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Review

Aquatic exercise training and stable heart failure: A systematic review and meta-analysis☆

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ABSTRACT

Aim: A meta-analysis and review of the evidence was conducted to determine the efficacy of aquatic exercise training for individuals with heart failure compared to traditional land-based programmes.

Methods: A systematic search was conducted for studies published prior to March 2014, using MEDLINE, PUBMED, Cochrane Library, CINAHL and PEDro databases. Key words and synonyms relating to aquatic exercise and heart failure comprised the search strategy. Interventions included aquatic exercise or a combination of aquatic plus land-based training, whilst comparator protocols included usual care, no exercise or land-based training alone. The primary outcome of interest was exercise performance. Studies reporting on muscle strength, quality of life and a range of haemodynamic and physiological parameters were also reviewed.

Results: Eight studies met criteria, accounting for 156 participants. Meta-analysis identified studies including aquatic exercise to be superior to comparator protocols for 6 minute walk test ($p < 0.004$) and peak power ($p < 0.044$). Compared to land-based training programmes, aquatic exercise training provided similar benefits for VO_{2peak}, muscle strength and quality of life, though was not superior. Cardiac dimensions, left ventricular ejection fraction, cardiac output and BNP were not influenced by aquatic exercise training.

Conclusions: For those with stable heart failure, aquatic exercise training can improve exercise capacity, muscle strength and quality of life similar to land-based training programmes. This form of exercise may provide a safe and effective alternative for those unable to participate in traditional exercise programmes.

1. Introduction

Exercise training is a recommended component of the comprehensive management of patients with heart failure (HF). Exercise based rehabilitation programmes have consistently shown positive improvements in patient symptoms, exercise capacity and quality of life, and a possible impact upon hospital readmissions and mortality [1,2].

Traditional land-based training programmes however, may not be suitable for all patients. The frail elderly and those with co-morbid conditions including chronic pain, orthopaedic or balance disturbances for example, may find these programmes difficult, contributing to lower levels of physical activity participation [3]. Aquatic exercise (exercise conducted in thermoneutral [32–34 °C] water) has been proposed as a possible alternative for these patients. The warm water and low weight bearing environment reduce pain, and using the principles of hydrodynamics, allows exercise to be undertaken which may improve postural stability, exercise capacity and walking endurance [4–7].

Historically, aquatic exercise has not been recommended for individuals with HF. Immersion in warm water leads to an increase in venous return as a consequence of hydrostatic pressure. Clinicians have long been concerned that this increase in central blood volume and cardiac preload may not be tolerated by those with HF, leading to worsening of symptoms and a reduction in exercise capacity [8]. This potential risk has hampered trials and there are currently no clear recommendations for clinical practice. Recent small studies however, have demonstrated that patients with stable HF not only tolerate immersion and exercise in this environment, but also benefit from a number of physiological sequelae [9–11]. The purpose of this systematic review and meta-analysis was to determine the effect of aquatic exercise training on a variety of functional and physiological outcome measures in this population. Specifically, the study sought to determine functional benefits of aquatic exercise compared to usual activity and/or land-based exercise in people with heart failure.

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2. Methods

2.1. Search strategy and study selection

MEDLINE, PUBMED, Cochrane Library, CINAHL and PEDro databases were searched using the key words "aquatic exercise" OR "hydrotherapy" OR "water exercise" AND "heart failure" OR "cardiomyopathy", OR "ventricular dysfunction". The search was limited to studies published prior to March 2014 in any language. Identified titles and abstracts were independently scrutinised by two reviewers (JA and JP) and reference lists were assessed for additional relevant articles that met criteria. Full text articles were extracted and independently reviewed by both reviewers when required, and any further disagreement was resolved by discussion between reviewers.

Randomised controlled trials, pseudorandomised controlled trials, trials with historical controls and single group studies were included in the review. Case studies, didactic articles and narrative reviews were excluded. Studies were accepted if they included an aquatic exercise intervention of at least two weeks duration, conducted in a heated pool. Only trials that recruited adult patients with left ventricular dysfunction (reduced or preserved ejection fraction) were accepted. For intervention groups, training included either aquatic exercise alone or aquatic + land-based training. Comparator groups included land-based training, usual activity or no exercise. As single group studies were included in the review, it was also possible for there to be no comparator group. Exercise activities conducted in spas, sauna baths or other non-hydrotherapy pools were also excluded. Included studies were independently scored for quality by the two reviewers using the validated PEDro scale [12]. Original authors were contacted for clarification of material or to provide missing data when required.

2.2. Outcome measures

The primary outcome measure was change in exercise performance measured using either peak oxygen consumption (VO_{2peak}), six minute walk test (6MWT) or peak power. Secondary outcomes included change in muscle strength, cardiac dimensions, haemodynamic parameters (including cardiac output, systemic vascular resistance and blood pressure), brain natriuretic peptide (BNP) and quality of life (QoL).

2.3. Data synthesis

Comprehensive Meta-analysis software™ was used to compare results between studies. For continuous variables, effect size for each individual study was determined using the Hedges g model, by calculating the difference between changes in the intervention group and comparator group by the pooled standard deviation. The data were pooled using the fixed effect model, however when heterogeneity was statistically significant, (Q statistic $p < 0.01$), the data were reanalysed using the random effects model. Meta-analyses were conducted for VO_{2peak}, peak power and 6MWT. Due to insufficient studies reporting on specific outcomes, heterogeneity of methodology and lack of availability of some raw data, meta-analysis was not possible on other parameters.

3. Results

3.1. Studies included in the review

Of the 73 papers identified, 37 were immediately excluded on the basis of duplication. An additional 12 abstracts were excluded based upon criteria, leading to a review of 24 full text articles. Of these, 16 were excluded for the purposes of not being clinical trials, investigating alternative outcome measures or for not including a water based exercise intervention of greater than two weeks duration. As demonstrated in the flow diagram in Fig. 1, this systematic review and meta-analysis was conducted on the eight remaining studies, which included five randomized controlled trials (RCTs) [9–11,13,14], two pre–post test design studies without a control group [15,16] and one prospective cohort intervention with follow-up [17]. Six of the eight studies originated from two research centres, thus decreasing generalisability. All studies were published in English.

3.2. Study quality and participants

Quality scores for included studies are listed in Table 1. Main concerns included lack of assessor blinding [9–11,13–17], allocation to groups not being concealed [11], no documented evidence of outcome measures being obtained from >85% of participants [10] and no documented evidence of "intention to treat" analysis [10].

Baseline characteristics for the eight included studies are depicted in Table 2. Studies were relatively small (n = 12–25), and the overall total number of participants was 156. The study groups were well matched for participant numbers, age, gender, left ventricular ejection fraction (LVEF) and HF aetiology. Participants were predominantly male (n = 139) with mean age 52–70 years. All participants had heart failure with reduced ejection fraction (HFREF) which in most studies this was defined as LVEF <40–45%, whilst one study recruited only those with LVEF <35% [16]. Aetiology of HF was defined in all but one study [16], and included ischaemic (n = 95) and dilated (n = 39) cardiomyopathies. Studies mostly recruited participants with NYHA II–III symptoms. Participants with co-morbid disease, including orthopaedic or neurological conditions, were excluded from three of the eight studies [9–11].

3.3. Study design

Training parameters for each study are reported in Table 3. All protocols were undertaken by experienced exercise professionals at local health facilities with water temperature maintained between 30 °C and 34 °C. Depth of immersion varied and was either fixed (1.3 m) [13–15], or individualized to the level of the xiphisternum [11] or the neck [9,10,16]. Immersion depth was not defined in one study [17] and humidity was not reported in any of the included studies.

Training protocols varied between studies. The aquatic intervention was confined to a water programme in only half of the studies with the exercise duration for these being 45 min. In the remaining four studies, the intervention included a combination of both aquatic and land-based training, the latter being 30 min of cycle ergometry. Heterogeneity also existed for the length of the programme, varying from three weeks to 24 weeks. In each of the short duration programmes, participants trained for either four [15] or five days per week [13,14,16], compared to three times per week in longer programmes.

Protocols predominantly consisted of endurance training prescribed at an intensity of 40–70% maximum heart rate reserve (HRR) or 50–70% VO_{2peak}. Resistance training was included in two studies [9,10].

3.4. Comparator protocols

Comparator protocols also varied. For the four studies that employed an isolated aquatic intervention, two were compared to usual activity [9,10], one used participants as self-controls following a period of no exercise [17] and there was no comparator in one study [16]. For the combined interventions (aquatic + land training), three of these studies compared outcomes to a land-based intervention alone [11,13,14], whilst the remaining study used self-controls as the comparator [15]. In each of the combined interventions (aquatic + land), exercise intensity was matched across the two environments and total duration of exercise was equal for participant groups.

3.5. Summary of findings

Meta-analysis was conducted for the primary outcomes of VO_{2peak}, peak power and 6MWT (Fig. 2). Secondary outcomes were unsuitable