An Ai Chi-based aquatic group improves balance and reduces falls in community-dwelling adults: A pilot observational cohort study

Elizabeth H. Skinner, PhD, BPhysio (Hons). MAPA, Tammy Dinh, BPhysio, Melissa Hewitt, BSc Physio (Hons). MAPA, Ross Piper, B.App Sci (Physio), and Claire Thwaites, BPhysio

Objective: The objective of the study was to pilot the implementation of an aquatic group based on Ai Chi principles (Aquabalance) and to evaluate the safety, intervention acceptability, and intervention effect sizes. Design: Pilot observational cohort study. Methods: Forty-two outpatients underwent a single 45-minute weekly group aquatic Ai Chi-based session for eight weeks (Aquabalance). Safety was monitored using organizational reporting systems. Patient attendance, satisfaction, and self-reported falls were also recorded. Balance measures included the Timed Up and Go (TUG) test, the Four Square Step Test (FSST), and the unilateral Step Tests. Results: Forty-two patients completed the program. It was feasible to deliver Aquabalance, as evidenced by the median (IQR) attendance rate of 8.0 (7.8, 8.0) out of 8. No adverse events occurred and participants reported high satisfaction levels. Improvements were noted on the TUG, 10-meter walk test, the Functional Reach Test, the FSST, and the unilateral step tests (p < 0.05). The proportion of patients defined as high falls risk reduced from 38% to 21%. The study was limited by its small sample size, single-center nature, and the absence of a control group. Conclusions: Aquabalance was safe, well-attended, and acceptable to participants. A randomized controlled assessor-blinded trial is required.

Introduction

Falls have been associated with morbidity, health-care burden, loss of independence, and mortality (World Health Organization, 2007) and are attributed to the majority of hospitalized injuries for older people (Tovell, Harrison, and Pointer, 2014). The annual incidence of falls in community-dwelling adults older than 65 years is approximately 30% (Gillespie et al., 2012) and the incidence increases with age (World Health Organization, 2007). Falls prevention is an international health priority for these reasons (Renehan et al., 2012). Older people have higher rates of injury related to falls (World Health Organization, 2007) and balance impairment is a risk factor for falls in community-dwelling adults (Muir et al., 2010a; Muir et al., 2010b).

Land-based group exercise programs have been shown to reduce the rate and risk of falls (Gillespie et al., 2012), while Tai Chi has also been shown to reduce the risk of falls in community-dwelling older adults (Gillespie et al., 2012). However, for some patients, issues such as pain and fear of falling can make land-based programs difficult. For such patients, the physical properties of water make aquatic exercise an alternative option as the warmth aids pain by reducing muscle spasm, buoyancy offloads painful joints, and the viscosity allows more time for balance recovery when perturbed (Hall, Bisson, and O’Hare, 1990; Morris, 2010; Ruoti, Morris, and Cole, 1997). Water pressure also supports proprioception of the body in space, improving balance reactions (Morris, 2010). These advantages may improve intervention acceptability and self-management for aquatic programs over land-based programs. Gill, McBurney, and Schulz (2009) showed that patients awaiting total knee replacement experienced less pain associated with an aquatic therapy intervention, which was better.
tolerated with similar clinical outcomes, while another study demonstrated higher adherence rates in participants with osteoarthritis attending aquatic programs (Fransen et al., 2007).

Evidence supports the use of aquatic therapy for balance retraining (Booth, 2004; Douris et al., 2003; Geytenbeek, 2002; Roth et al., 2006); however, there are limited recommendations as to which specific techniques are the most effective. Ai Chi is a water exercise and relaxation program likened to Tai Chi (Sova and Konno, 1999) and has been identified as an emerging technique for balance retraining and falls minimization (Cunha et al., 2010; Noh, Lim, Shin, and Paik, 2008). Teixeira, Perez, Lambeck, and Neto (2010) investigated the effects of an Ai Chi program on balance and fear of falling, with significant improvements in balance; however, these findings have not yet been published.

The aim of this pilot study was to evaluate the feasibility of implementing a group Ai Chi program (Aquabalance), specifically with regard to patient attendance, satisfaction, and explore any treatment effects on balance and falls, to inform the design of a larger randomized controlled trial.

Methods

This study complies with the reporting requirements of STROBE for cohort studies (von Elm et al., 2007) and aimed to establish relevant pilot and feasibility information using previously reported guidance (Shanyinde, Pickering, and Weatherall, 2011; Thabane et al., 2010).

Trial design, setting, and location

The institutional review board approved the study (Protocol number: QA2015.13). The study was conducted in Community-Based Rehabilitation at a tertiary hospital (Sunshine Hospital, Western Health) from April 2011 to July 2013 inclusive. This study was a retrospective audit of routinely available longitudinal clinical data from a cohort of patients participating in the Aquabalance therapy program and as such the requirement for informed consent was waived as per the Australian National Statement on Ethical Conduct in Human Research (2007).

Participants

Patients were eligible for participation in the Aquabalance program if they were: attending the Community-Based Rehabilitation program; screened by the treating Physiotherapist and deemed appropriate for aquatic therapy; and if they had balance-retraining or falls prevention therapy goals and sufficient cognitive capacity to follow Ai Chi instructions safely in a group setting. Exclusion criteria were: medically unstable to participate in hydrotherapy as per the institution’s screening protocol, informed by Appendix I and II of the Australian Physiotherapy Association guidelines for aquatic physiotherapists working in and/or managing hydrotherapy pools (Larsen et al., 2015). A risk assessment (high, low, or nil) was made based on the presence or absence of the following: epilepsy; headaches/dizziness; hyper-/hypotension; cardiac condition; peripheral vascular disease; respiratory condition; fecal incontinence; urinary incontinence (including presence of indwelling catheter); open wounds; skin sensitivity to chlorine; other skin conditions (e.g. psoriasis); ear infection/hearing impairment/hearing aid; eye infection/discharge/visual impairment; feet condition (tinea/warts/papilloma); febrile condition; renal impairment; acute inflammatory condition (e.g. rheumatoid arthritis); swallowing problems; radiotherapy in past three weeks; infectious disease (including HIV, Herpes Simplex, hepatitis); diabetes; or pregnancy. Where the risk assessment was unclear, a general practitioner clearance for aquatic therapy participation was sought, and the Department of Infection Control at the institution was contacted in the event a second opinion was required.

Interventions

Participants attended a single 45-minute Aquabalance session per week for eight weeks. Session length, program duration, and staffing ratios were modeled on the existing land-based falls prevention program offered at the center. The sessions covered Ai Chi postures 1–18 and Ai Chi was selected on the basis of its potential effect on balance outcomes (Cunha et al., 2010; Noh, Lim, Shin, and Paik, 2008; Teixeira, Perez, Lambeck, and Neto, 2010). Two physiotherapists and one allied health assistant staffed each session of the Aquabalance program, with a maximum of six patients attending each session. Two staff members were in the pool assisting patients, while one staff member demonstrated the Ai Chi postures poolside. We have provided a summary of our intervention conditions described according to the TIDieR guidelines (Hoffmann et al., 2014) in Table 1.

Procedure

Treating physiotherapists in Community-Based Rehabilitation screened participants attending
**Table 1. Description of intervention according to the TIDieR criteria (Hoffmann et al., 2014).**

| TIDieR criteria | Study 1 intervention |
|-----------------|----------------------|
| Item 1. Brief name: Provide the name or a phrase that describes the intervention | Aquabalance. |
| Item 2. Why: Describe any rationale, theory, or goal of the elements essential to the intervention | Pain and fear of falling can preclude meaningful participation in land-based programs for some patients. The physical properties of water provide an alternative as the warmth aids pain by reducing muscle spasm, buoyancy offloads painful joints, and the viscosity allows more time for balance recovery when perturbed (Hall, Bisson and O’Hare 1990; Ruoti, Morris and Cole 1997, Morris 2010). Water pressure also supports proprioception of the body in space, improving balance reactions (Morris 2010). Ai Chi is a water exercise and relaxation program likened to Tai Chi (Seva and Konno 1999) and has been identified as an emerging technique for balance retraining and falls minimization (Noh, Lim, Shin and Paik 2008, Cunha et al. 2010). |
| Item 3. What (materials): Describe any physical or informational materials used in the intervention, including those provided to participants or used in intervention delivery or in training of intervention providers | An Ai Chi DVD and textbook were utilized for staff training, prior to any clinician leading an Ai Chi aquatic session. The DVD is an 80-minute in-pool lecture and demonstration of techniques. The Ai Chi book contains the movements with written instructions for the movements. Due to the noisy environment of the hydrotherapy area, a portable microphone and speaker were purchased for the demonstrator of Ai Chi by the pool for patients to hear the instructions. Pictures depicting the positions were photocopied onto an A4 document for patients to take home on discharge (example provided in Supplemental File 1). Clinicians separated the positions and grouped according to basic and intermediate based on the textbook clinical experience. |
| Item 4. What (procedures): Describe each of the procedures, activities, and/or processes used in the intervention, including any enabling or support activities | Prior to implementing the program, the Senior Aquatic Physiotherapist participated in Level 3 APA Aquatic Physiotherapy Course and attended a training session at Barwon Health, under the guidance of an aquatic therapy expert (RP). The Senior Aquatic Physiotherapist then trained three staff (two Grade 2 Neurology/Aged Care Physiotherapists and Allied Health Assistant), who staffed the program. To ensure program sustainability, rotational staff working in the Neurological and Aged Care streams were also trained in the event they needed to relieve the regular Aquabalance staff during leave periods. These staff familiarized themselves with the above resources prior to taking any aquatic classes. New staff were also given time to practice in the pool as required with opportunities to consolidate their skills 1:1 with patients in a regular morning session for Neurological patients. An Ai Chi demonstration session led by the Senior Aquatic Physiotherapist was also added to the Aquatic Therapy professional development program. All physiotherapy professionals had entry-level allied health degrees as a minimum. Orientation of new staff members to the health-care organization, aquatic therapy, and Aquabalance was provided as a part of standard human resources procedures. Allied Health Assistants do not require formal qualification, but must have a certificate III or IV (Australian Qualifications Framework Council, 2013) and all operate under the direction of an allied health professional. |
| Item 5. Who provided: For each category of intervention provider (for example, psychologist, nursing assistant), describe their expertise, background and any specific training given | Face-to-face group patient interaction. One staff member demonstrated the positions poolside, with two staff members in the pool with the patients. The poolside staff member was able to observe and correct techniques, and the in-pool staff were able to facilitate and modify the techniques for patients as required. |
| Item 6. How: Describe the modes of delivery (such as face to face or by some other mechanism, such as internet or telephone) of the intervention and whether it was provided individually or in a group | Aquatic therapy pool in Community-Based Rehabilitation at Sunshine Hospital, Australia. The Sunshine Hospital pool has both stairs and hoist entry/exit. In accordance with existing guidelines, patients were supervised with both entry and exit if they were classified as moderate – high falls risk. They used either form of entry/exit based on the referral from their treating physiotherapist. The pool was 1–1.5 m in depth at a temperature of 32°C. The hydrotherapy pool was maintained according to the Australian Standards for Hydrotherapy Pools. The program was delivered over eight weeks, one session per week on a Friday morning. This time slot was selected due to pool availability. The session lasted 45 minutes with a 2-minute warm-up at the beginning of walking laps. Each position was completed with 8–10 repetitions. Depending on patient ability, some positions were modified whereby patients were allowed to use the rail for support initially, with progression to independence without support as the weeks continued. The group was an open group; therefore, at any session, the independence of patients varied. |
| Item 7. Where: Describe the type(s) of location(s) where the intervention occurred, including any necessary infrastructure or relevant features | (Continued) |
outpatient rehabilitation for eligibility. Where eligibility criteria were fulfilled, the treating therapist referred the patient to Aquabalance as routine usual care. A referral form including the outcome measures was completed. The treating physiotherapist completed the outcome measures again following Aquabalance completion, or where deemed appropriate by the treating therapist, allied health assistants completed the outcome measures. No staff members were blinded to patient participation in Aquabalance.

Outcome measurement

The outcomes were selected on the basis of published guidance in order to provide requisite information to inform the design of future large randomized controlled trials (Shanyinde, Pickering, and Weatherall, 2011; Thabane et al., 2010).

Safety, patient satisfaction, and intervention acceptability

The occurrence of any adverse events (e.g. Code Blue, falls) during the program was recorded. A consumer satisfaction survey was developed in English in consultation with the Western Health Manager of Community Participation and Cultural Diversity (Table 2). The survey was administered to participants at the completion of the program in order to ascertain participant perspectives of intervention acceptability.

Process and feasibility measures

Therapist impressions of how well outcome measures and interventions were understood by patients were collected, along with the length of time to complete assessments, and whether staff could incorporate screening/outcome measures/referrals into their workloads.

Program staff and treating therapists were also asked whether there were any specific challenges in running the program, collecting data, data entry, or any outcome measures that therapists felt should have been collected.

Effect sizes – outcome measures

Effect sizes were calculated according to Cohen (1988), using the following outcome measures measured on a single occasion pre and post Aquabalance by the referring physiotherapist.

Functional Reach Test

The Functional Reach Test (Duncan, Weiner, Chandler, and Studenski, 1990) was developed to assess dynamic
standing balance. The test is administered by measuring at shoulder height, the maximum distance the patient can reach forward beyond arm’s length against a fixed wall rule (without exceeding their limits of stability). The test has excellent test-retest reliability (Bennie et al., 2003; Duncan, Weiner, Chandler, and Studenski, 1990; Weiner, Duncan, Chandler, and Studenski, 1992) and some evidence of criterion validity (Bennie et al., 2003; Weiner, Duncan, Chandler, and Studenski, 1992). The minimal clinically important difference (MCID) has not yet been established.

**Left and right step test**

The unilateral step tests were performed in a dynamic single-stance stepping the foot on and off a 7.5-cm block as often as possible within 15 seconds (Hill et al., 1996).

**Four Square Step Test (FSST)**

The FSST involves stepping over four canes laid on the ground at 90 degree angles to each other in a “plus” sign, with the patient stepping in a clockwise direction, then counterclockwise after commencing in standing in the bottom left square of the plus (Dite and Temple, 2002). The FSST has been shown to have excellent reliability and criterion validity (Dite and Temple, 2002; Whitney, Marchetti, Morris, and Sparto, 2007) and has higher combined sensitivity and specificity than the Step Test, the TUG test, and the Functional Reach test (Dite and Temple, 2002). A cutoff score of 15 seconds has been identified as optimal to distinguish between multiple fallers and non-multiple fallers (Dite and Temple, 2002).

**Timed Up and Go (TUG) test**

The TUG test was designed as a measure of mobility and performance (Podsiadlo and Richardson, 1991) and modified from the original Get Up and Go test (Mathias, Nayak, and Isaacs, 1986), which ranked the falls risk of the participant during the test. The TUG test measures how quickly a person can rise from a standardized seated position (in a chair with arms), walk three meters, turn around, walk back to the chair, and sit down (Podsiadlo and Richardson, 1991). The TUG has been validated against the Berg Balance Scale, the Barthel Index, and walking speed (Podsiadlo and Richardson, 1991) and a variety of functional outcome measures including the two-minute walk test and the Functional Independence Measure (FIM) (Brooks, Davis, and Naglie, 2006). The TUG has excellent test-retest reliability (Bischoff et al., 2003; Lin et al., 2004; Ries, Eckernach, Nof, and Gagnon Blodgett, 2009; Steffen, Hacker, and Mollinger, 2002); strong evidence of construct validity (Bischoff et al., 2003; Samson et al., 2000; Steffen, Hacker, and Mollinger, 2002), and may possess predictive validity for decline/improvement in activities of daily living and falls risk (Lin et al., 2004). Normative data have been published for the TUG, with the mean test time of 9.4 seconds for individuals > 60 years of age (Bohannon, 2006). A cutoff score of 13.5 seconds has also been used to define patients at high risk of falls (Shumway-Cook, Brauer, and Woollacott, 2000).

**10-meter walk test**

The 10-meter walk test was developed to test gait speed (in meters per second) over a short duration and normative data has been published (Bohannon, 1997). The test has excellent reliability (Bohannon, 1997; Wolf et al., 1999), some evidence of construct validity (Wolf et al., 1999), and responsiveness (Perera, Mody, Woodman, and Studenski, 2006).

The MCID has been reported to be 0.04–0.06 m/s (small) and 0.08–0.13 m/s (substantial) in the geriatric populations (Perera, Mody, Woodman, and Studenski, 2006).

**Self-reported falls**

Falls in the preceding six months were recorded prior to the program and in the preceding two months
following completion of the program. Falls frequency was verbally self-reported by the patient to the referring physiotherapist at both time points.

No assessors were blinded. Interpreters were provided for outcome measurement where required.

**Statistical analysis**

The sample size was a sample of convenience, determined in the absence of previous research on which to base a sample size and with no specific sample size required for pilot studies (Shanyinde, Pickering, and Weatherall, 2011; Thabane et al., 2010). The sample of convenience included all the patients who completed Aquabalance during the study period. Cohen’s effect size was calculated and interpreted within-group from baseline to follow-up where applicable (0.4 or less = small; 0.5 = moderate; and 0.8 = large) (Cohen, 1988). The normality of distributions was assessed using the Kolmogorov–Smirnov statistic. Non-normally distributed data were analyzed using Mann–Whitney U for independent samples and Wilcoxon-signed ranks tests for dependent group data. Paired t-tests were used to analyze parametric differences in HR-QoL over time. Categorical group differences were analyzed with χ² tests and Yates’ Correction for Continuity. Sample sizes were estimated using G*Power (Version 3.1.9.2, Universität Düsseldorf, Düsseldorf, Germany) (Faul, Erdfelder, Lang, and Buchner, 2007).

Data are reported as median (IQR) unless otherwise specified. Statistical analysis was performed using SPSS using IBM* SPSS* Statistics V20 (IBM Corp, Armonk, NY, USA) and p < 0.05 was accepted as statistical significance. Missing data were ignored and no data were imputed.

**Results**

Forty-two patients (30 female (71.4%); and 12 male (28.6%)) attended the Aquabalance program across the study period, with a mean (SD) age of 64.2 (14.2) years. No patients were lost to follow-up. Thirteen patients (31.0%) were referred to the program with a diagnosis of stroke; 10 (23.8%) patients were referred with falls; three (7.1%) were referred with Parkinson’s disease; and 16 patients (38.1%) were referred for other diagnoses. Eleven patients used a gait aid at the time of their pre-program assessment (single point stick (n = 4); forearm crutches (n = 3); and four-wheeled frames (n = 3)), which was unchanged at the post-program assessment.

**Feasibility and adherence rates**

The median (IQR) sessions attended were 8.0 (7.8, 8.0) out of 8. No adverse events occurred during the program.

The patient satisfaction survey was completed 64.3% of the time (n = 27/42), with the primary barriers being patients not speaking sufficient English and availability of staff. In 93% of the completed questionnaires (n = 25/27), patients responded either Good or Excellent to the first five questions, which incorporated satisfaction with class frequency, the Ai Chi postures, and perceived improvement in walking, balance, and assistance with activities at home.

Patients often required the full 8-week program to progress to some level of independence with the Ai Chi postures. Patients were still offered the full eight sessions if they missed a session due to illness. The only additional primary therapist time required outside the standard aquatic referral process was for completion of the outcome measures on referral and on program completion. As Aquabalance referrals were completed at the same time as the initial land-based Physiotherapy assessment, outcome measures were completed as part of routine assessment. Patients understood the intervention as a balance program aimed at ensuring ongoing self-management at the local pool, and were able to follow the Ai Chi postures demonstrated by the poolside staff member. Participants did not receive any specific education regarding outcome measure completion other than that provided by the treating therapists in their assessment sessions.

Treating staff were able to screen patients for participation and assess outcome measures as part of referral to the program; however, the FSST and the Functional Reach Test had the highest rates of missing data (Table 3), due to time pressures on treating therapists in the assessment of outcome measures. Treating physiotherapists completed initial outcome measurement and allied health assistants conducted discharge outcome measures on occasion. Outcome measures usually took 15 minutes to complete at baseline and discharge assessments. No additional measures were identified that would have been useful to include in the program outcomes.

Conduct of a randomized trial would benefit from dedicated program staff to ensure screening of patients and referral to the program could be completed in a timely fashion, as there were low numbers of attendance at times. This was attributed to staffing rotations and leave, which affected staff awareness of the program. Furthermore, within the community-based rehabilitation neurology patient cohort, fluctuations in the
number of external referrals received and level of patient independence meant that some patients required 1:1 sessions in the pool prior to gaining enough independence to attend a group setting. There were no challenges identified with data entry.

**Effect sizes and planned sample size**

Effect sizes were generally moderate, although confidence intervals were wide (Table 3). The largest effect size point estimates were seen for the Step Tests, the TUG, and the 10-meter walk tests (Table 3). Estimated sample sizes per group for a future RCT, using a two-sided test for difference between two independent group means, using an alpha of 0.05, a power of 80%, and an allocation ratio of 1:1 and the TUG as the primary outcome (well validated, normative data, feasible with moderate effect size), were 48 in each group (total n = 96, not including recruitment for attrition). To detect a difference with 90% power (other assumptions unchanged), sample sizes were 64 in each group (total n = 128, not including attrition). If we assumed a smaller effect size for the TUG (as the patients/assessors weren’t blinded in this study), d = 0.40, then for a power of 80% (other assumptions unchanged) a sample size of 200 is required (n = 100 each group).

**Cohort differences in outcome measures over time**

Statistically significant improvements were noted on the TUG, the 10-meter walk test, the Functional Reach Test, the 4 Square Step Test, and the unilateral step tests (Table 3). The median (IQR) rate of falls during the 6 months preceding the program was 1 (0–3) with median (IQR) 0 (0–0) falls during the program period, with the median of the difference (95% CI) 1.0 (0.5, 2.0), p < 0.001.

The proportion of patients defined as high falls risk reduced from n = 16/42 (38.1%) before the program to n = 9/42 (21.4%) following the program (Shumway-Cook, Brauer, and Woollacott, 2000).

**Discussion**

The implementation of an aquatic group program based on Ai Chi principles was safe, feasible to run, was well-attended, and acceptable to patients with falls or balance impairment. Patients with balance impairments and falls history completed an aquatic exercise group safely with no adverse events, despite the obvious risks of treating this population in a potentially slippery environment and with the need to shower and change after aquatic exercise. The results of the pilot cohort study suggest that it would be feasible to run an adequately powered randomized controlled trial of this intervention in the population of elderly community-dwelling patients with balance impairment. The primary methodological implications are that project staff would be required to recruit eligible patients and conduct blinded initial and follow-up outcome measurement. The Aquabalance program itself was staffed within existing departmental resources, and although treating therapists were able to screen, it is possible that recruitment rates/attendance levels would be facilitated by the presence of dedicated project staff to screen for eligible patients. No other major methodological limitations to consider for the design and conduct of a randomized controlled trial were identified.

Effect sizes were moderate; however, it should be noted that the overall cohort had relatively low balance impairment. The cohort median pre- and post-program FSST scores were both below 15 seconds in the context of the FSST cutoff score of 15 seconds, which distinguishes between multiple fallers and non-multiple fallers (Dite and Temple, 2002). It is possible that the effect sizes would be higher in patients with worse balance impairment, and the results may not be generalizable to those patients, and it is possible that the intervention could either be more effective in those patients, or less effective if those with severe balance impairments are less responsive to intervention. However, the cohort was heterogeneous and consisted of patients with mixed diagnoses, including stroke and neurological disease as well as patients referred specifically with falls and therefore the results are likely generalizable to other patients with these diagnoses.
Balance outcomes and self-reported falls did improve following completion of the program, although it must be noted that causative effects cannot be drawn in the absence of a control group. The findings of this pilot study support previously published literature on Ai Chi programs, which have demonstrated balance improvements (Cunha et al., 2010; Noh, Lim, Shin, and Paik, 2008). Several other studies have been conducted in stroke (Noh, Lim, Shin, and Paik, 2008) with pilot studies conducted in balance and fear of falling (Teixeira, Perez, Lambeck, and Neto, 2010) and multiple sclerosis (Bayraktar et al., 2013). It is clear that a rigorous multicenter randomized controlled trial is warranted to test the hypothesis that Ai Chi improves balance and reduces falls and injury in the elderly community-dwelling population.

There are some limitations to the interpretation of the results: the sample size was small (although this was only a pilot trial); falls were measured by self-report and over different time periods, which may introduce bias; assessors and patients were not blinded; aquatic therapy was provided in addition to land-based programs; and there was no long-term follow-up to determine whether gains were maintained. The heterogeneity of the included cohort was high, and while this is a limitation of the study, it also may improve the generalizability of the results to different clinical populations, as previously noted. Qualitative data from the trial suggested that patients were willing to maintain their therapy in their local pools, and it is possible that long-term adherence to maintenance is more sustainable in aquatic programs if patients enjoy them more than land-based programs. It is also important that future randomized controlled trials evaluate the cost-effectiveness of the intervention, particularly in a group such as this, which was staffed with two therapists and an allied health assistant, although it should be noted the staffing ratios were not different from equivalent land-based programs at the center. The program could potentially be run with fewer staff, though the addition of the staff member poolside demonstrating the techniques was beneficial in this population, which comprised a large number of culturally and linguistically diverse participants, which may not be the case in other cohorts.

An aquatic program of Ai Chi postures was safe, feasible, and acceptable to patients, and patients completing the program demonstrated improvement in balance and self-reported falls; however, the trial was not powered, nor controlled, to attribute these findings to effect of the intervention. A large randomized controlled trial is now required to test the cost-effectiveness of Ai Chi intervention in improving balance and reducing falls in the elderly community-dwelling population.

Acknowledgments

The authors acknowledge Collin McIlveen and the physiotherapy team in Community-based Rehabilitation at Sunshine Hospital, Western Health, for their support in the conduct of this study. The study received in-kind support from the Community-based Rehabilitation and Physiotherapy Departments of Western Health, Monash University, and The University of Melbourne. No formal funding was received.

Declaration of interest

The authors report no declarations of interest. The authors alone are responsible for the content and writing of the article.

ORCID

Elizabeth H. Skinner http://orcid.org/0000-0003-0268-7160

References

Australian National Statement on Ethical Conduct in Human Research 2007 National Health and Medical Research Council, the Australian Research Council and the Australian Vice-Chancellor’s Committee (Updated March 2014).

Australian Qualifications Framework Council 2013 Australian Qualifications Framework. http://www.aqf.edu.au/

Bayraktar D, Guclu-Gunduz A, Yazici G, Lambeck J, Batur-Caglayan HZ, Irkek C, Nazliel B 2013 Effects of Ai-Chi on balance, functional mobility, strength and fatigue in patients with multiple sclerosis: A pilot study. NeuroRehabilitation 33: 431–437.

Bennie S, Bruner K, Dizon A, Fritz H, Goodman B, Peterson S 2003 Measurements of balance: Comparison of the timed up and go test and functional reach test with the berg balance scale. Journal of Physical Therapy Science 15: 93–97.

Bischoff HA, Stahelin HB, Monsch AU, Iversen MD, Weyh A, von Dechend M, Akos R, Conzelmann M, Dick W, Theiler R 2003 Identifying a cut-off point for normal mobility: A comparison of the timed ‘up and go’ test in community-dwelling and institutionalised elderly women. Age and Ageing 32: 315–320.

Bohannon RW 1997 Comfortable and maximum walking speed of adults aged 20–79 years: Reference values and determinants. Age and Ageing 26: 15–19.

Bohannon RW 2006 Reference values for the timed up and go test: A descriptive meta-analysis. Journal of Geriatric Physical Therapy 29: 64–68.
Booth CE 2004 Water exercise and its effect on balance and gait to reduce the risk of falling in older adults. Adaptation and Aging 28: 45–57.

Brooks D, Davis AM, Naglie G 2006 Validity of 3 physical performance measures in inpatient geriatric rehabilitation. Archives of Physical Medicine and Rehabilitation 87: 105–110.

Cohen J 1988 Statistical power analysis for the behavioral sciences. New Jersey, USA, Lawrence Erlbaum Associates.

Cunha MC, Alonso AC, e Silva TM, de Raphael AC, Mota CF 2010 Ai Chi: Aquatic relaxing effects on functional performance and quality of life in elderly. Fisioterapia em Movimento 23: 409–417.

Dite W, Temple VA 2002 A clinical test of stepping and change of direction to identify multiple falling older adults. Archives of Physical Medicine and Rehabilitation 83: 1566–1571.

Douris P, Southard V, Varga C, Schauss W, Gennaro C, Reiss A 2003 The effect of land and aquatic exercise on balance scores in older adults. Journal of Geriatric Physical Therapy 26: 3–6.

Duncan PW, Weiner DK, Chandler J, Studenski S 1990 Functional reach: A new clinical measure of balance. Journal of Gerontology 45: M192–197.

Faul F, Erdfelder E, Lang AG, Buchner A 2007 G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behavior Research Methods 39: 175–191.

Fransen M, Nairn L, Winstanley J, Lam P, Edmonds J 2007 Physical activity for osteoarthritis management: A randomized controlled clinical trial evaluating hydrotherapy or Tai Chi classes. Arthritis and Rheumatism 57: 407–414.

Geytenbeek J 2002 Evidence for effective hydrotherapy. Physiotherapy 88: 514.

Gill SD, MCBurney H, Schulz DL 2009 Land-based versus pool-based exercise for people awaiting joint replacement surgery of the hip or knee: Results of a randomized controlled trial. Archives of Physical Medicine and Rehabilitation 90: 388–394.

Gillespie LD, Robertson MC, Gillespie WJ, Sherrington C, Gates S, Clemson LM, Lamb SE 2012 Interventions for preventing falls in older people in the community. Cochrane Database of Systematic Reviews 9: CD007146.

Hall J, Bisson D, O’Hare P 1990 The physiology of immers. Physiotherapy 76: 517–521.

Hill KD, Bernhardt J, McGann AM, Maltese D, Berkovits DA 1996 A new test of dynamic standing balance for stroke patients: Reliability, validity, and comparison with healthy elderly. Physiotherapy Canada 48: 257–262.

Hoffmann TC, Glasziou PP, Boutron I, Milne R, Perera R, Moher D, Altman DG, Barbour V, Macdonald H, Johnston M, Lamb SE, Dixon-Woods M, McCulloch P, Wyatt JC, Chan AW, Michie S 2014 Better reporting of interventions: Template for intervention description and replication (TIDieR) checklist and guide. BMJ 348: g1687.

Larsen J, Pryce M, Harrison J, Burton D, Geytenbeek J, Howell D, Deane R, Touma R 2015 Guidelines for Physiotherapists Working in and/or Managing Hydrotherapy Pools, 2nd edn. Hawthorn BC, VIC, Australia, Australian Physiotherapy Association, Aquatic Physiotherapy Group.

Lin MR, Hwang HF, Hu MH, Wu HD, Wang YW, Huang FC 2004 Psychometric comparisons of the timed up and go, one-leg stand, functional reach, and Tinetti balance measures in community-dwelling older people. Journal of the American Geriatrics Society 52: 1343–1348.

Mathias S, Nayak US, IsacCs B 1986 Balance in elderly patients: The “get-up and go” test. Archives of Physical Medicine and Rehabilitation 67: 387–389.

Morris D 2010 Aquatic therapy to improve balance dysfunction in older adults. Topics in Geriatric Rehabilitation 26: 104–119.

Muir SW, Berg K, Chesworth B, Klar N, Speechley M 2010a Balance impairment as a risk factor for falls in community-dwelling older adults who are high functioning: A prospective study. Physical Therapy 90: 338–347.

Muir SW, Berg K, Chesworth B, Klar N, Speechley M 2010b Quantifying the magnitude of risk for balance impairment on falls in community-dwelling older adults: A systematic review and meta-analysis. Journal of Clinical Epidemiology 63: 389–406.

Noh DK, Lim JY, Shin HI, Paik NJ 2008 The effect of aquatic therapy on postural balance and muscle strength in stroke survivors—A randomized controlled pilot trial. Clinical Rehabilitation 22: 966–976.

Perera S, Mody SH, Woodman RC, Studenski SA 2006 Meaningful change and responsiveness in common physical performance measures in older adults. Journal of the American Geriatrics Society 54: 743–749.

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.

Renehan E, Dow B, Lin X, Blackberry I, Haapala I, Gaffy E, Cyarto E, Brasher K, Hendy S 2012 Healthy Ageing Literature Review. Melbourne, Victoria, Department of Health.

Ries JD, Echternach JL, Nof L, Gagnon Blodgett M 2009 Test-retest reliability and minimal detectable change scores for the timed “up & go” test, the six-minute walk test, and gait speed in people with Alzheimer disease. Physical Therapy 89: 569–579.

Roth AE, Miller MG, Ricard M, Ritenour D, Chapman BL 2006 Comparisons of static and dynamic balance following training in aquatic and land environments. Journal of Sport Rehabilitation 15: 299–311.

Ruoti R, Morris D, Cole A 1997 Aquatic Rehabilitation. Detroit, MI, Lippincott-Raven Publishers.

Samson MM, Meeuwsen IB, Crowe A, Dessens JA, Duursma SA, Verhaar HJ 2000 Relationships between physical performance measures, age, height and body weight in healthy adults. Age and Ageing 29: 235–242.

Shanyinde M, Pickering RM, Weatherall M 2011 Questions asked and answered in pilot and feasibility randomized controlled trials. BMC Medical Research Methodology 11: 117.

Shumway-Cook A, Brauer S, Woollacott M 2000 Predicting the probability of falls in community-dwelling older adults using the Timed Up & Go Test. Physical Therapy 80: 896–903.

Sova R, Konno J 1999 Ai Chi Balance, Harmony and Healing. Port Washington, WI, DSL Ltd.

Steffen TM, Hacker TA, 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.
Teixeira R, Perez L, Lambeck J, Neto F 2010 The Influence of Ai Chi on balance and fear of falling in older adults: A randomized controlled trial. Presented at the Aquatic Exercise Association International Aquatic Fitness Conference, World Aquatic Coalition Inc.

Thabane L, Ma J, Chu R, Cheng J, Ismaila A, Rios LP, Robson R, Thabane M, Giangregorio L, Goldsmith CH 2010 A tutorial on pilot studies: the what, why and how. BMC Medical Research Methodology 10: 1.

Tovell A, Harrison JE, Pointer S 2014 Hospitalised injury in older Australians, 2011–12. Canberra, Australian Institute of Health and Welfare.

von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP; STROBE Initiative 2007 Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: Guidelines for reporting observational studies. BMJ 335: 806–808.

Weiner DK, Duncan PW, Chandler J, Studenski SA 1992 Functional reach: A marker of physical frailty. Journal of the American Geriatrics Society 40: 203–207.

Whitney SL, Marchetti GF, Morris LO, Sparto PJ 2007 The reliability and validity of the Four Square Step Test for people with balance deficits secondary to a vestibular disorder. Archives of Physical Medicine and Rehabilitation 88: 99–104.

Wolf SL, Catlin PA, Gage K, Gurucharri K, Robertson R, Stephen K 1999 Establishing the reliability and validity of measurements of walking time using the Emory Functional Ambulation Profile. Physical Therapy 79: 1122–1133.

World Health Organization 2007 Global Report on Falls. Prevention in Older Age. Geneva, Switzerland, Author.