their ability to perform safe and effective exercises on land (Freedman et al., 2002; Lindle et al., 1997; Rantanen et al., 2002). Discomfort from weight-bearing activities, fear of falling, and poor mobility due to orthopedic or musculoskeletal conditions, excess adiposity, and/or other medical conditions, may discourage older adults from adopting a regular exercise program. Exercising in shallow water may help to minimize some of the barriers that prevent older adults from participating, but the question is: Does functional exercise in the pool result in improved ability to perform ADL on land? Further study is needed to identify water exercise programs and *task-specific* exercises that when performed in water will transfer to better ADL mobility on land.

Water exercise, or aquatic exercise, is defined as vertical (upright) training in shallow or deep water to target various aspects of fitness in a reduced impact or non-impact, suspended environment. Pools may vary from large community pools to small therapy pools or flumes, some of which have treadmills and high velocity water jets. Popular programs utilizing the buoyancy and resistance of the water include high intensity interval training, functional fitness, water walking/running, traditional cardio programming (choreographed and non-choreographed options), resistance training with specialized equipment, mind-body programming (yoga, Pilates, Ai Chi), and stretching techniques. It is considered an inclusive exercise option that attracts all ages and ability levels - from de-conditioned to athletes, children to older adults, and group exercise to personal training (Sanders, 2000). The objective of this study is to investigate functional ADL programs conducted as group exercise in shallow-water community pools, without jets or treadmills.

Benefits of water exercise

Water exercise may provide an attractive alternative to land-based exercise for achieving improved health and fitness in older populations. Although swimming is a popular form of water-based exercise, it requires specific skills and requires a baseline intensity level that is too high for many older adults. Upright, water-based exercise has been suggested as perhaps a more viable type of water-based training that would appeal to a wide variety of individuals (Meredith-Jones et al., 2011). Upright water exercise performed in shallow water has become increasingly popular among older adults because water immersion reduces the fear and risk of falling, providing a safe, comfortable and effective alternative to land-based training for improving health and mobility. Participants who are overweight find chest-deep water to be appealing because their bodies are hidden from the view of others during training (Lepore et al., 1998). The dual effects of buoyancy and resistance create an environment that requires moderate to high levels of energy expenditure with minimal strain on lower extremity joints. Water acts as an equalizing medium; its gravity-minimizing nature reduces compressive joint forces, providing a better exercise environment for patients with arthritis, back pain, osteoporosis, or other medical conditions that may restrict training on land.

Water training has resulted in general health improvements. Exercising in water's natural resistance increases the energy cost required to perform certain types of work (Costill, 1971; Evans et al., 1978). During exercise in water, participants were found to elicit significant improvements in cardiorespiratory fitness, muscular strength/endurance body fat and total cholesterol among older women (Bocalini et al., 2008; Campbell et al., 2003; Colado et al., 2009; Devereux et al., 2005; Meredith-Jones et al., 2009, 2011; Nagle et al., 2013; Tauton, et al., 1996; Tsourlou et al., 2006).

A number of studies have measured the functional ADL outcomes of shallow water exercise programs (Table 1). Investigators reported improvements in functional fitness (ADL) including arm curl, chair stand, agility, walking speed and steps taken, coordination, muscular strength/endurance, side stepping, jumping height, balance, postural mobility, upper body and lower body flexibility, general well being and cardiorespiratory endurance (Sanders et al, 2013; Sanders et al, 2009; Suomi & Collier, 2003: Takeshima et al, 2002;Bravo et al, 1997; Simmons & Hansen, 1996). Two studies, with one conducted in Japan, reported no changes in static or dynamic balance after training (Sanders et al, 2007; Hale et al, 2012). Balance training, in particular, requires sufficient stimulus that leads to motor learning where the nervous system undergoes structural and functional changes that are specific to the demands of the task (Grabiner et al., 2014). Water exercise design and conditions of the training, especially water depth, need to be considered.

The purpose of this study was to examine the impact of a shallow water program on ADL of older, sedentary but healthy Japanese women. The proportion of people aged 65 years or older in Japan was 23.1% in 2010 and is projected to be as high as 26.9% in 2015 (Japanese Health and Welfare Statistics Association, 2011). The rapidly growing older adult population in Japan is also associated with an increase number of frail elderly. Many of these older adults live alone and eventually low levels of functional fitness limit them in performing ADL. Thus, focusing on ADL as a fundamental outcome measure of an exercise intervention for older adults is very important (Rosendahl et al., 2006). Research over the past two decades clearly shows that regular physical exercise is effective for maintaining and promoting functional independence in older adults and more information is needed about safe and effective exercise programs that will help older adults maintain independent lives (Nelson et al., 2007).

Author, Year	**Subjects & Sample Size**	**Program Design (community pools)**	**Intensity/Duration**	**Key ADL Fitness Findings**
Simmons & Hansen, 1996	Elderly (80 yrs) healthy adults (n=39) [a] WEX (13) Water Sitters (13) [b] LE (13) Land Sitters (13)	4 Groups Frequency: 2Xwk, 5 wks WEX: Shallow water (32°C/89°F): walk, kick, side steps Water Sitters: Sat in water and talked Land EX: walk, kick, side step Land: Played cards	45 minutes: simple exercises or socializing	Improved fitness (p<.05): WEX increased functional reach every week, LE increased only week 1 5 week change (inches): WEX: 13.4 +/- 1.6 [b] LE: 11.3 +/- 1.5 Water & land sitters: no change
Bravo *et al.*, 1997	Postmenopausal women (50-70 yrs) with bone mineral density (BMD) below fracture threshold (n=77). WEX (77)	Xiphiod depth water exercise only Frequency: 3Xwk, 52 weeks Focus was to train upper body, pelvic girdle	60 minutes: 10 min stretch 40 min jumping + muscular endurance 15-20 repetitions that increased over time 10 min cool down stretch	Improved fitness (p<.001): Sit & Reach (6%) Agility (8%) Arm curl (18%) Cardio endurance (6%) Wellbeing (9%) Spinal BMD decreased , no change in femoral BMD
Suomi & Collier, 2003	Men & women with arthritis (68 yrs), (n=30) WEX (10) LE (10) [c]CON (10)	Aquatic Foundation Aquatic Program (AFAP) and the land-based People With Arthritis Can Exercise (PACE) Includes flexibility, cardio and muscular endurance, mobility Frequency: 2Xwk, 8 wks 1.05m (32°C/89°F)	45 minutes: Easy pace: Range of motion, kick walk, side stepping	Improved fitness both groups (p<.05): Sit & Reach (8.8% WEX, 12% LE) Arm curl (20-21% WEX, 18-21% LE) Balance & agility (12% iLE only) No change in cardioendurance both groups CON: No change
Katsura *et al.*, 2010	Men & women, healthy adults (69 yrs), (n=20) WEX 1: Resistance (12) WEX 2: No resistance (8)	Shallow water (32°C/89°F) 2 WEX groups: Unique leg equipment for added resistance (WEX 1) & no equipment (WEX 2) Frequency: 3Xwk, 8wks General conditioning and walking	90 minutes: 15 min warm-up/stretch 60 min muscular endurance, dance & walking Intensity: Moderately strong	Improved fitness (p<.05): Sit & Reach (12% WEX 1, 19% WEX 2) Agility (12% WEX 1, 7% WEX 2) 5-m Walk (16% WEX 1 only)
Sanders *et al.*, 2013	Sedentary women (73yrs), (n=66) WEX (48) CON (18)	Golden Waves® Program Frequency: 3Xwk, 16 wks Xiphoid depth (1.0m), (29°C, 84°F) Focus was general conditioning and ADL using task specific exercises	45 minutes: 10 min warm–up/cooldown stretch 35 min interval training Intensity: somewhat hard to hard for ADL task specific patterns and general cardio exercises (walk, kick, jump, rock)	Improved fitness (p<.05): Flexibility (8%) Chair stand (31%) Walk speed (16%) Stride length (10% Agility (20%) Stair climb (22%) Arm curl (39%) Static balance (42-48%) No change: Dynamic balance CON: No change

Table 1 Selected shallow-water training studies

[[a] WEX defined as aquatic exercise, shallow water community pool; [b] LE defined as land-based exercise; [c] CON defined as control group]

Method

Participants

In response to a public posting (leaflets and oral) through community associations in Nagoya City, Japan, 26 sedentary but apparently healthy older women volunteered to participate in this study. They were then divided into a water-based exercise group (WEX) (n=13, age 70.8± 4.0yr) or a control group (CON) (n=13, age 70.1± 3.2yr). The CON took part only in the measurements performed before and after the exercise program and spent the rest of the 12-week period without changing their daily physical activity and nutrition patterns.

The ethical committee of the Graduate School of Natural Sciences at Nagoya City University, Japan approved the study. All participants received written and oral instructions for the study and each gave their written informed consent before participation.

Intervention

Water exercise. Shallow water training was based on The Golden Waves® Program (Sanders & Maloney-Hills, 1999) with minor modifications to simulate the ADL of Japanese older adults. The WEX performed training for 12 weeks, 3 times a week, and 60 minutes per session in an indoor swimming pool (25m X 11m) in Kita Ward of Nagoya City. The depth of the water was 0.9-1.0 meter and at approximately the xiphoid-level of the participants. The water temperature was maintained at approximately 30^0C, and the room humidity was maintained at approximately 33%. Training was performed on three different days of the week with at least one day of rest between sessions.

The exercise program consisted of 10 minutes of warm-up and 10 minutes of cool-down stretching exercises on poolside, and 40 minutes of upright water training. During the water training, special attention was given to target basic patterns of movement that simulated ADL. Training exercises varied based on the daily objectives but generally included: movements that simulated ADL (15 minutes), cardiovascular endurance (15 minutes) and muscular performance training (10 minutes) (Photo 1). All progressions began by first having participants demonstrate good posture while stabilizing the body in an upright stationary position using a flat sculling technique with the hands. Aqua Mitt gloves (MIZUNO Corporation, Osaka, Japan) were used to increase the surface area of the hands for enhanced stability and to help “grip” the water during movements.

Photograph 1 – Water exercise group (WEX) using Aqua Mitt gloves to add resistance

Simulated-ADL training included exercises such as single legged stands (useful for donning socks while standing one leg), performing squat jumps (useful for rising from a chair), walking or jogging with changes in speed (agility and dynamic balance) while being interrupted by a command to 'freeze' and stand stationary on one leg (static balance), or falling to one side and then recovering to a standing position. Each of these movements was performed for 30 seconds followed by a rest period of 10 seconds. During this short break, the participants practiced deep breathing under the guidance of the instructor.

During cardiorespiratory exercises, one of the six basic movements that included walking, jogging, rocking, kicking, jumping and scissor-kicking performed. Participants were encouraged to work vigorously (at their own pace) during the work intervals. Each of these movements was performed for continuously for 30 seconds followed by a rest period of 10 seconds, during which participants practiced deep breathing under the guidance of the instructor.

Photograph 2 – Participants were cued to gear up to a "vigorous" pace and then gear down to "easy" for recovery in order to tailor intensity levels to individual perceptions

During muscular performance training, exercises were performed to target major muscle groups. Participants performed leg extension and leg flexion for each leg, bilateral heel raises, bilateral toe raises, half squats (so that the face was not submerged in water), bilateral arm curls while wearing Aqua Mitt gloves, bilateral elbow extensions while wearing Aqua Mitt gloves, bilateral arm spreading (starting with the arms to the front and then abducted through the water to 90 degrees of lateral extension) while wearing Aqua Mitt gloves. Each exercise was performed for 10 repetitions.

The intensity of the cardiorespiratory endurance exercises was set to approximately 13 (somewhat hard) on Borg's Rating of Perceived Exertion scale (Borg, 1982). In order to maintain the intensity over time, participants progressed at their own pace by adding surface area equipment (Aqua Flex paddles by MIZUNO Corporation, Osaka, Japan) and by opening the webbing of the Aqua Mitt gloves. Warm-up and cool-down stretching exercises targeting major joints and their ligaments were performed on poolside before and after each training session. Each exercise session was conducted by a professional instructor and was supervised by the researchers.

Control group. The control group was instructed to continue their daily physical activity and nutrition patterns.

Measurements

Participants were instructed to come to the testing site fully rested (no exercise for 24 hours prior). There were no dietary restrictions. Body height and mass as well as functional fitness were measured before and after the 12-wk exercise intervention. A battery of field tests, having good test-retest reliability and validity, was used to assess the components of functional fitness (Duncan et al., 1990; Rikli and Jones, 1999; Miotto et al., 1999).

Upper-body strength was assessed using the 30-s Arm Curl Test [AC] (Rikli and Jones, 1999) where participants flexed and extended the elbow of the dominant hand, lifting a weight (men: 8-pound [3.6 kg] dumbbell, women: 5-pound [2.3 kg] dumbbell) through the complete range of motion, as many times as possible in 30 sec (score =

number of repetitions). A practice trial of one or two repetitions was given, followed by two test trials with the best performance used for analysis.

Lower-body strength was assessed using the 30-second Chair Stand Test [CS] (Rikli and Jones, 1999) where participants rose to a full standing position from a chair and then returned to a fully-seated position, and continued to complete as many full stands as possible in 30 seconds (score = number of stands). A practice trial of one or two repetitions was given, followed by two test trials with the best performance used for analysis.

Photograph 3 – 30-second chair stand test was conducted pre- and post- program

Upper-body flexibility was assessed using the Back Scratch Test [BS] (Rikli and Jones, 1999) where participants placed the preferred hand behind the same-side shoulder and the other hand behind the back, reaching up in an attempt to touch or overlap the extended middle fingers of both hands. The score was the number of centimeters the middle fingers were short of touching (minus score) or overlapped each other (plus score). A practice trial of one or two times was given, followed by two test trials with the best performance used for analysis.

Lower-body flexibility was assessed using the Chair Sit and Reach Test [SR] (Rikli and Jones, 1999) where participants sat on a chair and then slowly reached forward, sliding the hands down an extended leg in an attempt to touch the toes (without bending the extended knee). The score was the number of centimeters short of reaching the toes (minus score) or reached beyond the toes (plus score). A practice trial of one or two times was given, followed by two test trials with the best performance used for analysis.

Balance and agility were assessed using the 8-foot Up and Go Test [UG] (Rikli and Jones, 1999) and Functional Reach Test [FR] (Duncan et al., 1990). To perform UG, participants stood from a fully-seated position in a chair, walked as quickly as possible around a cone placed 8 feet (2.44 m) ahead of the chair, and returned to a fully seated position on the chair. The test was a timed test and the best performance time of the test trials was recorded in units of 0.1 second. Participants walked through the test one time as a practice and then were given two test trials with the best performance time used for analysis.

For functional reach, the participant stood with feet together and both arms raised in front horizontally and held at the 0 centimeter level of the functional reach scale and then leaned forward, moving the hands forward along the scale as far possible without losing balance (score (cm) = maximal distance the participant could reach forward beyond arms' length). A practice trial of one or two times was given, followed by two test trials with the best performance used for analysis.

Cardio-respiratory fitness was assessed by performing the 12-minute Walk Test [12-MW] which assessed the maximum distance walked in 12 minutes around a 60-meter rectangular course marked into 5-meter segments (Takeshima et al., 1992; Yamauchi et al., 2005). The score was the total number of meters walked in 12 minutes.

Photograph 4 – 12-minute walk test

In addition, a Balance Master Platform System (NeuroCom International, Clackamas, OR, USA) was used to measure static (SB) and dynamic balance (DB). In the present study, postural sway velocity (SV) was measured to assess SB and the limits of stability (LOS) was measured to assess DB. SV was measured while standing on different surface conditions (firm or foam pad) of the Balance Master Platform System with the eyes open or closed. The force platform was marked to maintain consistency in foot placement. Each trial required 10 seconds of data collection. A trial was considered unsuccessful if the participant took a step or was unable to balance for the required time period without aid from a spotter. Composite SV (SVcomp) scores were calculated based on each sway velocity condition as an index of SB.

During the LOS test, eight targets appeared on a computer monitor placed in front of the participant around a center square while conducting the test. The participant's center of pressure (COP) appeared on the monitor as a human-shaped cursor and moved as subjects shifted their weight toward an identified target, holding the position for 5 seconds. Each LOS trial measured endpoint (EPE) and maximum excursion (MXE). The EPE ends when the COP movement first ceases progression toward the target. The EPE is expressed as a percentage of the distance to the target. Hence, a subject whose initial movement ends precisely at the target has an EPE of 100%. When initial attempts are substantially short of the target, most people initiate additional movements after the EPE is recorded. To represent this additional movement and COP excursion, an additional measurement, the MXE, is used. The MXE is the maximum distance the COP is displaced toward the target over the entire duration of the trial (Rogers et al., 2003). The MXE is also expressed as a percentage of the distance to the target. Composite EPE and MXE scores were calculated based on movements toward all eight targets and were used for analysis. All measurements were completed within one week before and after the interventions.

Statistical analyses

Unpaired t-tests were used for the comparison of groups before the exercise intervention. The effects of exercises were studied with repeated measures analysis of variance (ANOVA). In cases where a significant interaction (group × time effects) was detected, we judged those exercises were effective. Effect size (ES) was calculated for each test. Cohen's definition of small, medium, and large ES (ES = 0.2, 0.5, and 0.8 respectively) was used for interpretation (Cohen, 1988). The significance level was set at ($p < .05$).

Results

Pretraining data

No significant differences at baseline were present between WEX and CON for age, height and body mass (Table 2). Among FF variables and Balance Master Platform System variables, no significant differences at baseline were present between WEX and CON for AR, BS, FR, SVcomp and MXEcomp (Table 2) but significantly higher scores were noted at baseline in WEX compared to CON for CS (Table 3) and significantly better performance was noted at baseline in CON than WEX for UG, SR and 12-MW (Table 2).

Table 2 General characteristics of participants at baseline.

	WEX (13)	Control (13)
Age (yr)	70.8±4.0	70.1±3.2
Height (cm)	149.4±3.2	152.1±4.2
Body mass (kg)	58.9±9.5	54.1±7.4
BMI	26.4±4.1	23.5±3.5

Values are means (±SD); WEX = water-based exercise group; BMI = body mass index

Training data

All of the participants continued the water training with an adherence rate of 86.1% without any case of injury. Participants did not suffer any injuries as a result of the training program. Following the 12-wk intervention, significant improvements were noted for AC (22%), CS (21%), UG (13%), SR (50%), and 12-MW (15%) in WEX compared to CON (Table 2). WEX showed increased performance in FR (16%) and BS (54%) but no significant interaction was noted when compared to CON. No significant changes were noted in SV and LOS either in WEX or in CON after the 12-wk period (Table 3).

Table 3 Effects of Water-Based Exercises (WEX) vs. Controls (CON) on Functional Fitness and Balance in Older Japanese Women

	Pre Mean ± SD	Post Mean ± SD	Change	Interaction (group×time)	Effect size
Arm curl (times/30sec)					
WEX **Control**	23.0±3.2 22.5±3.6	28.1±4.5 22.9±4.1	22.5% 2.0%	F (1, 24)= 20.0 P<0.0001	0.455
Chair stand (times/30sec) *					
WEX **Control**	22.2±4.7 20.3±2.7	26.8±6.9 21.7±4.0	20.4% 6.7%	F (1, 24)= 07.4 P=0.012	0.236
Up and Go (sec) #					
WEX **Control**	5.3±1.0 4.8±0.4	4.6±0.9 4.7±0.4	12.6% 1.1%	F (1, 24)= 16.3 P<0.0001	0.404
Back scratch (cm)					
WEX **Control**	-6.0±12.8 0.3±8.0	-3.9±12.8 1.3±7.5	2.2cm 1.0cm	F (1, 24)= 01.2 P=0.293	0.046
Sit and reach (cm) #					
WEX **Control**	12.7±9.8 17.9±3.2	19.0±6.4 19.8±5.4	6.3cm 1.9cm	F (1, 24)= 04.5 P=0.046	0.170
Functional reach (cm)					
WEX **Control**	26.2±4.0 25.6±3.9	30.1±3.8 27.5±3.4	16.3% 8.6%	F (1, 24)= 01.8 P=0.191	0.070
12-min walk distance (m) #					
WEX **Control**	941.2±177.6 1062.7±62.5	1062.5±143.6 1060.9±61.3	14.8% -0.1%	F (1, 24)= 23.3 P<0.0001	0.493
Composite mean of sway velocity [SVcomp (degree/sec)]					
WEX	1.1±0.3	1.0±0.3	1.9%	F (1, 24)= 0.6	0.026

Control	1.0±0.1	0.9±0.1	-7.9%	P=0.444	
Composite mean of endpoint excursion for limits of stability [EPEcomp (%)]					
WEX **Control**	77.6±14.4 81.7±10.4	77.0±15.2 85.2±8.5	1.5% 5.0%	F (1, 24)= 0.6 P=0.442	0.026
Composite mean of maximum excursion for limits of stability [MXEcomp (%)]					
WEX **Control**	92.1±11.1 92.4±7.6	90.1±10.0 94.9±6.2	-0.7% 3.0%	F (1, 24)= 1.1 P=0.306	0.045

Discussion

A number of international initiatives have called for the development of safe and effective evidence-based programs to address functional health and ADL issues related to aging adults (ACSM, 2009, 2011; Japanese Health and Welfare Statistics Association, 2011). Physical activity is linked to successful ADL performance, however many adults choose to be inactive. Water exercise has been shown to provide some positive health benefits, but further investigation is needed to identify specific exercises that effectively improve ADL skills on land. The purpose of this study was to examine ADL and balance outcomes among older Japanese women, participating in a shallow water program. The exercise program was adapted from the Golden Waves®: Functional Water Fitness Program developed in the USA (Sanders et al, 2013; Sanders & Maloney-Hills, 1998, 1999). This program was designed with careful consideration given to the properties of water and their effect on *task-specific* land-based functional ADL training. Some components of the USA program design included:

Buoyancy management. Buoyancy is a force that provides resistance downward and assists movements toward the surface; it affects the degree of lower body impact which varies based on an individual's body density, water depth, and movement speed (Harrison et al., 1987; Becker, 1997; Becker & Cole, 1997).

Application. Changing depths provided a variety of off-loading and gravity-loading challenges depending on the objective of the exercise. Participants were instructed to feel their feet grounded on the bottom of the pool as their base of support during all ADL exercises. Water depths varied from navel to xiphoid level, and to mid thigh/hip depth on some exercises performed on an aquatic step. During the general conditioning for sections targeting cardiovascular training, participants could move to deeper depths (xiphoid or nipple) where buoyancy minimized impact during the more dynamic higher intensity, full body movements.

Drag resistance challenge. Eddies, wakes and drag forces provide water turbulence for overload and body stabilization challenges as the arms and legs move in different planes. This effect is enhanced further as the body travels through the water and as the surface area of the moving limb or body increases (Campbell et al., 2003; Colado and Triplett, 2009; Colado et al., 2009; Pöyhönen , 2002; Skinner and Thompson, 1989).

Application. These properties of water were blended with land-based functional ADL components into an interval training method called the S.W.E.A.T.™ system. Instructors use this system as a blueprint to cue progressive changes in speed (power), surface area, direction of movement (raise and lower, push and pull), range of motion (rotation) and travel (locomotion). ADL exercises were designed to be *task-specific*, using patterns and speeds that trained for better performance on land. Intensity was cued as: vigorous or somewhat hard to hard during work intervals. General cardiovascular training applied the method using full body movements such as jog, kick, jump and scissors. During resistance exercises, participants isolated muscle groups and applied equipment for further overload (Sanders et al, 2013; Sanders & Maloney-Hills, 1998, 1999).

During the current study, the original Golden Waves®USA program was modified to accommodate participant needs and pool facilities in Nagoya, Japan. This study was conducted for 12-weeks (70 minutes) vs. 16 weeks (60 minutes) in the USA. Participants were cued at a somewhat lower intensity by incorporating longer rest periods between segments. This study also did not include the use of the aquatic step that the USA participants used to create very shallow water depth variations, especially during balance training.

ADL - Chair Stand and Arm Curl Performances

Standing up from a chair stand, in particular, is a critical skill for ADL, mobility, and independence. The components of functional exercise included in the chair stand and arm curl include rise/lower and push/pull. Timed measures such as chair stand, arm curl, agility, walking speed, and standing balance have been validated as objective measures of ADL that require muscle power output (Reid & Fielding, 2012). This modified 12-week Golden Waves® Program conducted in Nagoya, Japan was found to be effective for improving arm curl (22%) and chair stand (21%). The arm curl improvements are in accordance with the results from 8 weeks of training (20-21%) during the Aquatic Foundation Aquatic Program (Suomi & Collier, 2003) and higher than the arm curl improvement (18%) reported after 52 weeks of training, 60 minutes/session by Bravo et al. (1997).

Improvements in chair stands were similar to the outcomes collected during a Golden Waves® Program evaluation conducted in Osaka, Japan. During that program women (50-80 yrs) volunteered to participate in the on-going community-based program, self- selecting to attend 1, 2 or 3 days/week, 60 minutes. After 52 weeks, participants in the Osaka program (n=35) also improved chair stand (22%) (Sanders et al., 2009). In comparison, after 16 weeks of training, the USA Golden Waves® group improved to a greater extent for both arm curl (31%) and chair stands (30%). All of the programs resulted in arm curl and chair stand improvements, with programs varying in length from 8 weeks to 52 weeks, and session times ranging from 45–70 minutes in length. Programs that incorporated equipment and higher intensity training appear to have yielded greater gains. Equipment was available to increase overload in all programs except Bravo et al. (1997).

Land-based exercise. Outcomes of land- and water-based training studies were somewhat similar, except that training time on land appears to be shorter. Takeshima et al. (2013) found a 23% improvement for arm curl and a 21% improvement for chair stand after 12 weeks of an elastic band-based resistance exercise program performed on land for 30 minutes/day, 2 days a week. Yamauchi et al. (2005) reported an 18% improvement in arm curl with only a 6% in chair stand after a home-based exercise program performed for 26 minutes/day, 3 days/week for 12 weeks. Machine-based resistance exercise training performed for 60 minutes/day on two days a week for 12 weeks, where the intensity was higher than that of the current water exercise study, resulted in improvements in arm curl (31%) and chair stand (33%) (Takeshima et al., 2007). These land-based training results are similar to those reported by the current water exercise study and a number of studies previously discussed. Although the water-based training may take more time, it is encouraging to show that older adults can improve critical ADL skills such as arm curl and chair stand even if they are unable to perform resistance training on land or have limited access to resistance exercise equipment. Future studies should compare the dose-response relationship for muscle strengthening during water-based exercise programs

ADL – Agility Performance

Agility incorporates a combination of skills and abilities including muscular power, dynamic balance, body transfer. The task combines functional components of rise and lower, rotation, push, and locomotion (King & Stanforth, 2013). Information must be derived from the visual, vestibular and somatosenory systems, especially using the feet as the base of support. In addition, the movement requires the muscular and nervous systems to be trained in order to respond to the demands of the complex task (Grabiner, et al., 2014).

For most of these studies, the 8-foot up-and go assessment was used to measure agility. Suomi & Collier (2003) reported no improvements in the water exercise group, while the land exercisers improved 10%. However, when Bergamin et al. (2013), compared land and water exercisers (n=17 in each group), who exercised for 24 weeks, 2 days/week, for 60 minutes, they found significant improvements for both the land participants (13%) and mid-sternum depth water exercisers (19%). No equipment was added during either the land or water exercise programs. This result was similar to those reported by Tsourlous et al. (2006), who conducted a randomized 24-week shallow water program by older women (n=22), exercising 3 days/week, 60 minutes/day for 60 minutes. They found that the water exercise group improved agility by 20%. In the current study, agility improved by 13% in the water exercise group, which was similar to the study by Katsura et al. (2010) where participants (n=20) exercised in shallow water for 90 minutes, 3 days/week, with 12 participants assigned to use overload equipment resulted in a 12% improvement. Takeshima et al. (2002) also reported a 22% improvement in side stepping agility after training. These results were similar to the agility improvements resulting from the similar 16-week USA Golden Waves® program (20%) conducted at a higher intensity and for a longer duration (Sanders et al., 2013).

Water depth variations due to exercises conducted on the aquatic step and the higher intensity intervals used during the USA study may have increased the challenge during the 8-foot up and go timed task, resulting in somewhat higher scores. In addition, the body weight difference of 12.2 kg between the Japanese participants vs the USA participants (58.9kg Japanese vs. 71.1kg USA), may have had an effect on the extent of weight bearing, with the heavier forces providing a greater training stimulus, more specific to land-based task performance.

Land based exercise. A land-based home program performed for 26 minutes/day, 3 days per week for 12 weeks, show similar improvements in agility of 14% (Yamauchi et al., 2005) compared to the current water-based study. Again, water shows promise for a safe and effective modality to improve a complex task requiring dynamic balance and power.

ADL - Walking Speed Performance

Walking speed is as effective at predicating lifespan as blood pressure and body weight and better than traditional medicine at predicting declines in mobility and independence (Abellan van kan et al., 2009; Schrack, et al., 2010). Functional components include: locomotion, lower body push, and rotation (to change directions).

During the current study, water exercise participants improved performance during the 12–minute walk test by 15%, which was similar to the 16% improvement reported after the USA program (Sanders et al., 2013). Similarly, Katsura et al (2010) reported improvements in the 5-m walking speed test (16%). These improvements are impressive because for every 0.1 m/second improvement in walking speed, the chances of dying in the next 10 years drop by 12% (Abellan van kan et al., 2009; Schrack, et al, 2010). Shallow water walking may play an important and safe role in increasing land-walking speed for better health.

ADL – Flexibility using Back Scratch and Sit and Reach Performances

During this study, lower body flexibility as measured by the sit-and-reach test improved by 16% while upper body range of motion as measured by the back scratch test improved 54%, but not significantly when compared to the control group. Other shallow water studies that measured lower body flexibility using the sit-and- reach assessment reported post-training improvements ranging from 8-12% (Sanders et al., 2013: Katsura et al., 2010; Bento et al., 2012; Tsourlou et al., 2006). These improvements are encouraging, especially for flexibility gains in the lower body, important for tying shoes, but further investigation is needed to identify effective exercise designs that improve both lower and upper body range of motion. In addition, it should be kept in mind that age-related changes in flexibility are reported to have large individual variation (Campanelli, 1996).

Balance: Dynamic and Static Performances

The mechanisms underlying the relationships between exercise and health are reasonably clear except for those between exercise and fall prevention. Increased muscle strength/power and improved balance may contribute to step recovery to avoid a fall after a stumble, but more investigation is needed. Task-specific perturbation may appear to be a superior approach to fall prevention (Grabiner et al., 2014). Shallow water offers unique training opportunities for providing support during perturbation exercises, but little is known about effective task-specific exercises, given the off-loading effects of buoyancy and the resistance to movement that slows reaction time during stepping.

In the current study, dynamic balance was trained by including fall/recovery exercises while static balance was challenged during stationary “freeze” holds, as the water turbulence pushed and pulled against the body. Results from showed no significant change in dynamic balance after 12 weeks of water training. Dynamic balance also did not improve during a similar program conducted in the USA (measured during a staggered walking pattern) nor in the same program conducted in Osaka, Japan after 36 weeks of training (Sanders et al., 2013; Sanders et al., 2007).

In contrast, Devereaux et al. (2005) randomized 50 women (73 years) into shallow water exercise or control groups. All were diagnosed with osteopenia or osteoporosis. After 10 weeks (2 days/week, 60 minutes) of shallow water training that included walking with long strides, challenges that simulate fall recovery and stepping from a stumble, lower body strengthening and tai chi exercises that were transferred to water, investigators reported significant improvement in the step test for dynamic balance. Simmons & Hansen, (1996) investigated the effect of 5 weeks (2 days/week) of shallow water exercise that included posture errors and correction, in a group of 39, healthy older adults (80 years). They found significant gains in postural mobility, measured by functional reach, for the water exercise group that continued to improve over the 5-week period.

Static balance measured as sway velocity in the current study did not improve. One explanation for the lack of improvement for static and dynamic balance parameters could be that the current water training program failed to provide adequate stimulus to improve balance due to program time or intensity of the exercises achieved at the available water depth. In contrast, during the similar 16-week, USA Golden Waves® program, participants improved static balance, measured as a 30 second single legged stand, (42% right leg, 48% left leg). One main difference in this program was the frequent use of aquatic steps, which allowed participants to minimize the effects of buoyancy by working at mid-thigh to hip depth (Sanders et al, 2013). Another difference was in the height and weight of participants. Both programs were conducted in water 1 meter deep, however, USA participants were 13 cm taller than the Japanese participants (149cm vs 162cm). The USA participants were approximately 62% submerged while the Japanese women were 67% immersed (5%) difference. Estimating the body load supported by the feet, the USA women supported 38% of their weight while the Japanese participants experienced 33% of their land-based weight (Becker & Cole, 1997). When the USA participants were working on the aquatic step, they supported roughly 40-60% of their land based weight. As previously mentioned, the USA group was 12.2kg (27 lbs) heavier than the Japanese women. When compared to the Japanese program, although the USA classes were shorter in duration by 15 minutes, the participants exercised 4 weeks longer and were cued to work at higher intensities (i.e., rated somewhat hard to hard). Considered together, these differences may have had an impact on outcomes which could depend on water turbulence to create balance challenges, coupled with a specific load or grounding threshold using the feet as the base of support to stimulate static balance improvement.

Understanding effective exercise for balance and fall reduction under any condition is challenging due to a number of variables. The effects of varying water depths and exercise program frequency, time, duration and intensity vary widely and are not clearly defined. Further study is needed to design water training programs that effectively challenge the control systems involved with balance so that that they can improve balance and reduce fall risk in older adults (Rogers et al., 2003).

Conclusions

This shallow water program based on the USA Golden Waves®: Functional Water Fitness Program, performed for 12 weeks, 60 minutes/day, three times per week by older Japanese women showed that among the water exercise group some land-based ADL measures (for arm curl, chair stand, agility, 8-feet up & go, chair sit/reach, and the 12-min walk) improved. Although the program did not result in improved dynamic or static balance as measured in the lab, the ADL tasks that are associated with dynamic balance and locomotor skills did improve which may indicate that some underlying changes in motor control may have occurred that could eventually lead to better quality of movement.

References

Abellan van Kan, G., Rolland, Y., Andrieu, S., Bauer, J., Beauchet, O., Bonnefoy, M., … Vellas, B. (2009). Gait speed at usual pace as a predictor of adverse outcomes in community-dwelling older people an International Academy on Nutrition and Aging (IANA) Task Force. *The Journal of Nutrition Health and Aging, 13,* 881-889.

American College of Sports Medicine. (2009). Exercise and physical activity for older adults- Position stand. *Medicine and Science in Sports and Exercise, 41,* 1510-1530.

American College of Sports Medicine. (2011). Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: Guidance for prescribing exercise. *Medicine and Science in Sports and Exercise, 43,* 1334-1359.

American College of Sports Medicine (2014*). Guidelines for Exercise Testing and Prescription* (9th ed.), Baltimore, MD: Lippincott, Williams & Wilkens.

Becker, B.E. (1997). Aquatic physics. In: R. Ruoti, P. Morris & A. Cole (Eds.). *Aquatic Rehabilitation*. Philadelphia: Lippincott (pp.15-23).

Becker, B.E. & Cole, A.J. (1997). Comprehensive Aquatic Therapy. Butterworth-Heinemann, Boston, MA.

Bento, P.C., Lopes, M.F., Cebolla, E.C., Wolf, R., & Rodacki, A. (2015). The Effects of a Water-based Training on Static and Dynamic Balance of Older Women. *Rejuvenation Research,* [Epub ahead of print]

Bergamin, M., Ermolao, A., Tolomio, S., Berton, L., Sergi, G., & Zaccaria, M. (2013). Water- versus land-based exercise in elderly subjects: Effects on physical performance and body composition. *Clinical Interventions in Aging, 8,* 1109-1117.]]

Bocalini, D.S., Serra, A., Murad, N., & Levy, R.F. (2008). Water-versus land-based exercise effects on physical fitness in older women. *Geriatrics and Gerontology International, 8,* 265-271.

Booth, F.W. (2003). Exercise: Hot topics. Philadelphia, PA: Hanley & Belfus.

Borg, G.A.V. (1982). Psychophysical bases of perceived exertion. *Medicine and Science in Sports and Exercise, 14,* 377-381.

Bravo, G., Gauthier, P., Roy, P.M., Payette, H., & Gaulin, P. (1997). A weight-bearing, water-based exercise program for osteopenic women: its impact on bone, functional fitness, and well-being. *Archives of Physical Medicine and Rehabilitation, 78,* 1375-1380.

Campbell, J.A., D'Acquisto, L.J., D'Acquisto, D.M., & Cline, M.G. (2003). Metabolic and cardiovascular response to shallow water exercise in young and older women. *Medicine and Science in Sports and Exercise, 35*, 675-681.

Campanelli, L.C. (1996). Mobility changes in older adults: Implications for practitioners. *Journal of Aging and Physical Activity, 4*, 105-118.

Cohen, J. (1988). Statistical power analysis for the behavioral sciences (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum.

Colado, J.C., Triplett, N.T., Tella, V., Saucedo, P., & Abellán, J. (2009). Effects of aquatic resistance training on health and fitness in postmenopausal women. *European Journal of Applied Physiology, 106*, 113-122.

Colado, J.C., & Triplett, N.T. (2009). Monitoring the intensity of aquatic resistance exercises with devices that increase the drag force: An update. *Journal of Strength & Conditioning Research 31*, 94-99.

Costill, D.L. (1971). Energy requirements during exercise in the water. *The Journal of Sports Medicine and Physical Fitness, 11*, 87-92.

Devereux, K., Robertson, D., & Briffa, N.K. (2005). Effects of a water-based program on women 65 years and over: a randomized controlled trial. *Australian Journal of Physiotherapy, 51*, 102-108.

DiPietro, L. (1996). The epidemiology of physical activity and physical function in older people. *Medicine & Science in Sports & Exercise, 28*(5), 596-600.

Duncan, P.W., Chandler, J., & Studenski, S. (1990). Functional reach: A new clinical measure of balance. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 45*, M192-M197.

Evans, B.W., Cureton, K.J., & Purvis, J.W. (1978). Metabolic and circulatory responses to walking and jogging in water. *Research Quarterly for Exercise and Sport, 49*, 442-449.

Forrest, K.Y., Zmuda, J.M., & Cauley, J.A. (2006). Correlates of decline in lower extremity performance in older women: A 10-year follow-up study. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, *61*, 1194-1200.

Freedman, V.A., Martin, L.G., & Schoeni, R.F. (2002). Recent trends in disability and functioning among older adults in the United States: A systematic review. *The Journal of the American Medical Association, 288*, 3137-3146.

Grabiner, M.D., Crenshaw, J.R., Hurt, C.P., Rosenblatt, N.J. & Troy, K.L. (2014). *Exercise-based fall prevention: can you be a bit more specific? Exercise and Sport Sciences Reviews*, *42*, 161-168.

Hale, L.A., Waters, D., & Herbison, P. (2012). A randomized controlled trial to investigate the effects of water-based exercise to improve falls risk and physical function in older adults with lower-extremity osteoarthritis. *Archives of Physical Medicine and Rehabilitation*, *93*, 27-34.

Harrison, R.A., Hillman, M., & Bulstrode, S. (1992). Loading of the lower limb while walking partially immersed: Implications for clinical practice. *Physiotherapy, 78,* 164-166.

Japanese Health and Welfare Statistics Association (2011/2012). Population Trend in Japan (Kokumin- Eisei-no-Doko). Tokyo: *Health and Welfare Statistics Association; 2011* (in Japanese). Retrieved from http://www.mhlw.go.jp/stf/shingi/2r9852000001zz5s-att/2r9852000001zz79.pdf#search='Kokumin+EiseinoDoko+2011%2F2012'

Katsura, Y., Yoshikawa, T., Ueda, S.Y., Usui, T., Sotobayashi, D., Nakao, H. … Fujimoto, S. (2010). Effects of aquatic exercise training using water-resistance equipment in elderly. *European Journal of Applied Physiology, 108,* 957-964.

King, M. & Stanforth, D. (2013). 10,000 Workouts in 10 minutes. *ACSM's Health & Fitness Journal*, *17*(1), 8-14.

Lee, S., Islam, M.M., Rogers, M.E., Kusunoki, M., Okada, A., & Takeshima, N. (2011). Effects of hydraulic resistance exercise on peak torque, velocity, and power in untrained healthy older adults. *Journal of Strength and Conditioning Research, 25,* 1089-1097.

Lepore, M., Gayle, G.W., & Stevens, S.F. (1998). Adapted Aquatics Programming: A Professional Guide. Champaign, IL: Human Kinetics (pp.12–16).

Lindle, R.S., Metter, E.J., Lynch, N.A., Fleg, J.L., Fozard, J.L., Tobin, J., … Hurley, B.F. (1997). Age and gender comparisons of muscle strength in 654 women and men aged 20-93 yr. *The Journal of Applied Physiology, 83,* 1581-1587.

Meredith-Jones, K., Jones, L.M., & Legge, M. (2009). Circuit-based deep water running improves cardiovascular fitness, strength and abdominal obesity in older, overweight women. *Medicine and Sport, 13,* 5-12.

Meredith-Jones, K., Waters, D., Legge, M., & Jonese, L. (2011). Upright water-based exercise to improve cardiovascular and metabolic health: A qualitative review. *Complementary Therapies in Medicine, 19,* 93-103.

Miotto, J.M., Chodzko-Zajko, W.J., Reich, W.J., & Supler, M.M. (1999). Reliability and validity of the Fullerton Functional Fitness Test: An independent replication study. *Journal of Aging and Physical Activity, 7,* 339-353.

Nagle, E.F., Sanders, M.E., Shafer, A., Gibbs, B.B., Nagle, J.A., Deldin, A.R., … Robertson, R.J. (2013). Energy expenditure, cardiorespiratory and perceptual responses to shallow water aquatic exercise in young adult women. *The Physician and Sports Medicine, 41,* 67-76.

Narita M., Islam, M.M., Rogers, M.E., Koizumi, D., & Takeshima, N. (2015). Effects of customized balance exercises on older women whose balance ability has deteriorated with age. *Journal of Women & Aging, 00,* 1–14. DOI: 10.1080/08952841.2014.933633.

Nelson, M.E., Rejeski, W.J., Blair, S.N., Duncan, P.W., Judge, J.O., King, A.C. … Castaneda-Sceppa, C. (2007). Physical activity and public health in older adults: Recommendation from the American College of Sports Medicine and the American Heart Association. *Medicine and Science in Sports and Exercise, 39,* 1435-1445.

Pöyhönen, T., Sipilä, S., Keskinen, K.L., Hautala, A., Savolainen, J., & Mälkiä, E. (2002). Effects of aquatic resistance training on neuromuscular performance in healthy women. *Medicine and Science in Sports and Exercise, 34,* 2103-2109.

Rantanen, T., Avlund, K., Suominen, H., Schroll, M., Frandin, K., & Pertti, E. (2002). Muscle strength as a predictor of onset of ADL dependence in people aged 75 years. *Aging Clinical and Experimental Research, 14 Suppl.,* 10-15.

Reid, K.F., & Fielding, R. (2012). Skeletal muscle power: A critical determinant of physical functioning in older adults. *Exercise and Sports Sciences Review*, 40, 4-12.

Rikli, R., & Jones, C.J. (1999). Development and validation of a functional fitness test for community-residing older adults. *Journal of Aging and Physical Activity, 7,* 129-161.

Rogers M.E., Rogers, N.L., Fujita, E., Islam, M.M., & Takeshima, N. (in press). Muscle strength and size gains in older women after four and eight weeks of high-intensity resistance training. *International Journal of Physical Education and Applied Exercise Science.*

Rogers, M.E., Rogers, N.L., Takeshima, N., & Islam, M.M. (2003). Methods to assess and improve the physical parameters associated with fall risk in older adults. *Preventive Medicine, 36,* 255–264.

Rosendahl, E., Lindelöf, N., Littbrand, H., Yifter-Lindgren, E., Lundin-Olsson, L., Håglin, L., … Nyberg, L. (2006). High-intensity functional exercise program and protein-enriched energy supplement for older persons dependent in activities of daily living: A randomised controlled trial. *Australian Journal of Physiotherapy, 52,* 105–113.

Sanders, M.E. (Ed). (2000). *YMCA's Water Fitness for Health*. Human Kinetics: Champaign, IL.

Sanders, M.E., Constantino, N.L., Hsieh, J.J., & Rogers, M.E. (2007) Water-based exercise: Transfer of benefits to land for older women in the USA and Japan [Abstract 2302]. *Medicine and Science in Sports and Exercise, 39(5), Supplement*.

Sanders, M.E., Constantino, N.L., Hsieh, J.J., & Rogers, N. (2009). Water-based exercise: Balance benefits to land for older women in the USA and Japan [Abstract 2495]. *Medicine and Science in Sports and Exercise*, 41(5), *Supplement*.

Sanders, M.E., & Maloney- Hills, C. (1998). Aquatic exercise for better living on land. *ACSM's Health & Fitness Journal, 2(3),* 16-23.

DOI: https://doi.org/10.25035/ijare.10.01.01

Sanders, M.,E.. & Maloney-Hills, C. (1999). The Golden Waves Functional Water Training for Health Program and The Golden Waves, Functional Water Training for Health, Leadership Program videos. Sanford Center for Aging: University of Nevada, Reno and WaterFit, Reno, Nevada. (available at www.HumanKinetics.com/Continuing-Education)

Sanders, M.E., Takeshima, N., Rogers, M.E., Colado, J.C., & Borreani, S. (2013). Impact of the S.W.E.A.T. water-exercise method on activities of daily living for older women. *Journal of Sports Science and Medicine, 12,* 707-715.

Schrack, J.A., Simonsick, E.M., & Ferrucci, L. (2010). The energetic pathway to mobility loss: an emerging new framework for longitudinal studies on aging. *Journal of the American Geriatrics Society, 58 Suppl2,* S329-S336. DOI: 10.1111/j.1532-5415.2010.02913.x.

Simmons, V., & Hansen, P.D. (1996). Effectiveness of water exercise on postural mobility in the well elderly: an experimental study on balance enhancement. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 51,* M233-M238.

Skinner, A.R., & A.M. Thompson (1989). Duffield's Exercise in Water, 3rd edition. Philadelphia: Bailliere Tindall (pp.4-46).

Spirduso, W.W. (2005). *Physical Dimensions of Aging*. Human Kinetics: Champaign, IL.

Suomi, R. & Collier, D. (2003). Effects of arthritis exercise programs on functional fitness and perceived activities of daily living measures in older adults with arthritis. *Archives of Physical Medicine and Rehabilitation, 84,* 1589-1594.

Takahashi, T., Koizumi, D., Islam, M.M., Watanabe, M., Narita, M., & Takeshima, N. (2011). Effects of passive exercise machine based training on day care service user frail elderly. *Rigakuryoho Kagaku (Physical Therapy Science), 26,* 209-213 (in Japanese).

Takahashi, T., Islam, M.M., Koizumi, D., Narita, M., & Takeshima, N. (2012). The effects of low intensity exercises performed by community-dwelling chronic stroke patients on passive movement-type machines. *Rigakuryoho Kagaku (Physical Therapy Science), 27,* 545-551 (in Japanese).

Takahashi, T., Islam, M.M., Moriwaki, R., Inoue, T., Narita, M., & Takeshima, N. (2014). Benefits of passive exercise machine-based training for elderly female nursing home residents. *Rigakuryoho Kagaku (Physical Therapy Science), 29,* 927–931 (in Japanese).

Takeshima, N., Tanaka, K., Kobayashi, F., Sumi, K., Watanabe, T., & Kato, T. (1992). Validity of the maximal aerobic capacity estimated from submaximal cycling exercise and field performance tests in the elderly. *Japanese Journal of Physical Fitness and Sports Medicine, 41,* 295-303.

Takeshima, N., Rogers, M.E., Wantanebe, E., Brechue, W.F., Okada, A., Yamada, T., … Hayano, J. (2002). Water-based exercise improves health-related aspects of fitness in older women. *Medicine and Science in Sports and Exercise, 33,* 544-551.

Takeshima N., Rogers, N.L., Rogers, M.E., Islam, M.M., Koizumi, D., Nasu, E., & Lee, S. (2007). Functional fitness gain varies in older adults depending on exercise mode. *Medicine and Science in Sports and Exercise, 39,* 2036-2043.

Takeshima N., Islam, M.M., Rogers, M.E., Rogers, N.L., Sengoku, N., Koizumi, D., … Naruse, A. (2013). Effects of Nordic walking compared to conventional walking and band-based resistance exercise on fitness in older adults. *Journal of Sports Science and Medicine, 12,* 422-430.

Taunton, J.E., Rhodes, E.D., Wolski, L.A., Donelly, M., Warren, J., Elliot, J., … Lauridsen, B. (1996). Effect of land-based and water-based fitness programs on the cardiovascular fitness, strength and flexibility of women aged 65-75 years. *Gerontology, 42,* 204-210.

Tsourlou, T., Benik, A., Dipla, K., Zafeiridis, A., & Kellis, S. (2006). The effects of a twenty-four week aquatic training program on muscular strength performance in healthy elderly women. *Journal of Strength and Conditioning Research, 20,* 811-818.

Yamauchi, T., Islam, M.M., Koizumi, D., Rogers, M.E., Rogers, N.L., & Takeshima, N. (2005). Effect of Home-based Well Rounded Exercise in Community-dwelling Older Adults. *Journal of Sports Science and Medicine, 4,* 563-571.

U.S. Department of Health and Human Services. (1996). Physical Activity and Health: A Report of the Surgeon General. Atlanta, GA: *Center for Disease Control and Prevention.* National Center for Chronic Disease Prevention and Health Promotion, S/N 017-023-00196-5.