Effects of a water-based program on women 65 years and over: A randomised controlled trial

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The purpose of this study was to assess the effects of a water-based exercise and self-management program on balance, fear of falling, and quality of life in community-dwelling women 65 years of age or older with a diagnosis of osteopenia or osteoporosis. Fifty women with an average age of 73.3 years (range 65.5–82.4, SD 3.9) were randomised to intervention or control groups. The intervention group received a 10-week water-based exercise and self-management program compiled by Community Physiotherapy Services and conducted by a physiotherapist at an aquatic centre twice a week for one hour. The control group did not receive any instructions and were not encouraged to change their physical activity, activities of daily living or social habits during the study. Change in balance, measured using the step test, from baseline to follow-up differed between intervention and control groups, with mean (95% CI) between-group differences of 1.7 (0.9 to 2.6) and 2.1 (1.1 to 3.1) steps on the left and right sides respectively. Between-group differences in score changes were also significant in four of the eight domains of quality of life measured using the Short Form 36 questionnaire (SF36; physical function 8.6 (0.4 to 16.8), vitality 12.0 (2.3 to 21.8), social function, and 14.1 (0.6 to 27.7) mental health 10.2 (2.0 to 18.4)), but not fear of falling measured using the modified falls efficacy scale (0.25 (-0.3 to 0.81). It is concluded that a water-based exercise and self-management program produced significant changes in balance and quality of life, but not fear of falling, in this group of community-dwelling women 65 years of age or older with a diagnosis of osteopenia or osteoporosis. **[Devereux K, Robertson D and Briffa NK (2005): Effects of a water-based program on women 65 years and over: A randomised controlled trial. *Australian Journal of Physiotherapy* 51: 102–108]**

Key words: Balance; Falls; Water Exercise; Physiotherapy

Introduction

In Australia, it is expected that the number of people over the age of 65 years will rise from 2.2 million in 1998 to 3.5 million in 2016 (Hall et al 1999). In this age group, falls and fall-related injuries constitute a significant clinical problem due to the associated mortality, morbidity, and costs that burden patients, their families and society as a whole (Dominguez and Bronstein 2000, Stevens and Olson 2000). Older people who fall at least once per year can experience a heightened fear of falling, loss of self-efficacy in their ability to perform routine activities of daily living, and a reduction in their level of function and physical activity (Rose and Clark 2000, Stevens and Olson 2000, Tinetti et al 1988).

Ageing and deconditioning are associated with changes in body composition, increased fat mass and a progressive decline in skeletal muscle mass and bone mineral density (Evans 1999, Wagner et al 1994). Together these factors result in the age-related decreases in muscle strength and aerobic capacity that contribute to decreases in functional independence (Fielding 1995). Increasing levels of regular physical activity, even late in life, can attenuate some of the age-related changes in muscle structure and function and decrease the risk of hip fracture by 40–60% (Fielding 1995, Gregg et al 2000, Mitchell et al 1998, Petranick and Berg 1997, Stevens and Olson 2000). Physical activity has been demonstrated to improve muscle strength, aerobic power, flexibility, and balance; help improve quality of life; maintain function; and decrease the risk of falls and fall-related injuries (Barnett et al 2003, Campbell et al 1999, Gregg et al 2000, Mitchell et al 1998). Conversely, physical activity can increase the opportunity for a fall to occur (Gregg et al 2000) and the perceived risk of falling is a recognised barrier to exercise (Tinetti et al 1988).

Research has indicated that fall prevention programs should include multifactorial interventions such as behavioural modification, education (Clemson et al 2004), and physical activity, in order to address both intrinsic and extrinsic falls risk factors (Gillespie et al 2004, Salkeld et al 2000, Stevens and Olson 2000). Risk factors for falls include increasing age, muscle weakness, functional limitations, environmental hazards, use of psychoactive medications, and a history of falls (Gregg et al 2000, Newton 1995, Stevens and Olson 2000). Important elements in fall prevention programs include education and skill building to increase knowledge about fall risk factors, physical activity to improve strength and balance, home modifications to reduce fall hazards, and medication assessment to minimise side-effects (Guelich 1999, Stevens and Olson 2000).

Water is a supportive, low risk exercise environment that may reduce the likelihood of acute injury and fear of falling while improving participation and adherence (Hauer et al 2002, Skelton and Dinan 1999). The water environment may be beneficial to individuals who are frail, suffer from pain, are severely kyphotic, or have poor balance, such as the osteoporotic population (Forwood and Larsen 2000). One of the few studies that compared water to land-based activity showed greater improvement in functional reach in the aquatic environment (Simmons and Hansen 1996). It was hypothesised that these findings may be attributed to increased confidence and reduced fear of falling in water.

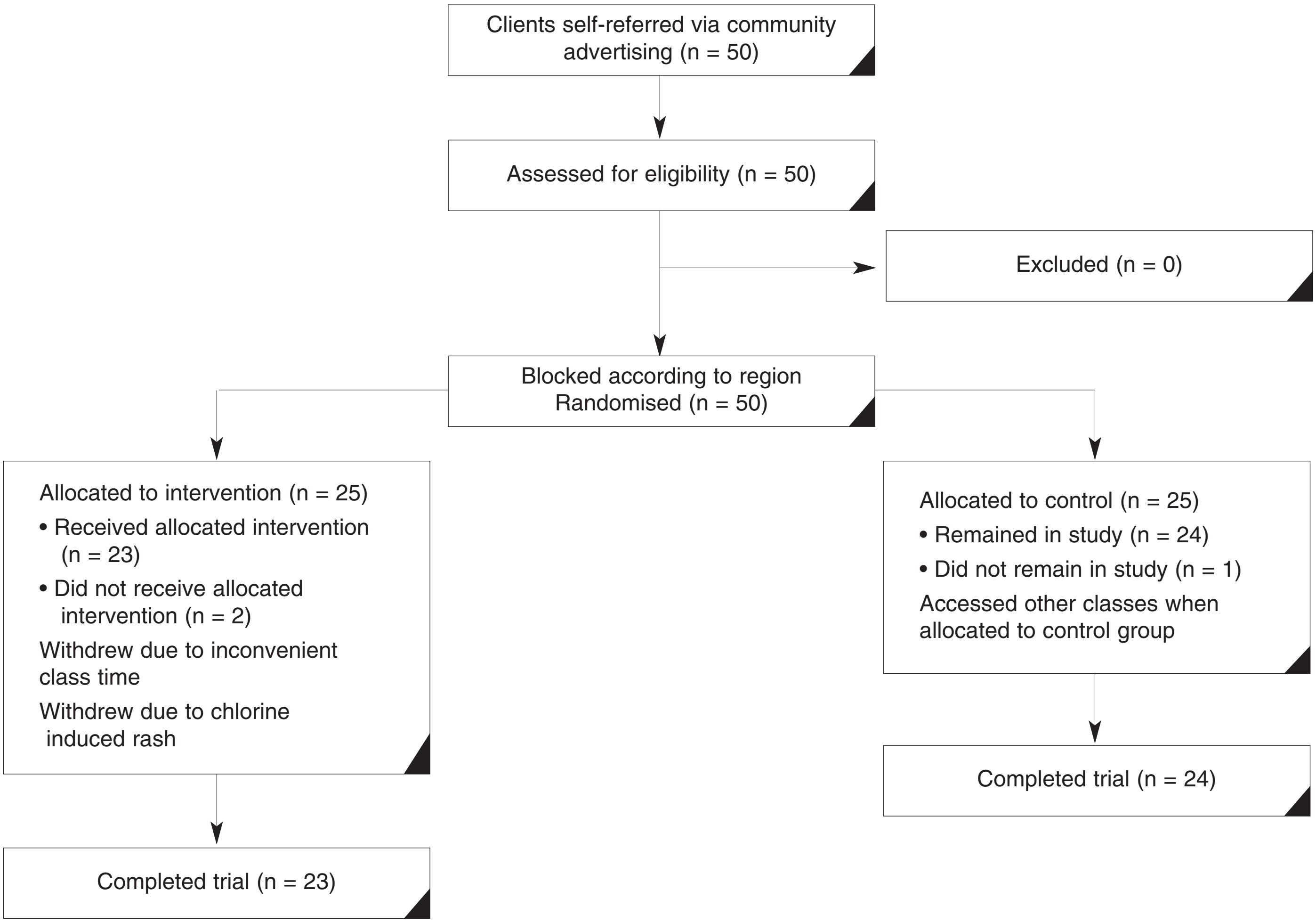

Figure 1. Client flow chart.

Aquatic exercise enables participants to exercise safely in a group setting with less supervision. In this time of limited health funding this setting may be more economically efficient. It is acknowledged that water-based exercise does not enhance bone strength. This study explored the effects of a water-based exercise and self-management program on balance, fear of falling, and quality of life in community-dwelling women 65 years and over.

Method

Study population This study involved a sample of 50 community-dwelling women 65 years of age or older with a diagnosis of osteopenia or osteoporosis and an average age of 73.3 years (range 65.5 to 82.4 years, SD 3.94) residing in the Metropolitan and Peel Regions of Western Australia. Subjects were recruited from June 2002 to December 2002 by self-referral in response to advertising on radio and in community newspapers, community health centres, and seniors' centres.

Subjects were excluded if they lived outside the Metropolitan or Peel Regions of Western Australia, were aged less than 65 years, unable to read, write or understand English, cognitively impaired (determined by the Mini Mental State Examination: MMSE < 23), with standard contraindications to hydrotherapy (Larsen et al 2002), marked uncorrected hearing or visual impairment, or had Meniere's Disease, benign paroxysmal positional vertigo (BPPV), Parkinson's disease, or neurological dysfunction. No subjects were excluded on the basis of these criteria (see Fig. 1). Subjects were blocked according to residential address (north of the river, south of the river and Peel) and then assigned to control or intervention groups using a concealed randomisation method utilising sealed envelopes. A senior physiotherapist from Community Physiotherapy Services enrolled the participants and coordinated the randomisation and allocation.

Prior to initial assessment and randomisation, volunteers completed a Community Physiotherapy Enrolment Form and their general practitioner completed a standard Community Physiotherapy Services Referral/Medical Profile form. Medical profiles and MMSE were utilised to screen for exclusion criteria. The study was approved by Royal Perth Hospital and Curtin University of Technology Human Research Ethics Committees and all subjects provided written informed consent.

Assessment procedure Initial and final assessments were conducted at the community aquatic centres. Assessment consisted of two self-administered questionnaires (SF36 and Modified Falls Efficacy Scale: MFES) and a physical assessment (Step Test). Assessors followed standardised step test instructions. Pre- and post-testing occurred at a similar time of day for each participant to account for diurnal variance. The MFES and SF36 were self administered with written instructions. The follow-up assessment was completed within one week of completion of the program. Assessing physiotherapists were not the treating therapists.

Although the intent was that assessing physiotherapists should be blinded to the group allocation for assessments, group allocation often became apparent as a result of subjects' comments.

Step Test (ST) Hill et al (1996a) suggested that there is no single clinical test of balance that accurately reflects its multidimensional nature and that clinical balance assessment should evaluate a number of tasks incorporating both static and dynamic aspects of balance. The ST is a test of dynamic standing balance. The subject is instructed to stand in front of a step 7.5 cm high without hand support. Whilst standing on one leg, they are asked to place the other foot completely onto the step and return it to the floor as many times as possible over a period of 15 seconds. The test is repeated on the other leg and the total number of completed steps is recorded for each leg (Hill et al 1996a). Step Test has high test-retest reliability, with intraclass correlation coefficients (ICC) > 0.90 in 14 healthy elderly and > 0.88 in 21 stroke subjects (Hill et al 1996a). Concurrent validity of ST was demonstrated by significant correlations ($p < 0.001$) between performance on the ST and functional reach (r = 0.68–0.73), gait velocity (r = 0.83) and stride length (r = 0.82–0.83) (Hill et al 1996a). As with locomotion, the ST places demands on both lower limbs as well as the trunk throughout the test. From these results, Hill et al (1996a) suggested that the ST would be sensitive to changes in performance over time and as such has the potential to discriminate change as a result of an intervention.

The ST, with its ease of clinical use and minimal equipment necessary for testing, fulfils the need for a balance test that utilises movement patterns and postural adjustments similar to those required during locomotion (Hill et al 1996a). Competent performance on the ST requires adequate strength, coordination and sensorimotor control of the stepping leg, as well as strength and lateral weight shift abilities of the stance leg to maintain a stable base of support while efficiently transferring weight between the legs (Hill et al 1996a). The portability and functionality of this test made it appropriate to the community setting of this study.

Modified Falls Efficacy Scale (MFES) It is important to assess fear of falling as it may confound when measuring postural performance, and deterioration in the physical ability to balance may result from activity restriction mediated through fear of falling (Powell and Meyers 1995). The MFES is a 14-item 'balance efficacy' questionnaire that measures a person's confidence in their ability to avoid a fall during each of 14 essential, non-hazardous activities of daily living (ADLs) (Hill et al 1996b). A higher score indicates greater independence or ability to balance. The MFES scale has been found to be internally consistent and demonstrates good test–retest reliability, (Hill et al 1996b). One potential limitation of the scale is the potential for a ceiling effect in higher-functioning seniors (Cumming et al 2000, Salkeld et al 2000).

Short Form 36 The SF36 health survey is a 36-item questionnaire with eight domains: physical function, role limitations due to physical functioning, bodily pain, general health, vitality, social functioning, role limitations due to emotional problems, and general mental health (Hall et al 1999, Hemmingway et al 1997). The questionnaire has been widely researched since 1988 and found to have good internal consistency and construct validity (Jenkinson et al 1999).

Intervention The intervention group undertook a 10-week water-based exercise and self-management program compiled by Community Physiotherapy Services and conducted by a physiotherapist, at a community aquatic centre twice a week for one hour between July 2002 and April 2003. Physiotherapists attended a training workshop to learn the relevant exercises. The control group did not receive any instructions and were not encouraged to change their physical activity, ADLs or social habits during the study.

The class comprised warm-up, stretches, aerobic, Tai Chi, strength, posture, gait, vestibular, proprioception, and balance activities (50 minutes in total) and education (10 minutes). The aims of the activities undertaken in the class were to increase dorsiflexion, knee flexion, hip extension, and stride length; improve ankle proprioception, trunk stability, contralateral coordination, and stimulate righting reactions and the vestibular system. Balance and vestibular tasks were performed in functional positions in water and practised in meaningful ways with decreased risk of injury compared to land. Exercises for the lower limbs, particularly for the hip flexors, quadriceps, and ankles were emphasised as they may be clinically important in improving toe clearance during the swing phase of the gait cycle (Dominguez and Bronstein 2000). Land-based Tai Chi movements were transferred to the water environment to enable subjects to perform activities they may not be able to achieve on land. Tai Chi has been demonstrated to improve flexibility, muscle strength, and balance and decrease the risk of falls in older people (Li et al 2001). Currently no studies have demonstrated the effects of water-based Tai Chi.

Self-management topics related to osteoporosis, medications, footwear, physical activity, goal setting, home exercise programs, and falls risks and hazards in the over 65 age group were facilitated by the physiotherapist during the pre-exercise 10-minute education period on dry land and reinforced while exercising. Education sessions utilised self-assessment questionnaires, checklists, group brainstorming, goal setting, and exercise diaries to promote self-management. Self-management strategies have been shown to be effective in conditions affecting seniors such as falls, arthritis, and pain (Keefe et al 1996, Lorig et al 2001).

Statistical analysis and sample size All subjects were given an identifying number for the purpose of data entry. Data from each subject were collected on a summary sheet, then entered into a spreadsheet and cleaned. The data was analysed using SPSS (v11). Control and intervention groups were tested for equivalence at baseline using unpaired *t*-tests. For each subject who completed the follow-up assessments, the change in each of the variables measured was calculated (i.e. post-score minus pre-score). Independent samples *t*-tests were used to compare the change scores for control and intervention groups. Intention to treat analysis was implemented, that is data from all subjects who completed the study were analysed with the group they were randomised to, regardless of the participant's adherence to their group allocation. Where variance for the two groups differed the

Table 1. Pre- and post-intervention means and standard deviations (SD), mean (SD) changes, and mean between-group differences and their 95% confidence intervals (CI).

	Control		Intervention		Mean change (SD)		Mean between-group difference	95% CI of the difference	
	Pre	Post	Pre	Post	Control	Inter-vention		Lower	Upper
Step test									
Left	15.6 (3.4)	15.6 (3.3)	13.0 (3.6)	15.6 (3.2)	0.0 (1.0)	1.8 (1.8)	1.7	0.9	2.6
Right	15.4 (3.3)	15.8 (3.3)	13.3 (2.8)	15.8 (3.4)	0.4 (1.1)	2.5 (2.1)	2.1	1.1	3.1
FES	10.0 (0.4)*	10.0 (0.0)*	9.9 (1.8)*	10.0 (1.4)*	0.03 (0.5)	0.3 (1.2)	0.25	-0.3	0.81
SF36									
Physical function	67.1 (23.3)	63.4 (20.5)	60.6 (24.0)	64.6 (23.0)	-4.6 (13.5)	3.9 (14.1)	8.6	0.4	16.8
Role physical	56.5 (40.7)	56.5 (45.3)	42.4 (44.9)	56.5 (45.4)	0 (31.9)	16.3 (44.3)	16.3	-6.7	39.3
Bodily pain	62.9 (24.1)	66.4 (24.9)	55.6 (63.5)	63.5 (23.0)	3.6 (17.6)	7.8 (23.2)	4.3	-7.8	16.5
General health	61.6 (19.0)	62.4 (17.8)	62.7 (15.1)	59.8 (15.1)	0.7 (11.6)	-2.9 (15.1)	-3.6	-11.9	4.6
Vitality	58.5 (18.6)	56.5 (21.7)	58.8 (21.1)	68.9 (17.0)	-1.9 (14.4)	10.1 (18.2)	12.0	2.3	21.8
Social function	83.7 (22.1)	84.8 (23.8)	73.4 (26.2)	88.6 (18.0)	1.1 (11.2)	15.2 (29.7)	14.1	0.6	27.7
Role emotional	69.7 (42.3)	71.2 (41.5)	63.6 (43.5)	80.3 (32.0)	1.5 (28.3)	16.7 (45.7)	15.2	-8.1	38.4
Mental health	79.9 (15.2)	79.5 (17.6)	75.9 (17.5)	85.6 (10.6)	-0.4 (10.9)	9.8 (16.2)	10.2	2.0	18.4

*Data are medians (interquartile range). Other data are means (SDs).

separate-variance *t*-test was used. As the dependent variables and associated hypotheses had been developed a priori there was no adjustment for multiple comparisons.

A priori sample size calculations were based on the ST. In this test, healthy adults aged > 60 years scored a mean (SD) of 18 (4) steps and the developers of the test consider a difference of three steps between the affected and unaffected limbs of patients with stroke to reflect considerably greater difficulty (Hill et al 1996a). On the basis of this information and assuming alpha = 0.05 and single-tailed power = 80%, it was estimated that a sample of 50 subjects would be sufficient to detect a 3-point difference between groups at the completion of the intervention, allowing for a 10% drop out rate.

Results

Control and intervention groups were comparable at baseline for all variables except the ST on the right side where the control group performed better than the intervention group (mean difference two steps, $p = 0.02$). Three subjects did not complete the final assessment, representing a dropout rate of 6% (Fig. 1). One subject in the control group withdrew as a result of choosing to participate in alternative physical activity options. One subject in the intervention group withdrew due to inconvenient class time and the other due to an adverse skin reaction to chlorine. There were no statistically significant differences between those who did and did not complete the intervention for any of the baseline measures ($p > 0.3$). Apart from the two subjects who withdrew from the study, all subjects randomised to the intervention group attended at least 80% of the scheduled sessions.

Step Test There was a larger improvement in the step test in the intervention group than in the control group on the left

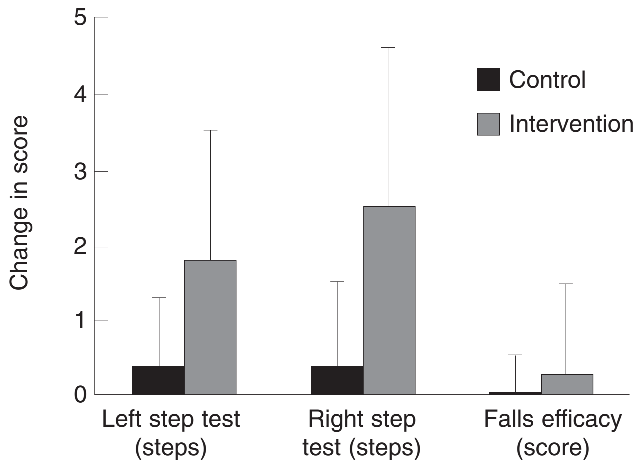

Figure 2. Mean (SD) change in left and right Step Test (steps) and falls efficacy scale (score). There was significantly greater improvement in the step test in the intervention group than the control group ($p < 0.01$). Changes in the falls efficacy scale were minimal in both groups.

($t_{33.6} = 4.2$, $p < 0.001$) and right sides ($t_{33.5} = 4.2$, $p < 0.001$) (Fig. 2, Table 1).

Modified Falls Efficacy Scale No statistically significant differences were found between groups in the change from baseline to follow-up in the MFES. ($t_{44} = 0.89$, $p = 0.38$) (Fig. 2, Table 1).

Short Form 36 The change from baseline to follow-up differed between the intervention and control groups for the

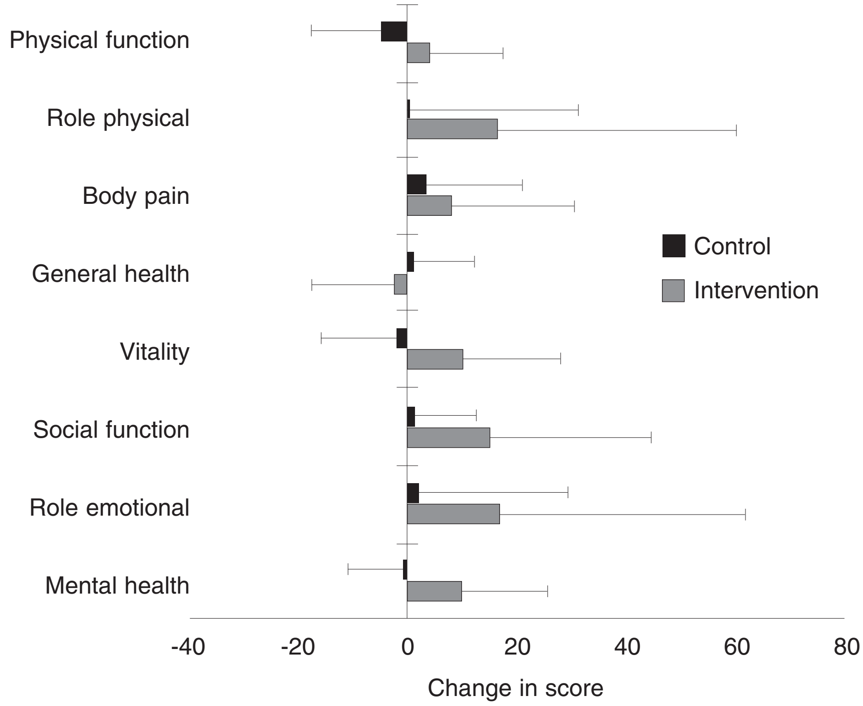

Figure 3. Mean (SD) change in the eight SF36 domains. Improvement was significantly greater in the intervention than control groups in physical functioning, vitality, social function, and mental health domains ($p < 0.04$). There was no difference in change between groups in the other domains.

SF36 domains of physical functioning ($t_{44} = 4.3$, $p = 0.04$), vitality ($t_{44} = 2.5$, $p = 0.02$), social functioning ($t_{28} = 2.1$, $p = 0.04$), and mental health ($t_{44} = 2.5$, $p = 0.02$). No differences were found for the domains of bodily pain ($t_{44} = 0.7$, $p = 0.49$), general health ($t_{42} = 0.9$, $p = 0.38$), role emotional or role physical (Fig. 3, Table 1).

Discussion

This study demonstrated significant improvements in left and right ST performance and physical functioning, vitality, social functioning, and mental health domains of the SF36 quality of life questionnaire. No significant difference was demonstrated between groups with respect to the MFES.

Step-test results indicate that this water-based, multifaceted group intervention resulted in significant improvement in dynamic standing balance. These balance changes concur with Simmons and Hansen's (1996) findings where greater improvement in functional reach occurred in subjects who had exercised in the aquatic environment. The aquatic environment is beneficial for populations with musculoskeletal problems that may represent a barrier to land-based exercise. Water-based physical activity enhances balance and coordination, while stimulating, visual, vestibular, and perceptual systems. Buoyancy reduces stress on joints and muscles and enables greater range of movement via supporting the weight of the body, changing depth allows for progression of resistance and warm water increases muscle efficiency (Skelton and Dinan 1999).

The aquatic environment challenges strength and balance control systems, enabling subjects with intrinsic falls risk factors to exercise safely in functional positions. Challenges to balance in the aquatic environment appear to improve dynamic standing balance on land. This is supported by motor learning literature, where learners demonstrated the ability to transfer what they had learnt across different practice conditions and/or movement skills (Rose and Clark 2000). Standing balance training, if sufficiently dynamic in nature, might also foster positive improvements in functional activities that combine elements of dynamic balance and overall mobility (Rose and Clark 2000).

Exercise and physical activity should be considered not only as a means of reducing falls, but also of reducing the fear of falls and depression, both of which are common among fallers (Tinetti et al 1994). In the area of balance rehabilitation, efficacy or confidence boosting may be as important as physical training itself (Powell and Meyers 1995). This study utilised the low-risk water environment to reduce the acute risk and fear of falling during exercise (Forwood and Larsen 2000). Tai Chi in the water was included to address the issue of fear (Skelton and Dinan 1999). Identification and modification of environmental and personal risks may also help reduce the fear of falling (Snowden et al 1996). Subjects used self-assessment tools to identify risks. Weekly goal setting and diary review was utilised to address modifiable risks.

No significant difference was demonstrated between groups with respect to the MFES, although clinically subjects were observed to increase the range of movement during striding and reaching activities. Qualitative information in subjects' diaries and course feedback also indicated increased confidence to prevent falls and an increase in physical activity levels, though no significant improvement was evident with the MFES. The MFES has been demonstrated to have a potential ceiling effect in higher-functioning seniors (Powell and Meyers 1995). The results of this study would tend to support this statement, in that a majority of subjects' baseline scores were at or approaching the maximum per task score of 10, leaving little opportunity for improvement as the result of the intervention. The MFES result suggests that the subjects in this study may be representative of seniors with a higher self-efficacy than anticipated and this may have occurred as a result of sampling bias resulting from the self-referred recruitment process.

Significant improvements were demonstrated in physical functioning and the mental health domains of the SF36 of vitality, social functioning, and mental health. Group interaction and socialisation resulting from the intervention may influence these psychological domains. The control groups did have the formalised social interaction that may account for some psychosocial effects observed. Petranick and Berg (1997) found that if subjects gained a positive attitude via socialization and group support in a supervised setting, there may be a better chance of adherence at home. Adherence to an exercise regime is necessary in order to mediate the functional and physiological changes desired. Qualitative information in diaries also indicated many subjects found the group setting was motivational. Would a water-based intervention be as effective if done individually? Further study could compare group-based and individual treatment outcomes.

The multifaceted intervention had many components that could have influenced Mental Health domains. Self-management strategies and life skills including goal setting and review and researching local physical activity opportunities may have had an impact on quality of life. Increased physical activity is also associated with improvement in quality of life (Gregg et al 2000). Lepore et al (1998) proposed that aquatic activity produces increased self-esteem, improved mood, decreased depression and anxiety. Also Skelton and Dinan (1999) have described Tai Chi as 'another way of increasing confidence by reducing fear of falling ... (via) its combination of safe tranquil, achievable, low impact moves, improved breathing patterns and increased feeling of wellbeing'.

Limitations and recommendations for future research Limitations of this study include the relative short-term nature of the study, potential sampling bias as a result of self-referral in the recruitment process and the assessor not being blinded to the group allocation. Recommendations for future research include a comparison of land- and water-based exercise groups with regard to objective measures and adherence. Longer-term follow-up is needed to determine the effect on incidence of falls, adequately address the issue of maintenance of between-group differences over time and differing length of participation to determine if there is an optimal time frame and frequency for improvement. Groups with varying levels of physical function and MFES scores could also be randomised to water exercise, land exercise or a combination of both to determine optimal clinical pathways. In addition, the effects of Tai Chi in water warrant investigation. Further studies utilising a greater range of balance tests could also identify components of balance most affected by water-based interventions.

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