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ORIGINAL ARTICLE

Aquatic Exercise Training is Effective in Maintaining Exercise Performance in Trained Heart Failure Patients: A Randomised Crossover Pilot Trial

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Background Providing flexible models and a variety of exercise options are fundamental to supporting long-term exercise participation for patients with heart failure (HF). The aim of this pilot study was to determine the feasibility and efficacy of aquatic exercise training during a maintenance phase for a clinical heart failure population.

Methods In this 2 x 2 crossover design trial, individuals who had previously completed HF rehabilitation were randomised into either a land-based or aquatic training program once per week for six weeks, after which time they changed to the alternate exercise training protocol for an additional six weeks. Six-minute walk test (6MWT), grip strength, walk speed, and measures of balance were compared for the two training protocols.

Results Fifty-one participants (43 males, mean age 69.2 yrs) contributed data for the analysis. Both groups maintained function during the follow-up period, however improvements in 6MWT were greater in the land-based training group (95% CI: 0.7, 22.5; p=0.038), by a mean difference of 10.8 metres. No significant difference was observed for other parameters when the two training protocols were compared.

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Conclusion Attending an aquatic exercise program once per week is feasible for patients with stable HF and may provide a suitable option to maintain functional performance in select patients.

Keywords Heart failure • Cardiomyopathy • Exercise training • Aquatic exercise • Hydrotherapy

Introduction

The benefits of exercise training for individuals with stable heart failure (HF) are well established [1]. Traditionally, training is undertaken in a hospital or community gymnasium for a period of 8 to 12 weeks, with the exercise program prescribed by experienced clinicians in accordance with current guidelines [2]. Once rehabilitation is complete, ongoing participation in regular exercise is recommended for all individuals in order to maintain health benefits. Despite the clear benefits of sustained exercise participation, it remains a worldwide challenge for many clinicians, with numerous authors reporting poor adherence during the follow-up period [3–6]. The HF ACTION trial for example, which is the largest exercise training trial conducted in patients with HF, reported only 30% of individuals achieved recommended exercise targets at 3 and 12 months follow-up [7].

Exercise adherence is a complex domain influenced by multiple factors [4,8]. For some individuals, structured, group exercise classes in the maintenance phase have proven beneficial [9,10]. For others, the type of exercise prescribed may be an important factor [11]. Some of the exercises commonly included in traditional programs for example (exercise bikes, treadmills), may not be enjoyable or may not be seen to be functionally relevant by some participants, which may thus impact upon exercise adherence [11]. Additionally, frailty, chronic pain and multiple co-morbidities are common in this population [12] and may thus preclude participation in traditional group programs. Providing structured, alternative exercise opportunities in the maintenance phase, that are perceived to be relevant, pleasurable and easily undertaken, may enhance long-term exercise participation [9,11]. Aquatic exercise may be one such option.

Aquatic exercise, (exercise conducted in thermoneutral water (33.5–35.5 °C)) has been shown to benefit a number of rheumatological [13], respiratory [14] and balance disorders [15]. It has only been in recent years that the benefits for those with HF have been advocated. Recent small studies suggest that in appropriately selected patients with stable HF, aquatic-based exercise rehabilitation may improve a number of outcomes [16]. To date however, studies investigating aquatic exercise training in HF patients remain few, methodology is highly variable, and outcome measures have predominantly focussed upon physiological parameters. Functional measures specific to patients who are frail or elderly have not yet been examined, and the role of aquatic exercise training in maintaining benefits following HF exercise rehabilitation, is yet to be explored.

The purpose of this pilot study was to determine the feasibility of implementing aquatic exercise training in a clinical HF population. For the purposes of this study, training was implemented during a maintenance phase following HF rehabilitation and efficacy was compared to a traditional land-based training program. The outcomes of this study were those functionally relevant to a clinical HF population with the primary outcome being submaximal exercise capacity and secondary outcomes included grip strength, gait speed and measures of balance.

Methods

Participants

Individuals with stable HF were recruited from Heart Failure Services at two large, tertiary teaching hospitals in Brisbane, Australia, during 2010 and 2013. Participants were eligible for inclusion if they had left ventricular dysfunction of any cause, were diagnosed by echocardiography, and they had recently completed a 12-week, land–based exercise rehabilitation program at one of the participating sites. Eligible participants were identified by the clinical staff of the HF Service at each site. For those interested, further information was provided by a blinded assessor who completed the consent process. All participants were on appropriate pharmacological therapy and had stable HF symptoms for the preceding three months. Participants were excluded if they had decompensated HF or any other condition that precluded them from undertaking the aquatic program, such as an active skin condition, chlorine sensitivity, incontinence, active infection or an acute inflammatory or heat sensitive condition.

Design

The study was conducted as a 2 x 2 crossover trial using participants as their own controls. Study participants were randomised at baseline into one of two maintenance exercise training protocols which included either land-based or aquatic exercise training, with randomisation defining the program in which individuals commenced. Training was undertaken in groups of six to eight attendees, with participants remaining in their same group throughout the duration of the study. Since one participating hospital was unable to provide the two exercise programs (aquatic + land-based training) concurrently, randomisation took place by a sealed envelope allocation at one centre and a block randomisation at this second facility.

All assessments were undertaken by the external assessor, blinded to the training protocol and the order in which participants undertook their training. Assessments were conducted at baseline, week 7 following the initial program and week 14, following the alternative training program. The

study complied with the Declaration of Helsinki and was approved by the Human Research Ethics Committee at both participating sites.

Intervention

Programs took place at each hospital in either the hospital gymnasium or heated pool, and were prescribed and progressed by the HF physiotherapist at each centre, and an accredited exercise physiologist at one of the centres. Staff at each site were highly experienced in prescribing exercise to patients with HF and both physiotherapists also had significant experience with respect to aquatic exercise training. Specialist HF nursing staff assisted in collecting pre and post session observations as well as providing supervision during the training sessions at both sites.

Training programs were conducted once per week for a period of six weeks, during which time individuals were also encouraged to undertake their usual level of physical activity. Participants commenced in their allocated maintenance training program (land-based or aquatic) followed by a one-week break prior to commencing in the alternative training intervention for a further six weeks. This training frequency was selected as a means of replicating usual clinical practice as precisely as possible. As such, consideration was given to a realistic attendance for this often frail population in a maintenance phase of their rehabilitation, as well as the practicalities and resources of a busy clinical setting.

Sessions were one-hour duration and included a warm-up and cool-down period which included walking and stretching activities. Following the warm-up, individually prescribed upper limb and lower limb endurance and resistance exercises were undertaken for 45 minutes by means of moderate intensity interval training. Whilst some exercises varied depending upon the individual's condition, participants undertook approximately six to seven different exercises, of which 30 minutes was dedicated to endurance training, and the remaining 15 minutes to resistance training.

For land-based training, participants used traditional equipment such as treadmills, exercise bikes, steps, free weights and multi-station resistance equipment. Balance activities were included as indicated. As it is not standard practice for HF patients in Australia to undergo a cardiopulmonary exercise test prior to commencing rehabilitation, exercise intensity was prescribed and monitored using a rating of perceived exertion (RPE) [17] of 9–14. All participants had previously completed a HF rehabilitation program and were thus very experienced with using this scale. For endurance activities, exercise duration was progressed on a weekly basis with intensity adjusted to maintain an RPE between 9 and 14. For resistance exercises, repetitions were progressed to three sets of 20 repetitions prior to increasing the load.

Exercises in the aquatic program were replicated as closely as possible to those performed on land with the aim of achieving a similar intensity (i.e. 9–14 RPE). Cycling, for example, was undertaken using floatation equipment and steps were used for stepping exercises. Equipment such as hand paddles and floatation rings were used to provide resistance and the speed of activities was modified to control exercise resistance and intensity. Pool temperature was maintained between 33–34° C and participants exercised at a depth with water at chest level.

Outcome Measures

Submaximal exercise capacity was measured using the 6MWT. This was performed according to recommended procedure, on a 30-metre track, with standard encouragement provided every minute [18]. Grip strength was measured using a hand held dynamometer (Saehan SH5001, Masan, Korea). For this measure, participants were positioned in a upright sitting position with the elbow 90° flexed by their side. Three trials were performed on each arm with the highest (best) result in kilogram strength recorded for the purposes of analysis. Ten-metre walk speed [19] was measured on a 14-metre flat track. To account for acceleration and deceleration effects during this test, the time in seconds taken for the participant to walk only the middle 10 metres of the track was recorded. Participants were asked to undertake the test at both a comfortable ''like a walk in the park'' and fast ''like hurrying for a bus'' pace. Two tests were performed for each test using their usual walking aid and the fastest (best) result for each test was recorded. Balance was measured using the Balance Outcome Measure for Elder Rehabilitation (BOOMER) [20]. This validated tool is a global measure of standing balance incorporating four commonly used balance tests including the Timed Up and Go Test (TUGT), Functional Reach Test (FRT), step test and the static standing with eyes closed test. Performance for each test is scored on a scale ranging from 0 to 4, with a maximal (best) possible score of 16.

Additional patient information including demographics, aetiology of HF, left ventricular ejection fraction (LVEF) and relevant past medical history, was obtained through patient interview and review of hospital medical records. Attendance and completion of sessions was recorded for each individual on a separate recording form each week. Blood pressure, heart rate, oxygen saturation, body weight blood glucose (in those with diabetes) and body weight were also recorded on this same recording form prior to and following each exercise session. Finally, survey data was collected from all participants to record perceptions about both training environments and in a small subset of patients, facilitators and barriers to participation were explored in more detail through formal patient interviews. Results of these will be reported elsewhere.

Data Analysis

Participants' demographic and clinical characteristics are summarised using standard descriptive statistics and compared between the two allocated groups using chi-square or

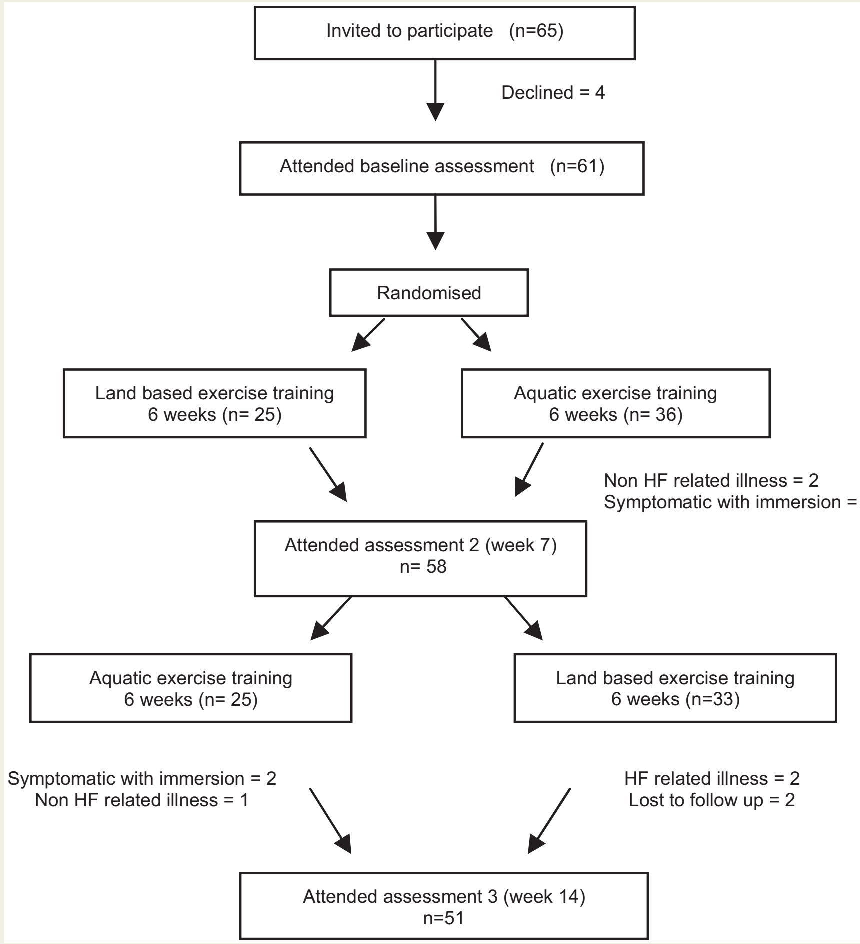

Figure 1 Flow diagram of study participants.

Fisher's exact test and t-tests, as appropriate for the categorical and continuous variables.

Change in outcomes for period 1 (baseline to week 7) and period 2 (week 7 to week 14) were described for each allocation group. The effect of treatment (aquatic or land-based exercise), period 1 or 2 (defined above), and sequence (order of treatment administration) of the treatment allocation for each of the six functional outcomes were analysed using the general linear model. Treatment, period, and sequence were assumed as fixed effects and subject-within-sequence was treated as a random effect in the model. Mean values with 95% confidence intervals for each of these functional outcomes were estimated and compared by the two treatment interventions. Accounting for a dropout rate of 15% and assuming alpha 0.05 and 80% power, 50 participants were calculated as being necessary to detect the minimally important difference for 6MWT distance in this study.

Results

Sixty-five individuals were identified as being eligible to participate in this study, four of whom declined on the basis of not wishing to exercise in water. Of the 61 individuals who consented to participate, 3 were unable to complete due to non HF related illness, 3 withdrew after becoming symptomatic with immersion, 2 withdrew due to an exacerbation of HF unrelated to the exercise training, and 2 were lost to follow-up (Figure 1). Fifty-one participants therefore contributed data for the analyses, of which 32 were from one facility and 19 from the other. Baseline characteristics of these participants are presented in Table 1. With the exception of age, there was no significant difference in measured characteristics between the two randomised groups. Participants were predominantly male, and most commonly had New York Heart Association (NYHA) class II symptoms, ischaemic aetiology, and a number of co-morbid conditions including atrial fibrillation, chronic obstructive pulmonary disease (COPD) and diabetes mellitus. Mean age was 69.2 +/- 11.6 years. Participants attended both programs similarly, with a mean attendance of 5.1 sessions for the aquatic training and 5.3 sessions for land-based training.

As demonstrated in Table 2, the effect of sequence (order of treatment administration) was non-significant for all outcome measures, indicating that the order in which the interventions were undertaken did not influence results. Period

Table 1 Baseline characteristics of participants.

Selected Characteristics	Overall sample (n=51) Mean (95% CI)	Aquatic then Land-based exercise (n=29) Mean (95% CI)	Land-based then Aquatic exercise (n=22) Mean (95% CI)	p-value
Age (yr)	69.2 (66.0,72.5)	72.9 (69.7,76.1)	68.3 (64.0,74.0)	0.01
Gender, n (%)	43 (84.3)	26 (81.3)	17 (89.5)	0.44
Male				
HF aetiology, n (%)				
Ischaemic	28 (54.9)	15 (51.7)	13 (59.1)	
Dilated CMP	15 (29.4)	7 (24.1)	8 (36.4)	0.17
HFPEF	8 (15.7)	7 (24.1)	1 (4.5)	
NYHA, n (%)				
I	3 (5.9)	2 (6.9)	1 (4.5)	
II	41 (80.4)	22 (75.9)	19 (86.4)	0.66
III	7 (13.7)	5 (17.2)	2 (9.1)	
AF, n (%)	17 (34.0)	10 (34.5)	7 (33.3)	0.93
COPD, n (%)	17 (33.3)	9 (31.0)	8 (36.4)	0.69
OSA, n (%)	9 (17.6)	3 (10.3)	6 (27.3)	0.15
DM, n (%)	15 (29.4)	10 (34.5)	5 (22.7)	0.36
CKD, n (%)	6 (11.8)	4 (13.8)	2 (9.1)	0.69
PVD, n (%)	4 (7.8)	2 (6.9)	2 (9.1)	1.00
LBP, n (%)	4 (7.8)	3 (10.3)	1 (4.5)	0.63
Depression, n (%)	6 (11.8)	4 (13.8)	2 (9.1)	0.69
	394.6 (359.0, 430.3)	375.1 (319.2, 430.9)	419.5 (377.6, 461.5)	0.22
6MWT (m)				
Grip Strength (kg)	30.2 (27.4, 33.2)	29.3 (25.5, 33.1)	31.3 (26.0,36.6)	0.53
TUG (secs)	9.4 (8.2, 10.7)	9.9 (8.1, 11.7)	8.8 (7.1, 10.5)	0.39
BOOMER	13.8 (13.2, 14.5)	13.9 (13.0, 14.8)	13.7 (12.6, 14.8)	0.80
Walk speed time (secs)				
Comfortable pace	9.0 (8.1, 9.9)	9.6 (8.2, 11.1)	8.1 (7.3, 8.9)	0.09
Fast pace	7.1 (6.3, 8.0)	7.6 (6.3, 9.0)	6.4 (5.8, 7.2)	0.17

CMP = cardiomyopathy; HFPEF = HF with preserved ejection fraction; AF = Atrial fibrillation; COPD = Chronic obstructive pulmonary disease; OSA = obstructive sleep apnoea; DM = Diabetes mellitus; CKD = Chronic Kidney Disease; PVD = Peripheral vascular disease; LBP = Low back pain; 6MWT = 6 Minute walk test; TUG = Timed up and go test; BOOMER = Balance Outcome Measure for Elder Rehabilitation

Table 2 Statistical significance of functional outcomes due to period and sequence.

Major functional outcome	Period (p-value)	Sequence (p-value)
6 minute walking distance (m)	0.057	0.457
Grip Strength (kg)	0.495	0.637
TUG (secs)	0.040*	0.533
BOOMER	0.062	0.699
Walk speed (secs)		
Comfortable pace	0.007*	0.093
Fast pace	0.412	0.131

Period = timing of treatment administration, Sequence = order of treatment administration, TUG = Timed Up and Go; BOOMER, Balance Outcome Measure for Elder Rehabilitation

*p-value < 0.05

effect was statistically significant for TUG and walk speed performed at a comfortable pace. As depicted in Supplementary Figure 1, improved performance was observed in period 2 for both parameters. This same trend was observed for all other outcomes. The non-significant effect of sequence justified the crossover design. Analysis was undertaken by using pooled data for all participants (n=51), adjusted for period and sequence to estimate the overall treatment effect of the two training protocols.

Table 3 illustrates the overall treatment effect of the training protocols for each outcome measure. Overall, functional measures were maintained or slightly improved throughout the 14-week follow-up period, regardless of initial allocation. Land-based training was associated with a slightly longer walking distance compared to the aquatic training protocol with a mean difference of 10.8 metres (95% CI: 0.7, 22.5, p=0.038). Figure 2 illustrates the change in 6MWT distance according to training protocol, for the three assessment time

Table 3 Mean with 95% confidence interval and significance for the treatment of aquatic and land-based exercise.

Major functional outcome	Baseline Mean (95%CI)	Aquatic exercise Mean (95%CI)	Land-based exercise Mean (95%CI)	p value
6MWT (metres)	394.6 (359.0, 430.3)	395.4 (387.7, 403.0)	406.2 (399.3,414.6)	0.038*
Grip Strength (kg)	30.2 (27.4, 33.2)	31.1 (30.2,32.0)	30.9 (30.0,31.8)	0.751
TUG (secs)	9.4 (8.2, 10.7)	9.1(8.9,9.4)	8.9 (8.7,9.2)	0.206
BOOMER	13.8 (13.2, 14.5)	13.8(13.5,14.1)	14.0 (13.7,14.3)	0.301
Walk speed (secs)				
Comfortable	9.0 (8.1, 9.9)	8.6 (8.3,8.9)	8.6 (8.4,8.8)	0.883
Fast pace	7.1 (6.3, 8.0)	7.1(6.9,7.4)	7.1 (6.8,7.3)	0.706

6MWT = 6 Minute walk test; TUG = Timed Up and Go; BOOMER = Balance Outcome Measure for Elder Rehabilitation
*p-value < 0.05 land versus aquatic training

points. There was no significant difference in outcomes between aquatic and land-based training for any of the other functional parameters.

Discussion

This study demonstrated that conducting weekly, supervised, aquatic exercise training in a clinical setting is feasible for a select group of HF participants who had recently completed a land-based rehabilitation program. To the authors' knowledge, this is the largest trial of aquatic exercise conducted in this population to date. Both training programs were equally well attended, and for all outcomes performance was maintained throughout the study duration. For the primary outcome of 6MWT, there was a statistically greater improvement in the distance walked with land-based training, by a difference of 10.8 metres. The clinical relevance of this finding however, is questionable since the minimal important difference for this parameter is 36 metres in this population [21]. Slightly greater functional gains were observed in the second period for all parameters. This occurred regardless of the order in which the interventions were undertaken and perhaps reflects the cumulative effect of longer exercise participation.

The consideration of aquatic exercise as a mode of exercise training has current clinical relevance. With the strong evidence for exercise training, it is now recommended that all patients with HF have access to specialist exercise interventions [22]. Whilst traditional centre-based rehabilitation programs provide an ideal environment in which to provide this training and support, poor uptake has led exercise clinicians to seek alternative models in which to engage these patients [4]. This is particularly relevant for select patient groups such as females, who are not only less likely to be referred to rehabilitation compared to their male counterparts, but who are also less likely to complete these programs [23]. In the current study, 84% of participants were male. Whilst this is not dissimilar to previously reported studies [8], it is possible that the requirement of study participants to have previously completed HF rehabilitation in our study, may have further concentrated the number of male participants. Barriers to participation, such as exercising in a swim-suit, must also be considered a contributing factor, however it was not the experience in this study.

Maintaining functional performance over time is an important result. Unless an individual continues to partake in regular aerobic activity, the benefits of exercise training are short-term only. From the few studies that report the rate of decline in exercise capacity following HF rehabilitation, it is known that detraining can occur within as little as three to six weeks [24,25]. There was little clinical improvement observed in this study over the 12 weeks, which may have been the consequence of individuals being recruited following an intense period of rehabilitation. Importantly there was also no deterioration in measured outcomes over this same period which would suggest that as a maintenance program, whose primary aim was to prevent deterioration in performance, both aquatic and land-based programs were similarly effective.

Attending a structured program as little as once per week was sufficient to maintain exercise performance, regardless of exercise type. Similar results have been reported in

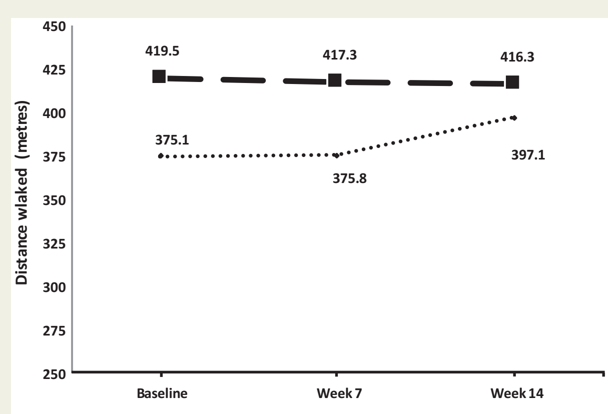

Figure 2 Change in 6MWT according to training protocol and time.

previous studies in which exercise training less than twice per week was sufficient to maintain health benefits [7,26]. Furthermore, as exercise outcomes are dose dependent, recommendations relating to specifics such as frequency, intensity and duration are often targeted for best outcomes. This may deter less active individuals. Tailoring advice to enhance participation and thus lessen sedentary behaviour should also be encouraged [27].

Three participants withdrew from the aquatic program due to symptoms which occurred during the training sessions. One participant with concomitant oxygen dependent COPD, experienced increasing shortness of breath when in the water. For two participants, dizziness was the primary symptom and occurred immediately upon first immersion on each individual's first attendance. Both participants had a history of biventricular HF and moderate to severe tricuspid regurgitation. These cases are similar to a case described by Svealv et al., in 2012 [28]. In this case report of a patient with biventricular failure, echocardiography during immersion demonstrated a reduction in right ventricle (RV) systolic function and an increase in RV pressure. The patient experienced no symptoms other than a perception of feeling cold for several hours afterwards. These haemodynamic changes led the authors to propose that aquatic exercise training may not be safe for those with biventricular failure and pulmonary hypertension. Our experience would appear to support this finding.

There are several limitations to our study. As aquatic training is not commonly employed as an exercise intervention for patients with HF in Australia, the sample was carefully selected and a conservative approach was undertaken in order to ensure safety. This conservative approach may have resulted in a low training stimulus. Whilst the majority of participants were recruited to the study immediately following their rehabilitation program, there was a small number for whom there was a delay, the duration of which was not recorded. Additionally, as the training duration was for a 12-week period only, we are unable to comment on the effect of the interventions beyond this time. A small difference in age was noted at baseline between the two randomised groups, however since all individuals completed both training programs and there was no sequence effect, it is unlikely that this influenced results. Furthermore, heated pools are not commonplace in many health facilities, thus limiting generalisability of results, however referral to appropriately tailored aquatic programs in the community may be a valid and worthwhile option for clinicians. Finally, we did not capture systematic data on other exercise being undertaken by participants at home.

Despite these limitations, this study adds to the practical application of aquatic exercise for HF patients. This study was conducted in a ''real world'' clinical setting using patients recruited to standard heart failure rehabilitation programs. Participants who attended the aquatic exercise training were not disadvantaged for doing so, when compared to the traditional land-based training program.

Conclusion

This pilot study demonstrates that it is feasible for aquatic exercise training to be undertaken in stable HF patients during a maintenance phase in a clinical setting. Attending one session per week was sufficient to maintain functional performance throughout the study duration. Future studies are warranted to further explore aquatic exercise as a viable option for HF rehabilitation, in particular, as a stand-alone intervention. Improved understanding of the haemodynamics and physiology of HF in the aquatic environment may help to enhance patient selection and exercise intensity to optimise this promising mode of exercise training.

Conflicts of Interest

There are no conflicts of interest.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.hlc.2016.10.017.

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