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A Systematic Review of Aquatic Exercise Programs on Balance Measures in Older Adults

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A SYSTEMATIC REVIEW OF AQUATIC EXERCISE PROGRAMS ON BALANCE MEASURES IN OLDER ADULTS

By

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Introduction

There are a variety of studies performed using aquatic exercise programs to evaluate balance measures using a case-control or pretest-posttest method on healthy young populations (Geytenbeek, 2002). Balance can be defined as either static; maintenance of an upright posture and stance or dynamic; posture adaption and maintenance control of movements and stability (Rose & Clark, 2000). An aquatic exercise program will henceforth be defined as any acute or chronic exercises performed in water with the head vertically and out of the water with the main goal to increase physical activity in a low risk environment. There is minimal data that includes observations on how these aquatic exercise programs affect the measurement of balance in an older population (40 years and older). Balance is an important part of movement during activities of daily living (ADL) for any individual, but especially with an older population who have an increased risk of falling (Arnold & Faulkner, 2010).

Physical activity in an aquatic environment can help with strength, endurance, and balance (Geytenbeek, 2002). Theoretically, aquatic exercise has a low risk for acute injury and can assist an older population with ADLs without the addition of fear from falling or enduring injuries (Devereux, Robertson, & Briffa, 2005). As people age there can be an increase in physical impairment, which includes a decrease in bone mass, increase in bone decay, and decrease in muscle function leading to an increased risk of falls (Pernambucoa, Borba-Pinheiroa, Gomes de Souza, Di Masia, Monteiroe, et al., 2013). According to recent data the most common health risk in an age group of 60 years old and older are falls, with it being one out of six top reasons for death in an older population (Dehkordi, Sokhangeoi, & Azarbayjani, 2012). If there is an increase in education about the benefits of aquatic exercise compared to the use of land exercise it could reduce the risk of falls in an older population who are generally timid to be involved in physical activity due to their decreased mobility and function (Becker, 2009).

To decrease the risk of falls and injuries in an older population, evidence needs to support the use of aquatic exercise programs for improving balance measures. Clinicians in the healthcare profession may be able to assist patients with their confidence in physical activity and improve their balance ability by using aquatic exercises as an option. The purpose of this review paper is to evaluate how an aquatic exercise program impacts the outcome of a variety of balance tests. The review will apply methods for a systematic review and will examine results of multiple studies on how aquatic exercise programs impact balance in an older population. Information from this review will help clinicians in the healthcare setting decide what types of exercises and activities should be included to create the most effective aquatic exercise program to improve balance measures to decrease risk of falls.

Methods

Search strategy

A systematic search was conducted by using Google Scholar and PubMed search engines with the broad range Google Scholar offered and the recent healthcare updates PubMed database provided (Draper, 2014). To search applicable information, the key words “aquatics and balance”, “balance and aquatic exercise”, “balance measures on aquatic exercises”, and “aquatics and balance on osteoporosis” were applied and only peer-reviewed articles were collected. If there was a reference in one of the articles that involved aquatic exercise programs and balance it was reviewed in Google Scholar and used in the data. The search strategy included the key words and had to include information on aquatic exercise programs performed over a course of time, measurements of balance, and the specified age of the population.

Inclusions

The articles included a population over the age of 40 who had been tested with at least one type of balance measurement after an aquatic exercise program. The balance measurement could be dynamic with movement or static using the measurement of COG (postural sway). Disease or disability did not affect the use of the article in this descriptive review. All years of publication in journals were used to collect as much data as possible.

Exclusions

Articles were not included if they had a population of healthy individuals under 40 years of age, did not incorporate an evaluation of balance, and the intervention exercise program did not include aquatic exercises. Any article that was not a peer-reviewed manuscript was not included, this controlled for studies that did not have a full methods, result, or conclusion sections. There were no other types of reviews included in this systematic review.

Studies included in the review

The initial search process included 25 articles from Google Scholar and PubMed combined with one article found in the reference page from one of the 25 articles. Out of the 26 final articles, there were three multiples leaving the total collection to 23. After eligibility of inclusions for each article was assessed, only 14 studies included the three important qualifications. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram (see *Figure 1*) displays the process of the final 14 articles (Moher, Liberati, Tetzlaff, & Altman, 2009).

PRISMA Flow Diagram

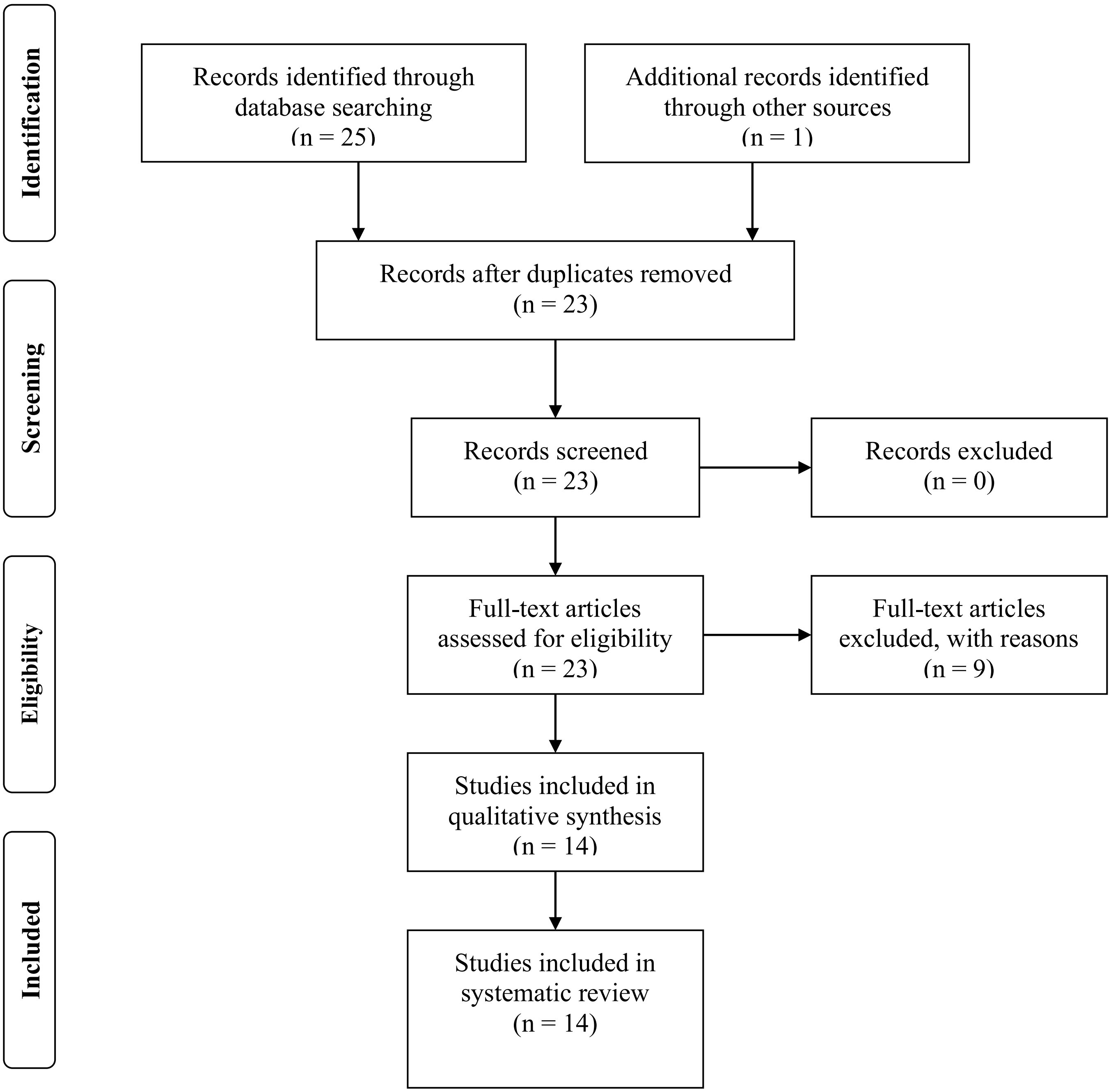

Figure 1. Flowchart of the Literature Selection Process (Moher, Liberati, Tetzlaff, & Altman, 2009).

Data Analysis

All articles were reviewed for balance procedure and measurement after an aquatics exercise program. The programs were evaluated for duration (weeks), duration of the session (minutes), frequency of sessions, and what types of exercises were included. The results summarized each of the articles and included the age of participants, the purpose of the aquatics exercise program, the measurement of balance, and what limitations the participants had if not listed as healthy. There were additional comments on specialized groups including osteoporosis, arthritis, and women who were post-menopause.

To evaluate the articles on research merit or internal validity the PEDro scale was used on the final 14 articles (Maher, Sherrington, Herbert, Moseley, & Elkins, 2003). This scale is based on a point system ranging from 0-10 with each point received relating to specific criteria the article must meet. Any score ranging from 9-10 is considered excellent validity, 6-8 good validity, 4-5 fair validity, and under a score of 4 is poor (de Morton, 2009). The validity for this systematic review had four articles with excellent validity, seven with good validity, three with fair validity, and none in the poor category.

Results

When referring to Table 1, 10 of the 14 final articles were case-control studies with eight articles having random assignments to the groups. There was one case-control study (non-randomly organized) that analyzed control verses experimental and compared pretest and posttest measurements. Only one of the four pretest-posttest studies had two groups with participants randomly assigned.

Sample size ranged from as low as 11 participants to as high as 129 participants with a large variety in between. The age groups were fairly consistent with nine of the 14 articles including participants over the age of 60 years old. Only two of the articles examined adults as young as 40 years old but included up to 70 years old and 89 years old and pertained to an older adult population.

Table 1
Study Design and Validity of the Articles

Article Authors	Sample Size	Age	Pretest-Posttest	Case-Control	Randomly Assigned	PEDro Scale Value
Suomi & Koceja, 2004	24	45-70		X	X	7
Douris et al., 2003	11	> 65	X			6
Lund et al., 2008	79	40-89		X	X	9
Katsura et al., 2009	20	> 65	X		X	7
Arnold et al., 2008	68	> 60		X	X	6
Arnold & Faulkner, 2010	79	> 65		X	X	9
Lord et al., 2006	129	Avg 71		X		5
Hale et al., 2012	39	> 55		X	X	8
De Oliveira et al., 2014	74	> 60		X	X	9
Bressel et al., 2014	18	52-78	X			5
Devereux et al., 2005	50	> 65		X	X	9
Dehkordi et al., 2012	30	60-70	X	X		5
Moreiera et al., 2013	100	Avg 59		X	X	7
Sanders et al., 2013	66	> 60		X		6

An important part of this review was to evaluate the types of aquatic exercise programs and their effect on balance measurements (see Table 2) to allow results to be replicated in a healthcare setting. All 14 articles had programs that were at least six weeks long and no longer than 24 weeks (Mean = 11.21, Median = 10, Mode = 6, 8) with sessions lasting from 30 minutes minimum to 90 minutes maximum (Mean = 54.58, Median = 55, Mode = 60). Sessions per week varied from once to three times maximum (Mean = 2.43, Median = 2.5, Mode = 3). Some articles did not specify water temperature for the aquatics exercise program but data showed the pools were not colder than 25°C or warmer than 34°C. The depth of the pool was rarely recorded but few articles included that it varied depending on the participant and their height. Water depth recorded in five of the 14 articles had a range from 1.00 meters to 1.52 meters.

Table 2
Individual Contents of the Aquatic Exercise Programs

Article Authors	Duration of Program (weeks)	Duration of Session (min)	Amt. per Week	Amt. of Total Exposure (min)	Water Temp (°C)	Water Depth (m)	Exercises Included	Healthy/ Disease
Suomi & Koceja, 2004	6	45	3	810	29-30	1.06-1.52	Yes	OA/RA
Douris et al., 2003	6	NR	2	NR	33	1.03-1.52	Yes	Healthy
Lund et al., 2008	8	50	2	800	33.5	NR	No	OA
Katsura et al., 2009	8	90	3	2,160	30-32	NR	Yes	Healthy
Arnold et al., 2008	20	50	3	3,000	30	Varied	Yes	OP
Arnold & Faulkner, 2010	11	45	2	990	Varied	Varied	No	OA
Lord et al., 2006	10	60	1	600	25-29	NR	Yes	Healthy
Hale et al., 2012	12	60	2	1,440	28	NR	Yes	OA
De Oliveira et al., 2014	12	60	2	1,440	30-34	1.20	No	Healthy
Bressel et al., 2014	6	30	3	540	30	Varied	Yes	OA
Devereux et al., 2005	10	60	2	1,200	NR	NR	No	OP
Dehkordi et al., 2012	8	NR	3	NR	Varied	Varied	Yes	Healthy
Moreiera et al., 2013	24	60	3	4,320	30-31	1.10-1.30	No	Post-Menopause
Sanders et al., 2013	16	45	3	2,160	28-29	1.00-1.20	Yes	NR

* NR = Not Reported, OA = Osteoarthritis, RA = Rheumatoid Arthritis, OP = Osteoporosis

There was a common focus in the aquatic exercise programs (see Table 3) which included stretching and flexibility, endurance exercises that challenged aerobic and cardio fitness, strength exercises with emphasis on resistance of the water (occasionally using water equipment to increase resistance), and movements that incorporated a balance effect in the water. Mobility of joints and increasing flexibility, as well as strength was emphasized in all the articles except two. Balance had a main focus and was included in 12 out of the 14 articles' programs. Endurance or aerobic centered exercises were not as standard and only half of the articles included it in their sessions. Half of the articles used additional equipment to increase resistance and emphasize strength aspects of physical activity in the water. Each of the articles had to include at least one balance measurement (Mean =1.57, Median = 1, Mode = 1).

Table 3
Aquatic Exercise Program Inclusions

Article Authors	Flexibility	Aerobic/ Endurance	Resistance/ Strength	Balance	Use of Equipment	# of Balance Measures
Suomi & Koceja, 2004	X		X			1
Douris et al., 2003	X		X	X		1
Lund et al., 2008	X	X	X	X		1
Katsura et al., 2009	X	X	X		X	2
Arnold et al., 2008	X		X	X	X	1
Arnold & Faulkner, 2010	X		X	X	X	1
Lord et al., 2006	X	X	X	X	X	2
Hale et al., 2012	X		X	X	X	3
De Oliveira et al., 2014	X	X	X	X	X	1
Bressel et al., 2014		X		X		1
Devereux et al., 2005	X		X	X		1
Dehkordi et al., 2012	X		X	X		2
Moreiera et al., 2013	X	X	X	X		2
Sanders et al., 2013	X	X	X	X	X	3

There was a mixture of balance measures (see Table 4) recorded in the articles since balance has two definitions, static and/or dynamic (Rose & Clark, 2000). One of the common ways to assess static balance was a force plate to measure COG sway with the main focus to stand as still as possible in a specified stance for a certain amount of time (Suomi & Koceja, 2002). Some studies varied with the type of stance the participant had to hold; double legged, single legged, or semi-tandem (Suomi & Koceja, 2002. Katsura, Yoshikawa, Ueda, Usui, Sotobayashi, et al., 2009. De Oliveira, Da Silva, Dascal, & Teixeira, 2014.) A possible addition to the COG test was if participants' eyes were open, closed, or both to compare how balance was affected with vision and without vision (De Oliveira, Da Silva, Dascal, & Teixeira, 2014. Lund, Weile, Christensen, Rostock, Downey, et al., 2008. Katsura, Yoshikawa, Ueda, Usui, Sotobayashi, et al., 2009).

Similar to the COG measurement on a force plate was the Sensory Organization Test (SOT) on the NeuroCom, a difference type of measurement machine. The NeuroCom tested vestibular, visual, and proprioception measurements, a gold standard procedure for balance (Bressel, Wing, Miller, & Dolny, 2014).

A second most commonly used test was the Timed-Up-and-Go (TUG) test. It was used in five of the studies and measured the dynamic balance of a person with the time it took to go from a seated position to standing, walking 3 meters, and walking back to the chair to sit down (Katsura, Yoshikawa, Ueda, Usui, Sotobayashi, & et al., 2009).

The Berg Balance Scale (BBS) was measured in three of the articles. This test included the participants to go through 14 functional items scored based on a scale from 0-4 on how the participant completed each individual task. Participants' final scores ranging from 41-56 were at a low risk of falls, 21-40 a medium risk, and 0-20 a high risk (Berg, Wood-Dauphinee, Williams, & Maki, 1992). The BBS has a high retest, inter-rater reliability, and is a common predictor of balance changes after an intervention (Arnold, Busch, Schachter, Harrison, & Olszynski, 2008).

The Step Test was a measurement in two articles and has high test-retest reliability. The process included standing in front of a 7.5cm high step, balancing on one leg while placing the other foot on and off the step as many times as possible for 15 seconds (Devereux, Robertson, & Briffa, 2005).

Dynamic testing was a broad term for balance testing done with a movement pattern, occasionally included timing the participant to start and complete the task, or included an error scoring system.

The two least commonly used balance measurements were done in the same study. The Maximal Balance Range Test (MBRT) measured the participant's anterior and posterior lean with both feet on the ground. The Coordinated Stability Test (CST) measured the participants' ability to adjust their balance with both feet stationary and draw a line within a pre-drawn track with a pen attached by a belt around their waist (Lord, Matters, St George, Thomas, Bindon, et al., 2006).

Table 4
Types of Balance Measurement

Article Authors	COG	DL	SL	Tandem	SOT/ NeuroCom	TUG	UST	BBS	Step Test	Dynamic Test	MBRT	CST
Suomi & Koceja, 2004	X	X										
Douris et al., 2003								X				
Lund et al., 2008					X							
Katsura et al., 2009						X						
Arnold et al., 2008								X		X		
Arnold & Faulkner, 2010						X		X				
Lord et al., 2006											X	X
Hale et al., 2012	X					X			X			
De Oliveira et al., 2014	X	X	X	X								
Bressel et al., 2014					X							
Devereux et al., 2005									X			
Dehkordi et al., 2012						X						
Moreiera et al., 2013						X	X					
Sanders et al., 2013			X							X		

* COG = Center of Gravity (Postural Sway), DL = Double Legged Stance, SL = Single Legged Stance, TUG = Timed-Up-and-Go, UST = Uni-pedal Stance Test, BBS = Berg Balance Scale, MBRT = Maximal Balance Range Test, CST = Coordinated Stability Test

1. Pretest-Posttest Design (N = 4)

Articles with pretest-posttest designs had three populations of healthy participants and one with osteoarthritis. The first healthy population measured balance with the BBS before intervention and after intervention on a group in a 6-week land exercise program and a group in a 6-week aquatic exercise program focused on flexibility, strength, and balance. The results concluded that both scores increased a statistically significant amount ($p < .001$) but there was no difference between land versus aquatic environment (Douris, Southard, Varga, Schauss, Gennaro, et al., 2003).

The next two articles measured balance with the TUG test. There was a statistically significant difference ($p < .0001$) in dynamic balance according to the TUG test (time decreased) in healthy participants who focused on flexibility, strength, and balance in an 8-week program (Dehkordi, Sokhangeoi, & Azarbayjani, 2012). The next article did not focus on balance in their 8-week exercise program but incorporated flexibility, endurance, strength, and resistance using types of aquatic equipment in one group and no resistance aquatic equipment in the other group (Katsura, Yoshikawa, Ueda, Usui, Sotobayashi, et al., 2009). The TUG test was statistically significantly ($p < .001$) from pretest to posttest in both the non-resistant aquatic equipment group and the resistant aquatic equipment group (Katsura, Yoshikawa, Ueda, Usui, Sotobayashi, et al., 2009).

The last study examined participants with osteoarthritis using the SOT to measure balance. During the 6-week program there was a focus on aerobic training on a water treadmill and balance. Results concluded a decrease in osteoarthritis pain and an increase in scores on the SOT that were statistically significant ($p < .03$-$.008$) (Bressel, Wing, Miller, & Dolny, 2014).

2. Case-Control (N = 10)

There were multiple test procedures that measured balance through COG that had positive results. The first study looked at data specific to sagittal sway, lateral sway, and total sway area, with results supporting the aquatics exercise program had a statistically significant reduction ($p < .05$) in lateral and total area sway with eyes open and eyes closed in the experimental group over the control group. These participants all had osteoarthritis or rheumatoid arthritis conditions and only focused on flexibility and strength in a 6-week program (Suomi & Koceja, 2004).

The next study used the NeuroCom with testing similar to the SOT but observed eyes-open and eyes-closed on a stable surface verses a moving surface and compared the data to both groups. These participants all had osteoarthritis knee pain and there was no change in pain or in the balance measures after a 8-week exercise program that focused on flexibility, endurance, strength, and balance (Lund, Weile, Christensen, Rostock, Downey, et al., 2008).

Another study included participants with knee and hip osteoarthritis over a 12-week program focused on flexibility, strength, balance, and resistance with the use of equipment, and measured balance with COG, TUG, and the Step Test. There was no significant data that showed an increase or decrease between the experimental group and the control group in all three of the balance tests (Hale, Waters, & Herbison, 2012).

A study included healthy participants for a 12-week program focused on flexibility, endurance, strength, balance, and resistance with aquatic equipment measured balance with COG in three different stances; double-legged, single-leg, and semi-tandem with eyes open and eyes closed comparing it to three intervention groups; mini-trampoline, land gymnastics, and aquatic gymnastics. Results concluded that COG postural data was statistically significant ($p < .05$) and increased but this occurred in all three intervention groups and there was no statically significant result ($p > .05$) between the aquatics group and the other two intervention groups (De Oliveira, Da Silva, Dascal, & Teixeira, 2014).

Two of the studies used the BBS for a balance measurement and results were not significantly significant ($p > .05$) comparing the aquatics exercise intervention with the control in both of the articles (Arnold, Busch, Schachter, Harrison, & Olszynski, 2008. Arnold & Faulkner, 2010). A 20-week program focused on flexibility, strength, balance, and resistance with aquatic equipment had an additional measurement of balance using a dynamic test of backwards tandem walking which was also not statistically significant ($p > .05$) in patients with osteoporosis (Arnold, Busch, Schachter, Harrison, & Olszynski, 2008). A different study on patients with osteoarthritis used another measurement during their 11-week program with the same focus but the use of the TUG test and similar results of no statistical significance ($p > .05$) was discovered between the experimental group and the control group (Arnold & Faulkner, 2010).

In a 10-week study with an emphasis on flexibility, strength, and balance the measurement of balance was the Step Test. The results concluded there was a statistically significant improvement ($p < .001$) in the experimental group over the control group with both the left foot and the right foot being placed on the step (Devereux, Robertson, & Briffa, 2005).

Two very different dynamic tests were done in a 10-week program with emphasis on flexibility, endurance, strength, balance, and resistance with aquatic equipment included the MBRT and the CST. Results concluded that both tests were statistically significant ($p < .05$) in the aquatics exercise group (Lord, Matters, St George, Thomas, Bindon, et al., 2006).

In another study the population was categorized as healthy but at risk due to age and a variety of conditions. These participants were involved in a 16-week program focused on flexibility, endurance, strength, balance, and resistance with aquatic equipment. Three balance measurements were recorded; a static test was performed balancing for 60 seconds on one leg, a dynamic test by shifting weight while walking in a pattern and having to hold weight for 4 seconds each step, and a Sit-to-Stand test (similar to TUG but the participant must sit up and sit back down as fast as possible for 30 seconds). There were no statistical differences between the aquatics group and the control group but comparing the tests from before the intervention to after, the dynamic and Sit-to-Stand Test were statistically significant ($p < .001$) as was the static balance test ($p < .05$) (Sanders, Takeshima, Rogers, Colado, & Borreani, 2013).

The only study done on post-menopause women lasted for 24-weeks and included flexibility, endurance, strength, and balance with a measurement of balance using the TUG test and the UST. Results concluded TUG scores were statistically significant ($p < .001$) in the aquatics exercise group over the control group but the UST results were not statistically significant ($p < .143$) compared to the control group (Moreiera, Fronza, Santos, Luzimar, Kruel, et al., 2013).

Discussion

The purpose of this review paper is to evaluate how an aquatic exercise program impacts the outcome of balance tests in an older population. This review attempted to summarize pertinent articles that included aquatic exercise programs and the effect the programs had on balance measurements in order to conclude if aquatic exercises are beneficial to reduce the risk of falls in this specific population.

It can be observed from our results the majority of the articles included supportive data that aquatic exercise programs increased a variety of balance measurements in healthy older populations and populations who suffered from osteoarthritis, rheumatoid arthritis, osteoporosis, and post-menopause in women. Each study included an aquatics exercise program with the focus on types of physical activity (flexibility, endurance, strength, balance, resistance) and at least one type of balance measurement (static and/or dynamic).

The data from all four pretest-posttest articles reported statistically significant ($p < .05$) results supporting the positive effect of aquatic exercise programs on balance. The measurement tests for balance included the BBS, the TUG, and the SOT. This information can support that aquatic exercise programs do provide beneficial aspects to balance in an older population. A limitation in two of the studies included two different groups (land vs. water and resistance vs. non-resistance) having a pretest-posttest design on balance measurements. Both groups had a statistically significant result comparing pretest and posttest but no significant difference between the groups. There is no supportive data that it was the aquatic exercises that had the beneficial factors over the land exercises or the resistance exercises in the water over non-resistant exercises. This data suggests that any type of physical activity increases a variety of balance measurements in an older population. It is essential to keep producing studies with more participants and a variety of balance measurements to reach a conclusion if aquatic exercise programs do affect balance over traditional land exercise programs.

Data from six of the 10 case-control studies were similar to the pretest-posttest studies with balance measurements supporting aquatics exercise programs influence balance in a positive way. In four studies there was no difference between experimental and control groups and all of these participants had osteoarthritis or osteoporosis. In the six studies with supportive evidence half of the studies included healthy participants and the other half included osteoarthritis, osteoporosis, and women with post-menopause. This is important when looking at limitations and how a type of participant depending on their health or disease could affect balance measurement and data outcome.

It is concerning there were studies reporting no difference in balance measurements after an aquatics exercise program and all of these articles included older participants with osteoarthritis and osteoporosis diseases. To understand why this occurred, more studies need to be performed to rule out if this was an experimental procedure issue, the type of participants affected the data, or there were too many external factors that affected the results.

There is evidence aquatic exercise programs do positively affect balance measurements in an older population but some articles are inconclusive with the data having no positive or negative affect on balance. According to the PEDro scale all of the articles had fair or above fair merit and internal validity. The articles with results that did not show any significant findings all had merit above a six (good validity) up to a nine (excellent validity). The pretest-posttest designs with significant results had two fair validity articles (five on the scale) and two good validity articles (six and seven on the scale). The case-control designs had one fair validity (five on the scale), three good validity (six, seven, and eight on the scale), and two excellent validity (nine on the scale) articles. This information supports the articles with no supportive data had average to above average merit and internal validity compared to the pretest-posttest articles with supportive data that had average to below average validity and case-control articles with all types of validity ranging from fair to excellent.

There need to be more studies that examine a set protocol of exercises to help other researchers recreate the study to increase validity and replication. It would be beneficial to have an increase of case-control studies since there was more discrepancy than the pretest-posttest designs in the review. There was a large variety of balance measurements used in the review and it would be valuable to have information on which tests are the best for this topic and this population. Overall there is supportive evidence that aquatic exercise programs have a statistically significant effect on balance but there are more questions that could be answered with future studies.

Conclusion

In conclusion to this review there is evidence that aquatic exercise programs do improve balance in an older population, which could decrease risk of falls and help with ADL in this age group. This is crucial information for healthcare professionals that work with patients who are healthy but also with patients who have a bone or joint disease, which affects their movement and balance. The exercises from the studies that showed an increase in balance can be collected and revised to create a program to help an individual with a high risk of falls or to create an additional aquatics exercise program for future studies.

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