Evidence-based systematic review of the effectiveness of hydrotherapy in acute and chronic medical conditions.

Dr. Gordon Doig,
Senior Lecturer in Intensive Care,
University of Sydney
www.EvidenceBased.net

gdoig@med.usyd.edu.au

Dr. Gordon Doig,
Senior Lecturer in Intensive Care,
Northern Clinical School,
University of Sydney,
Sydney, NSW
gdoig@med.usyd.edu.au

ISBN: 978-0-9756039-2-5
Title: Evidence-based systematic review of the effectiveness of hydrotherapy in acute and chronic medical conditions.
Edition: First
Author/Contributor: Doig, Gordon S;
Date of Publication: 31 July 2008
Format: WEB
Size: 297x210
No. of Pages: 36
Publisher: EvidenceBased.net, Sydney, NSW, Australia

gdoig@med.usyd.edu.au

gdoig@med.usyd.edu.au

Introduction

The purpose of this systematic review was to identify and summarise the evidence from randomised controlled trials supporting the use of hydrotherapy (aquatic exercise, pool therapy) in acute and chronic medical conditions. For the purposes of this review, no limits were set on water temperature but to be considered as *hydrotherapy*, some form of exercise had to be conducted in pool water.

This document is organised by medical condition. An overall summary of findings is presented for each condition. The conclusions of major published systematic reviews are presented where appropriate. The results of all identified randomised controlled trials are presented individually such that the reader can draw their own conclusions.

This review does not address issues relating to balneotherapy (spa hot tub or mineral spring treatment typically above 34^{o}C with no exercise), aqua-fitness for obesity, pregnancy or in healthy people, labour pools, water immersion, baths, sitz baths, whirl pools or other water based interventions that do not require a pool.

Search strategy.

Medline was searched using Pubmed up to 29 July 2008.

1) search for systematic reviews

(("hydrotherapy"[MeSH Terms] OR hydrotherapy[Text Word]) OR "aquatic exercise"[All Fields] OR "pool therapy"[All Fields]) AND systematic[sb]

On 29 July 2008, this search identified 41 potentially eligible papers.

2) search for recent RCTs

(("hydrotherapy"[MeSH Terms] OR hydrotherapy[Text Word]) OR "aquatic exercise"[All Fields] OR "pool therapy"[All Fields]) AND (randomized controlled trial[Publication Type] OR (randomized[Title/Abstract] AND controlled[Title/Abstract] AND trial[Title/Abstract]))

On 29 July 2008, this search identified 73 potentially eligible papers.

The reference lists of retrieved reviews (1-13) and additional unpublished reviews (14), were searched by hand.

Conference abstracts were not eligible for consideration in this review. Abstracts do not present enough detailed information regarding study methods and results to allow reliable appraisal and interpretation.

gdoig@med.usyd.edu.au

Economic evaluation

The best economic evaluations are driven by the results of a randomised controlled trial. If a well designed randomised controlled trial establishes a difference in clinical outcomes, comprehensive costing can be undertaken to determine the true costs associated with the observed improvement in outcome. Two papers were identified that based economic evaluations of hydrotherapy upon RCTs (15;16).

Summary of findings

Hydrotherapy may cost in excess of US$50,000 per quality adjusted life year gained. US$50,000 per quality adjusted life year is commonly accepted as a threshold for interventions considered to be prohibitively expensive (15).

Economic evaluation in Osteoarthritis

This economic analysis (15) randomised 249 participants with arthritis to the treatment or control groups using a stratified randomisation process.

Persons in the treatment group were directed to an Arthritis Foundation certified aquatic class. The aquatic program, run by certified instructors, is held in pools with a temperature of 85° F to 92° F. Participants engage in gentle upper- and lower-body activities to help increase joint flexibility and range of motion, and maintain muscle strength. Treatment group participants were asked to attend class at least twice weekly for the 20-week study period.

Participants in the control group were asked to follow their usual pattern of activities and to abstain from new exercise programs for the duration of the study.

Using non-active controls not receiving additional land-based exercises would tend to over-estimate the benefits of aquatic exercise.

A significant mean difference between groups was found for the participant-specific Current Health Desirability Rating score with the treatment group reporting a higher mean rating after class, whereas the mean rating for the control group declined. Treatment group scores were also significantly improved for the disability measure of the Health Assessment Questionnaire and the physical domain score of the Perceived Quality of Life scale.

Based on the observed magnitudes of clinical benefit, the authors calculated the cost-effectiveness of hydrotherapy for arthritis in excess of US$50,000 per additional quality adjusted life-year gained.

A subgroup analysis of this trial (12) focussed on the incremental cost-effectiveness in patients older than 60 (17). This 106 patient subgroup selected from the original 249 patient trial appeared to have a larger greater treatment effect, as measured by the Western Ontario and McMaster Universities Osteoarthritis (WOMAC) index.

Due to the larger treatment effect seen in this subgroup analysis, the incremental cost-effectiveness ratio for patients over 60 was calculated to range from £3838 to £5951 per quality-adjusted life-year (QALY) gained in comparison to usual care.

It is important to note that the authors report “uncertainty inherent in the data meant that the latter had wide 95% confidence intervals such that it was not possible to determine a ceiling valuation (with 95% confidence) for comparison with competing approaches.” Due to this issue, the overall costs of this program may be prohibitively expensive.

Economic evaluation in Fibromyalgia

Costs to the health care system and to society were considered in this study (16) of included 33 participants, randomly assigned to a hydrotherapy group (*n* = 17) or a control

gdoig@med.usyd.edu.au

group (*n* = 16). The intervention in the experimental group consisted of a 1-hour, supervised, water-based exercise sessions, three times per week for 8 months. Each QALY gained in association with the exercise programme cost an additional € 3,947/QALY (95% CI: 1,782 to 47,000) for a health care perspective and € 7,878/QALY (3,559 to 93,818) from a societal perspective.

The upper limit of € 47,000 per additional QALY marks this intervention as potentially prohibitively expensive.

Neurologic or Musculoskeletal Disease (Meta-analysis of trials conducted in hip/knee osteoarthritis, rheumatoid arthritis, fibromyalgia, multiple sclerosis and lower back pain)

A comprehensive systematic review published in 2008 by **Hall et al** (13) investigated the effects of hydrotherapy across different medical conditions. This systematic review conducted an extensive literature search that included 18 electronic databases. It identified 19 relevant RCTs which have been reviewed and are reported individually by medical condition in this document.

Summary of findings

Comparing hydrotherapy to no intervention, pooling trials across medical conditions **Hall et al** found a small post treatment pain relief effect in favour of hydrotherapy (*P*=0.04; standardised mean difference [SMD], -0.17; 95% confidence interval [CI], -0.33 to -0.01). **Hall et al** cautions the reader that "it was not possible to draw a firm conclusion about this effect because of the lack of consistency of evidence across studies".

Pain-relieving effects were found to be similar between aquatic and land based exercise (*P*=0.56; SMD=0.11; 95% CI, -0.27 to 0.50).

Overall, **Hall et al** conclude, "there is sound evidence that there are *no differences* in pain-relieving effects between aquatic and land exercise".

Hip and Knee Osteoarthritis

Two thorough, recent systematic reviews (2;11) were identified. They included three RCTs (18;19;20). Ten additional RCTs (21-30) were identified by the primary search. All thirteen RCTs were retrieved and reviewed.

Summary of findings

A systematic overview published in 2008 by **Dziedzic et al** (11) reviewed all other systematic reviews on the topic and concluded that there "is strong evidence for the effectiveness of therapeutic [land-based] exercise for patients with osteoarthritis". **Bartels et al** (2) conducted a review of clinical trials noted there is a lack of high-quality studies of hydrotherapy in this condition.

The presence of "strong evidence" supporting land exercise establishes land exercise as the appropriate comparison group against which to evaluate the incremental benefits of hydrotherapy.

Of the thirteen RCTs reviewed, six (18;19;22;28-30) RCTs compared water exercise to land exercise and failed to find a significant difference between water and land exercise. One trial compared water exercise to electro-acupuncture (20) and concluded "electro-acupuncture and hydrotherapy, both in combination with patient education, induce long-lasting effects, shown by reduced pain and ache and by increased functional activity and quality of life, as demonstrated by differences in the pre- and post-treatment assessments." A second trial compared hydrotherapy to Tai Chi (21) and concluded, "Access to either hydrotherapy or Tai Chi classes can provide large and sustained

gdoig@med.usyd.edu.au

improvements in physical function for many older, sedentary individuals with chronic hip or knee osteoarthritis."

Because of multiple study groups in certain RCTs, nine papers provide a comparison of hydrotherapy to *no exercise* control groups (19-21;23-28). Eight of the nine papers demonstrate some form of benefit in the hydrotherapy group compared to *no exercise* controls. One paper only showed benefit to land-based exercise compared to the *no exercise* controls. Land based exercise (18;19;22;28), electro-acupuncture (20) and Tai Chi (21) have all been demonstrated to have a positive effect compared to *no exercise* controls.

Hydrotherapy has not been shown to be superior to land-based exercise, electro-acupuncture or Tai Chi.

Systematic Review of RCTs

A comprehensive review of the literature was conducted by **Bartels et al** (2) in 2007.

Compared to *no exercise* controls, patients with combined knee and hip osteoarthritis demonstrated a small-to-moderate effect on function (SMD 0.26, 95% confidence interval (CI) 0.11 to 0.42) and a small-to-moderate effect on quality of life (SMD 0.32, 95% CI 0.03 to 0.61) immediately after exercise. There was no evidence of effect on walking ability or stiffness and no differences at 6 month follow-up with regards to pain, function, stiffness, mental health or quality of life.

This systematic review identified only one trial that compared aquatic exercise with land-based exercise. Immediately after treatment, there was a large reduction in pain in favour of hydrotherapy (SMD 0.86,95%CI 0.25 to 1.47; 22% relative percent improvement), but no evidence of effect on stiffness or walking ability.

RCTs comparing water exercise to land exercise

In 2008, **Lund et al** (28) randomised 79 patients with knee osteoarthritis to: 1) aquatic exercise (n = 27), 2) land-based exercise (n = 25) or 3) control (n = 27).

Both the aquatic and land-based exercise programs consisted of the following parts: warm-up, strengthening/endurance exercise, balance exercise and stretching exercise. Each session lasted 50 min, comprising 10 min warm-up, 20 min resistance exercises, 10 min balance and stabilising exercises, 5 min lower limb stretches and 5 min cool-down period. Both exercise interventions were carried out for 8 weeks with 2 sessions per week.

No effect was observed immediately after exercise cessation (8 weeks). At 3-month follow-up a reduction in VAS pain was observed only in the land-based exercise group compared with control (–8.1 mm, 95% confidence interval –15.4 to –0.4; p = 0. 039). There were no differences between groups for Knee Injury and Osteoarthritis Outcome Score questionnaire. There were no improvements following aquatic exercise.

Only land-based exercise showed some improvement in pain and muscle strength compared with the control group, while no clinical benefits were detectable after aquatic exercise compared with the control group.

Sylvester (29) randomised 14 patients with hip osteoarthritis to: 1) hydrotherapy or: 2) short wave diathermy and exercises. Both groups performed hip and walking exercises for 30 mins twice a week for six weeks.

There were no significant differences between the groups prior to treatment.

Following treatment, pain had decreased significantly ($p < 0.02$) in both groups.

After treatment, there were no significant differences *between* the two groups with regards to pain, functional ability, life satisfaction, gait and range of motion .

gdoig@med.usyd.edu.au

Wyatt et al (30) randomised 46 subjects between the ages of 45 and 70 years with knee osteoarthritis to: 1) aquatic exercise or 2) land exercise.

Both exercise groups performed knee exercises 3 times a week for 6wk. The aquatic exercise was conducted in a 1.5m therapeutic pool at 32.2°C.

Both exercise groups showed a significant ($p < 0.05$) increase in all measurements between pre- and posttests.

There were no significant differences between the aquatic exercise group and the land-based exercise group pertaining to knee ROM, thigh girth, and time for a 1-mile walk.

Subjective pain levels were significantly less in the aquatic group when compared with the land-based group.

Green et al (18) randomised 47 subjects with OA of the hip to: 1) a regimen of home exercises or 2) twice weekly hydrotherapy for 6 weeks in addition to home exercises. There was an improvement seen in both subjective and objective measures in both groups however there were no significant differences between the two groups.

Foley et al (19) randomised participants into one of three groups: 1) hydrotherapy (n = 35), 2) gym (n = 35), or 3) control (n = 35). The two exercising groups had three exercise sessions a week for six weeks. At six weeks an independent physiotherapist unaware of the treatment allocation performed all outcome assessments (muscle strength dynamometry, six minute walk test, WOMAC OA Index, total drugs, SF-12 quality of life, Adelaide Activities Profile, and the Arthritis Self-Efficacy Scale). Functional gains were achieved with both exercise programmes compared with the control group.

Silva et al (22) randomly assigned 64 subjects with osteoarthritis of the knee to one of two groups that performed exercises for 18 weeks: a water-based exercise group and a land-based exercise group. The outcome measures included a visual analog scale (VAS) for pain in the previous week, the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), pain during gait assessed by a VAS at rest and immediately following a 50-foot (15.24-m) walk test (50FWT), walking time measured at fast and comfortable paces during the 50FWT, and the Lequesne Index. Measurements were recorded by a blinded investigator at baseline and at 9 and 18 weeks after initiating the intervention.

Based on inspection of the 95% confidence intervals presented in Table 3, 4 and 5 in the publication (22), there were no significant differences between groups in outcomes measured at 9 and 18 weeks.

RCTs comparing water exercise to electro-acupuncture

Stener-Victorin et al (20) randomised 45 patients, aged 42–86 years, with radiographic changes consistent with osteoarthritis in the hip, pain related to motion, pain on load, and ache to; 1) electro-acupuncture or, 2) hydrotherapy, both in combination with patient education, or 3) patient education alone.

Electro-acupuncture and hydrotherapy, both in combination with patient education, induced long-lasting effects, shown by reduced pain and ache and by increased functional activity and quality of life, as demonstrated by differences in the pre- and post-treatment assessments however there were no differences *between* the electro-acupuncture and hydrotherapy groups.

gdoig@med.usyd.edu.au

RCTs comparing water exercise to Tai Chi

Fransen et al (21) randomly allocated participants to 12 weeks of hydrotherapy classes (n=55), Tai Chi classes (n=56), or a waiting list control group (n=41).

The authors report changes over time but do not report comparisons between groups. Direct inspection of the 95% confidence intervals calculated around the estimates of change fail to show any difference between hydrotherapy and Tai Chi.

Overall, the authors conclude: "Access to either hydrotherapy or Tai Chi classes can provide large and sustained improvements in physical function for many older, sedentary individuals with chronic hip or knee osteoarthritis."

N.B. - Some sources reference the **Fransen et al** (21) paper as: "*Nairn F, Winstanley J, et al. Hydrotherapy and Tai Chi provide clinical improvements for older people with arthritis. Arthritis Care Res 2007; :407-414.*" Both references lead to the same paper.

RCTs comparing water exercise to no exercise

Wang et al (23) randomised 38 participants from community sources to a 12 week aquatic programme or a non-exercise control condition. The 12-week aquatic programme consists of warm up, flexibility and strength training, and cool down. The exercises are divided into six sections, as shown in Table 1. The 50-minutes class focuses on joints in the trunk, shoulders, elbows, wrists, fingers, hip, knees, ankles and toes, and emphasizes muscle groups of upper and lower limbs.

Control participants were asked to continue their physical activity as usual and offered an opportunity to participate in the aquatic programme at the end of the trial.

The aquatic exercise group responded to exercise. A more appropriate and relevant control group would have been dry land exercise of the same duration, intensity and frequency.

Belza et al (24) randomised 249 adults with osteoarthritis to: 1) a 20-week Arthritis Foundation Aquatic exercise Program (n=125) or 2) a wait-list control group (n=124). Participants in the control group were asked to follow their usual pattern of activities and abstain from starting new exercise programs for the duration of the study, after which they were invited to attend an AFAP free of charge.

Participants allocated to receive exercise responded to exercise. This trial does not provide an objective comparison between water based exercises and the appropriate comparator group, gentle land based exercises. No inferences can be drawn regarding the added value of conducting the exercises in water.

Hinman et al (25) randomised 71 volunteers with symptomatic hip OA or knee OA to: 1) an aquatic physical therapy group (n=36), or; 2) a wait-list control group (n=35).

The aquatic physical therapy program comprised functional weight bearing and progressive exercises provided twice weekly (45–60 minutes each) for 6 weeks. An experienced aquatic physical therapist individually instructed participants in the hydrotherapy pool (water temperature_34°C), with a maximum of 6 participants per session. Quality of movement was emphasised, and the therapist palpated the lower-limb musculature to ensure appropriate contraction throughout the exercises.

The control group did not receive any additional physical therapy over the 6-week trial; however, these participants were offered the intervention following the 6-week assessment to minimise dropouts from this group. Control participants were instructed to continue with their usual daily activities and medication regimen and not commence any new exercise programs or treatments for their OA affected joints.

gdoig@med.usyd.edu.au

The findings demonstrated that a 6-week, twice-weekly exercise program leads to reduced pain and joint stiffness as well as improved physical function, hip muscle strength, and quality of life in people with OA. Due to the lack of an active control group, it is difficult to draw inferences from these results.

Suomi et al (26) randomised women with lower extremity arthritis to: 1) an aquatic exercise group (n = 14) or; 2) no-exercise control group (n = 10).

Arthritis Foundation Aquatic Program (AFAP) classes were conducted in three 45-minute training sessions weekly for 6 weeks following AFAP guidelines. The instructor for all AFAP classes was a graduate adapted physical education student certified as an AFAP instructor, with 2 years of AFAP teaching experience.

Control subjects were asked to refrain from engaging in any organized physical activity program or beginning any new physical activity during the duration of the investigation.

The women with arthritis who followed an aquatic exercise program for 6 weeks significantly reduced their total sway area and their sway in the medial-lateral direction under the full vision condition; they also reduced their total sway area and their sagittal and medial-lateral sway in the no-vision condition.

The authors found these results difficult to explain: studies performed to date have not found significant relationships between attributes of arthritis and increased postural sway. The association of increased postural sway with age, however, is well established.

In the present study, the subjects in the exercise group were significantly older than subjects in the control group.

The authors speculate that the increased levels of sway in the medial-lateral direction under both visual conditions were likely a function of the difference in ages between the two groups rather than being attributable to the impact of the intervention on the effects of arthritis.

Soumi et al (27) randomised women to participate in: 1) a pool exercise group (n=20) or; 2) a no exercise control group (n=10).

The pool exercise group received the Arthritis Foundation Aquatic Program three times a week for six weeks in a pool heated to between 85-87^{o}F.

The control group received no intervention and were asked to refrain from taking up any additional exercise during the study period.

Three patients randomised to the pool exercise group ‘dropped out’ and outcomes are not reported for these patients.

The intervention group, which received more exercise than the control group responded to exercise. Hip abduction isometric strength and range of motion were increased significantly in the exercise group however there were no changes over time in shoulder abduction isometric strength or range of motion.

Mixed osteoarthritis and rheumatoid arthritis populations

There were three RCTs (31-33) conducted that enrolled mixed patient groups. Outcomes were not adequately described such that effects could be attributed to either condition.

Summary of findings

One study reported a difference in self-reported pain compared to a *no exercise* control group. No trials reported differences between land and water based exercise with

regards to functional outcomes, quality of life measures, activities of daily living or joint range of motion.

RCT evidence

In 1989, **Minor et al** (33) randomised a mixed group of RA and OA patients to: 1) aquatic exercise (n=47) or; 2) land-based walking exercise (n=36) or 3) control (n=32).

Both aquatic and land exercise groups exercised at 60-80% of their maximal heart rate for 60 minutes, three times a week for 12 weeks.

The control group performed non-aerobic range of motion exercises.

The aquatics and walking exercise groups showed significant improvement over the control group in aerobic capacity, 50-foot walking time, depression, anxiety, and physical activity after the 12-week exercise program.

There were no significant differences between the aquatic and land-based exercise groups.

In 2003, **Suomi et al** (31) randomised a volunteer sample of 30 men and women with arthritis (osteoarthritis, n=22; rheumatoid arthritis, n=8), to 8 weeks of: 1) an aquatic exercise (n=10); 2) on-land exercise (n=10); 3) or control group (n=10).

Participants received the National Arthritis Foundation (NAF) aquatic and on-land exercise programs on functional fitness and perceived ability to perform activities of daily living (ADL) measures in older adults with arthritis.

Control patients received no intervention.

Based on inspection of the 95% confidence intervals around the post-intervention outcomes, there appear to be no differences between land or water based exercise groups. Both NAF exercise programs appeared to be effective in improving functional physical fitness and perceived ability to perform ADL measures in older adults with arthritis compared to no intervention controls.

In 1995, **Ahern et al** (32) randomised 30 patients with rheumatoid arthritis or osteoarthritis who had just completed a four day course of hydrotherapy to receive: 1) hydrotherapy for six more weeks (n=22) or; 2) no intervention control group (n=8).

Hydrotherapy consisted of two group sessions per week for six weeks.

The control group received no intervention.

Self-reported pain was significantly improved in the water exercise group compared to the no exercise controls however this did not translate to a difference in self-reported function (illness Behaviour Questionnaire, the Stanford Health Assessment Questionnaire or the Frenchay Activities Index), quality of life (Zung self-rating depression scale) or target joint range of motion between groups.

Juvenile idiopathic arthritis

There was one well conducted RCT on this topic (34).

Summary of findings

This trial was commissioned by the National Health Service Research & Development Health Technology Assessment (HTA) Programme. The authors concluded that there “appears to be no evidence to justify the costs of building pools or initiating new services specifically for use in this disease.”

gdoig@med.usyd.edu.au

RCT evidence

In 2005 **Epps et al** (34) conducted a clinical trial commissioned by the National Health Service Research & Development Health Technology Assessment (HTA) Programme.

This multicentre randomised controlled, partially blinded, trial allocated 100 patients to a control arm receiving land-based physiotherapy only (land group) compared to 100 patients in an intervention arm receiving a combination of hydrotherapy and land-based physiotherapy (combined group).

Disease improvement was defined as a decrease of 30% or more in any three of six core set variables without a 30% increase in more than one of the remaining three variables. This primary outcome measure was assessed at 2 months following completion of the intervention.

Two months after intervention 47% patients in the combined group and 61% patients in the land group had improved disease with 11% and 5% with worsened disease, respectively. The analysis showed no significant differences in mean costs and QALYs between the two groups.

The trailists state that "there appears to be no evidence to justify the costs of building pools or initiating new services specifically for use in this disease."

Rheumatoid arthritis

A systematic review (4) conducted in 2004 identified only one clinical trial in this population (35). Four additional clinical trials were identified by the primary search (36-39).

Although the paper by **Stenstrom et al** (35) has been reported as a 'randomised trial' in many other reviews, this paper is **not** a randomised trial. Patients were allowed to choose whether they participated in a 4 year water exercise program or not. If a particular patient declined an invitation to participate in a 4 year water exercise program, they were allowed to remain at home and served as *no exercise* 'controls'. Because factors such as the patient's current fitness level or their current ability to participate in exercise activities may have influenced their decision to choose exercise or control, it is difficult to attribute any differences in outcomes between the two groups to the intervention under study. This is not a randomised controlled trial and cannot be considered in this review.

Summary of findings

Two trials compared hydrotherapy to land-based exercise and failed to find any long term differences in quality of life, health status, pain or functional scores.

One trial, published in 2005, compared a 12 week period of twice weekly pool exercises to *no exercise* and found the pool exercise group improved in most measures of exercise tolerance however there were no differences between groups with regards maximal aerobic capacity or the physical domains of the SF-36.

One trial compared 12 weeks of aquatic exercise to *no exercise* and found significant improvements in measures of pain.

RCTs comparing water to land-based exercise

In 2007 **Eversden et al** (36) randomised 115 patients with rheumatoid arthritis to: 1) a weekly 30-minute session of hydrotherapy or; 2) similar exercises on land for 6 weeks.

The exercise content in each group was similar and exercises were tailored to each individual's ability. Participants warmed up by mobilising and stretching. The core exercises were repeated each week and focussed on joint mobility, muscle strength and functional activities.

gdoig@med.usyd.edu.au

Eleven patients allocated land exercise failed to complete the six week course compared with four patients allocated to hydrotherapy (p = 0.09).

Significantly more patients treated with hydrotherapy reported feeling much better or very much better than the patients treated with land exercise (87% vs 47.5%, p < 0.001 Fisher's exact test) immediately on completion of the treatment programme.

This perceived benefit was not reflected by differences between groups in 10-metre walk times, functional scores, repeatable quality of life measures (Health Assessment Questionnaire, EuroQual Visual Analog Scale), measures of health status (EuroQual 5D utility score), or pain measured by a Visual Analog Scale.

In 1998, **Sanford-Smith et al** (37) randomised 24 subjects to receive 1) aquaerobics or 2) home exercises.

The aquaerobics program received group sessions three times a week for 10 weeks. Each 1 hour session was conducted in a hydrotherapy pool heated to 36^{o}C and consisted of a 15 minute warm up, 20-25 minutes of aerobics with a target of 70% maximum heart rate and 15 minute cool down.

Control group participants received a 10 week program including range of motion and isometric strength exercises.

Both groups demonstrated improvements over time in response to exercise using measures that are considered to be general indicators of disease severity [active joint count, erythrocyte sedimentation rate, the Stanford Health Assessment Questionnaire or self limiting maximal exercise (stress) test].

There were no differences *between* groups with regards to any outcome.

RCTs comparing water-based exercise to no exercise

Published in 2005, **Bilberg et al** (38) conducted a trial involving 46 patients with chronic RA who were randomly assigned to: 1) exercise in a temperate pool twice a week for 12 weeks (n=20) or; 2) no additional exercise (n=23).

The treatment group exercised twice a week for 12 weeks in groups of eight or nine patients in a temperate pool. Each session was 45 min long and of moderate aerobic intensity. It comprised exercises for aerobic capacity, dynamic (eccentric and concentric) and static muscle strength, and muscle endurance in the upper and lower extremities, flexibility, coordination and relaxation. The pace of the exercises was guided by music. The sessions were led by two alternating physiotherapists, who gave individual instructions to each patient if needed.

The control group received no additional interventions.

The primary study outcomes, aerobic capacity, estimated using a submaximum ergometer cycle, and the physical component of the SF-36 did not differ between groups.

At six month follow-up, the group randomised to receive additional exercises demonstrated improvements in measures of exercise tolerance: the chair test and the shoulder endurance test, with 10 of the 13 demonstrating significant improvement.

Since the control group did not receive additional exercises, it is impossible to determine whether the improvements observed in the intervention group are attributable to a general increase in exercise level in the intervention group or the fact the exercises were conducted in water.

In 1996, **Rintala et al** (39) randomised 34 patients with rheumatoid arthritis to: 1) aquatic exercise (n=18) or; 2) control (n=16).

gdoig@med.usyd.edu.au

The aquatic exercise undertook a routine to improve aerobic power, muscle strength, endurance, and joint mobility in sessions of 45 to 60 mins twice a week for 12 weeks.

The control group received no additional exercise.

The aquatic exercise group reported a significant reduction in pain compared with control.

Fibromyalgia

There was one well conducted systematic review of non-pharmacological interventions for fibromyalgia (5) and one systematic review of all types of exercise (10).

Ten RCTs evaluating the effects of hydrotherapy were identified and retrieved (40-45; 46;47-49).

Summary of findings

Published in 2008, the review by **Busch et al** (10) concluded "There is moderate quality evidence that short-term aerobic-only exercise training at ACSM-recommended levels has medium-size positive effects on global well-being and physical function." The finding that *exercise* improves outcome establishes land-based exercise as the relevant control group against which the incremental benefits hydrotherapy need to be established. **Busch et al** were unable to make specific recommendations regarding the role of aquatic exercise.

Three trials compared hydrotherapy with a land based exercise group (43;45;47). There were no reported differences between hydrotherapy and land-based exercise with regards to major outcomes: functional capacity, tender points or depression.

Five trials (40;42;44;46;48) compared water based exercise programs to control groups that received no additional exercise. Benefits reported by these trials may simply be attributed to the increased exercise level experienced in the water exercise group.

One trial compared hydrotherapy to balneotherapy (hot spa with no exercises) (49). The hydrotherapy group received exercise training and demonstrated significantly less depression.

A final trial compared hydrotherapy with conventional land-based physiotherapy and attempted to measure the relaxing effects of water-based exercise by measuring sleep time and quality of life (41). This trial found that there were no significant differences between the two groups with regards to quality of life or Total Sleep Time but Total Nap Time was significantly higher in the traditional land-based physiotherapy group post intervention.

RCT evidence: Hydrotherapy vs exercise control group

In 2006, **Assis et al** (43) assigned sixty sedentary women with fibromyalgia, ages 18–60 years, to: 1) either deep water running (DWR) or; 2) land-based exercises (LBE).

Patients were trained for 15 weeks at their anaerobic threshold. Visual analog scale (VAS) of pain, Fibromyalgia Impact Questionnaire (FIQ), Beck Depression Inventory (BDI), Short Form 36 Health Survey (SF-36), and a patient's global assessment of response to therapy (PGART) were measured at baseline, week 8, and week 15. Statistical analysis included all patients.

There were no significant differences between groups with regards to VAS, PGART, FIQ total score, SF-36 domains BDI or fitness at the end of the 15 week sessions.

Jentoft et al (47) randomised 34 subjects diagnosed with fibromyalgia to: 1) pool-based exercise (n=18) or 2) land-based exercise (n=16).

gdoig@med.usyd.edu.au

Pool (34^{o}C water temp) and land-based exercises were designed to be similar with regards to training intensity and the muscle groups activated. The aim of each program was to improve cardiovascular capacity with minimal risk of injury.

No between group differences were found with regards to functional capacity, symptom profile (Fibromyalgia Impact Questionnaire, VAS symptom severity scales, VAS pain) or self-efficacy (Arthritis Self-Efficacy Scale) after 20 weeks of exercise.

The land exercise group had improved their grip strength after 20 weeks compared with the pool exercise group (P = 0.02). No between-group differences were found in other variables.

In 2008, **Evcik et al** (45) published a 63 patient trial comparing: 1) an aquatic exercise program (n = 33) with; 2) a home-based exercise program (n = 30).

The aquatic exercise program was undertaken in a swimming pool at 33°C. Each session was conducted in groups of 7–8 patients, lasted 60 min and was conducted 3 times a week, over 5 weeks.

The control home-based exercise program was also a 60 min program and was conducted 3 times a week, over 5 weeks.

Both groups demonstrated significant improvements in pain VAS and Beck Depression Index (BDI) scores over time.

At the end of the trial, pain VAS was significantly lower (P < 0.001) in the pool exercise group however this did not translate to a difference between groups in measures of functional capacity (measured using the Fibromyalgia Impact Questionnaire), number of tender points, or BDI scores.

RCT evidence: Hydrotherapy vs sedentary control group

Mannerkorpi et al (44) randomised 58 patients to: 1) 6 months of pool exercise combined with a 6 session education program for patients with fibromyalgia syndrome or; 2) no intervention control.

The active treatment hydrotherapy patients were instructed to match the pool exercises to their threshold of pain and fatigue while their education sessions focused on strategies for coping with symptoms and encouragement of physical activity.

The control patients received no interventions.

Compared to the control group that received no intervention, the authors reported significant improvements in the Fibromyalgia Impact Questionnaire total score (p = 0.017) and the 6 min walk test (p < 0.0001). Significant differences were also found for physical function, grip strength, pain severity, social functioning, psychological distress, and quality of life in patients who received aquatic exercise.

It is difficult to tease out the individual effects of the hydrotherapy and the exercise promoting education. If the control group had received exercise and / or exercise promoting education, the inferences drawn would have been more robust.

In 2006, **Gusi et al** (40) randomly assigned 34 women to: 1) a hydrotherapy exercise group (n=17) to perform 3 weekly sessions of training including aerobic, proprioceptive, and strengthening exercises during 12 weeks, or; 2) a control group (n=17).

The hydrotherapy exercise group trained in a waist high warm pool (33°C) three times per week for 12 weeks. Each 1-hour session included 10 minutes of warming up with slow walks and mobility exercises, 10 minutes of aerobic exercises at 65–75% of maximal heart rate (HRmax), 20 minutes of overall mobility and lower-limb strength exercises (4 sets of 10 repetitions of unilateral flexion and extension of the knee at slow pace with the

gdoig@med.usyd.edu.au

body in a vertical position using water as resistance), another set of 10 minutes of aerobics at 65–75% HRmax, and 10 minutes of cooling down with low-intensity exercises. Heart rate was monitored with a pulse meter (Polar Accurex Plus; Polar Electro Oy, Kempele, Finland).

The control group continued to follow normal daily activities, which did not include any form of exercise related to those in the therapy.

The group receiving exercise was found to improve measures of exercise tolerance. A more appropriate and relevant control group would have been dry land exercise of the same duration and frequency.

In 2007, **Tomas-Carus et al** (42) randomised 34 females with fibromyalgia into two groups: 1) a hydrotherapy exercise group, who exercised for 60 min in warm water, three times a week (N = 17); and 2) a control group, who continued their habitual leisure-time activities (N = 17).

The group receiving exercise was found to improve measures of exercise tolerance. A more appropriate and relevant control group would have been dry land exercise of the same duration and frequency.

In 1999, **Gowans et al** (46) randomised subjects to: 1) an exercise program or; 2) to serve as waiting list controls.

The exercise program lasted 6 weeks and consisted of 2 exercise classes and 2 multidisciplinary educational sessions per week. Exercise classes were conducted in a warm, therapeutic pool and were 30 minutes long. Each class consisted of 20 minutes of walking/jogging/side-stepping/arm exercises against water resistance and 5 minutes of stretching at the beginning and end of each class. Educational sessions were one hour long and were run in a group setting, immediately prior to pool classes. During educational sessions, patients were provided with information on exercise, postural correction, activities of daily living, sleep, relaxation, medication, nutrition, and psychosocial coping strategies.

Control subjects received no interventions and were evaluated at baseline and 6 weeks following enrolment.

Forty-five subjects (23 intervention subjects, 22 waiting list control subjects) were randomised however three intervention group subjects were subsequently excluded from analysis for attending less than 50% of the program.

Six minute walk distance, FIQ “Feeling bad days” and FIQ “morning fatigue” were significantly better in patients who completed the exercise and education program as compared to control patients. Failure to provide some form of exercise and education to the control group makes it difficult to draw inferences from these findings.

In 2007, **Munguia-Izquierdo et al** (48) randomly assigned 60 women to either; 1) an exercise training group (n = 35) to perform 3 sessions per week of aquatic training (32ºC) including mobility, aerobic, strengthening, and relaxation exercises for 16 weeks or; 2) a control group (n = 25).

The exercise group trained in a chest high warm pool (32ºC) 3 times per week for 16 weeks. Each session included 10 minutes of warm-up with slow walks and mobility exercises; 10-20 minutes of strength exercises developed at slow pace using water and aquatic materials as resistance, including a stepped progression during the program; 20-30 minutes of aerobic exercises developed progressively at intensity sufficient to achieve 50-80% of predicted maximum heart rate (220 – age); and 10 minutes of cooling down with low-intensity and relaxation exercises.

gdoig@med.usyd.edu.au

The control group received no intervention.

Six exercise training group patients and one control patient were excluded from the final analysis.

At baseline, before the intervention began, the exercise group demonstrated a significantly lower pain threshold than the control group in 5 tender points ($p < 0.05$).

The authors present the results of changes over time in each group but do not conduct direct tests between groups. Based on the means and standard deviations presented in this paper, 95% confidence intervals have been calculated for this report to allow between group comparisons of major outcomes.

The authors report significant differences over time with regard to pain thresholds however they admit the exercise group started the trial with significantly lower pain thresholds at baseline. Due to this confounding, between group comparisons of these measures could not be re-calculated for this report.

Although there was a significant difference between groups with regards to tender point count (exercise group 95% CI 8.9 to 12.6 vs control group 95% CI 14.4 to 17.7), these findings did not translate to differences in global measures of functional capacity (FIQ score 95% CI 59.35 to 66.84 vs 57.0 to 68.3 in controls) or pain (VAS pain 95% CI 61.5 to 72.2 vs 67.7 to 83.8 for controls). Failure to provide some form of exercise and education to the control group makes it difficult to draw inferences from these findings.

RCT evidence: Hydrotherapy vs balneotherapy

In 2004, **Altan et al** (49) randomised 50 female patients to: 1) pool-based exercise (n=25) or; 2) balneotherapy, applied in the same pool without any exercise (n=25).

The pool-based exercise program was given by a physiotherapist to 25 patients in a therapeutic pool at 37^{o}C for 35 min a day three times a week for 12 weeks. The program included warming (walking back and forth in the pool), activity (jumping in the pool and active joint motion range and stretching of the neck and the extremities), relaxation (lying supine on the water and slow swimming), and out-of-pool exercises (bending back and forth, squatting, and relaxing with deep breaths) for a period of 35 min.

The control balneotherapy sessions lasted 35 min three times a week for 12 weeks and were conducted in the same pool as the exercise group. Control patients were instructed **not** to perform any exercise during the sessions.

Comparison of the two groups on the basis of the post-treatment (weeks 12 and 24) percent changes and difference in scores relative to pre-treatment (week 0) values failed to show a significant difference between the groups for any parameter except the Beck Depression Inventory (P<0.01).

A dry land exercise based comparison group was not included in this study.

RCT evidence: Hydrotherapy and sleep

To assess the relaxing effects of water-based exercise, **Vitorino et al** (41) randomly assigned 50 outpatients, all female, 30–60 years old, diagnosed with Fibromylagia, to two groups to carry out 3 weeks of treatment with hydrotherapy or conventional physiotherapy.

The hydrotherapy exercises were composed of the following: (1) warm-up (5 min), (2) stretching (6 min in the beginning and in the end), (3) aerobic exercises (30 min), and (4) relaxation (13 min).

Patients in the conventional physiotherapy group were subjected to (1) surface heating by infrared lamp (10 min); (2) stretching (5 min in the beginning and in the end); (3) aerobic exercise (30 min); and (4) relaxation (10 min).

gdoig@med.usyd.edu.au

This trial found no significant differences between the two groups with regards to Total Sleep Time or quality of life however the Total Nap Time was significantly higher in the physiotherapy group post intervention.

Multiple Sclerosis

In 2001, **Sutherland et al** (50) randomised 22 people with MS to: 1) hydrotherapy (n = 11) or; 2) no-special-activity control (n=11)

The hydrotherapy session included water aerobics, water jogging and deep water running in 45 minute sessions conducted 3 times a week for 10 weeks.

The control group received no additional interventions.

Compared to *no exercise* controls, hydrotherapy sessions resulted in a significant reduction in fatigue and pain.

Low back pain and leg pain

Summary of findings

Extensive systematic reviews (11;51) of all exercise interventions concluded that there is strong evidence to support the use of land based exercise. Land-based exercise significantly reduces sick days during the first follow-up year. Because of the known strong effect of exercise, the appropriate control group against which to assess the incremental benefits of hydrotherapy is land-based exercise.

Four clinical trials were identified (52-55). Only one clinical trial and one pseudo-randomised trial compared hydrotherapy to land-based exercise. There were no differences between hydrotherapy and land-based exercise.

One trial compared hydrotherapy to no intervention, and the third compared two types of hydrotherapy.

Systematic review of land-based exercise

An extensive review by **Kool et al** (51) investigated whether land-based exercise alone or as a part of a multidisciplinary treatment reduces sick leave in patients with non-specific, non-acute, low back pain. The reviewers concluded that there is strong evidence that land-based exercise significantly reduces sick days during the first follow-up year.

Since land-based exercise is accepted to be effective, it serves as the appropriate control intervention against which to evaluate the effectiveness of hydrotherapy.

RCT evidence: hydrotherapy vs land based exercise

In 2004, **Yozbatiran et al** (55) randomised 30 patients to: 1) aquatic exercise (n=15) or; 2) land-based exercise (n=15).

Both groups followed similar programs, which included warm-up, stretching, a circuit of 15 progressive exercises, cool down with light stretching and light aerobic exercise. Sessions were conducted 3 times a week for 4 weeks.

No significant differences were found *between* the groups with regards to aerobic fitness, motor fitness (single leg balance test with eyes open or closed), musculoskeletal fitness, pain reports, Sorensen and Oswestry low back pain disability index scores.

gdoig@med.usyd.edu.au

Sjogren et al (53) 'sequentially allocated' sixty subjects in order of presentation with chronic low back pain to either: 1) hydrotherapy treatment or; 2) land treatment groups.

Due to the sequential allocation process, this trial should be regarded as pseudo- or quasi-randomised. Pseudo-randomised trials may be subject to severe forms of selection bias and allocation bias, and may over-estimate treatment effects by up to 40%.

Both the land and the hydrotherapy exercise programs consisted of two group sessions per week for a period of six weeks. Each subject had to participate in the full twelve sessions over this period. If a session was missed an alternative session was arranged and if more than two consecutive sessions were missed the subject was withdrawn from the study.

Twenty-eight subjects from each group attended all treatment and assessment sessions. Results indicated that both groups improved significantly in functional ability and in decreasing pain levels. Thoracolumbar mobility did not improve significantly in either group. Overall there was no significant difference found between the two types of treatment.

RCT evidence: hydrotherapy vs no exercise

In 1998, **McIlveen et al** (52) randomised 109 adults with lower back paain (LBP) or back and leg pain of more than three months duration to either: 1) hydrotherapy or; 2) control (delayed hydrotherapy) group.

Each hydrotherapy session was led by experienced pool volunteers with additional training in delivering the prescribed 20 spinal exercises. Ten repetitions of each prescribed exercise were included during each session. If a subject missed a session, an extra one was arranged. Any subject who missed more than one session in the four-week period was withdrawn from the study.

The control group received no intervention during the study period. They were placed on a 'waiting list' for hydrotherapy.

Forty-five 45 people in the experimental group, and 50 people in the control group completed the trial.

Significantly more people in the exercise group reported a change in functional status, as measured by the Oswestry Disability Questionnaire score (p=0.04).

Differences between the experimental and control groups were not significant for other measures of pain, light touch, reflexes, strength, or for the ranges of flexion, extension and passice straight leg raise. It is difficult to draw inferences from these results because the control group did not receive any active intervention.

RCT evidence: hydrotherapy vs hydrotherapy

In 2008, **Schrepfer et al** (54) randomised 49 patients to: 1) deep water walking or 2) deep water hanging. This study did not identify any significant differences between hydrotherapy groups. It also did not include a land-based exercise group as a control.

Ankylosing Spondylitis

There were two systematic reviews covering all aspects of exercise (land and aquatic) in this condition. One could not be included in this review because it is published in Portuguese (1). The comprehensive Cochrane Collaboration systematic review conducted by **Dagfinrud et al** in 2008 was retrieved (7). Because outcomes and interventions differed between trials to such a degree, the authors of this Cochrane Collaboration systematic review were not able to conduct a meta-analyses of any specific intervention.

gdoig@med.usyd.edu.au

Three clinical trials and one economic evaluation on this topic were identified (56;57-59) and retrieved for individual review.

Summary of findings

The English language abstract (available on PubMed) for the Portuguese language review concludes that physical exercise is helpful and acknowledges that the research supporting hydrotherapy looks 'promising'. The authors of the second systematic review, published in 2008 conclude, "we still do not know which particular treatment protocol to be recommended in the management of AS."

Inferences regarding the true benefits of hydrotherapy are difficult to draw from the three individual clinical trials. One trial compared an extensive spa resort holiday program to no holiday and no change in exercise (56). One trial compared an extensive exercise program, where hydrotherapy was provided after sporting exercises, with a control group that received a home exercise program (57). The third trial, which included three different groups, does not present standard errors or standard deviations for study outcomes thus direct comparisons between groups cannot be made (58).

RCT evidence

van Tubergen et al (56) randomised patients to receive a three week holiday at a resort spa, where they undertook an extensive five day a week exercise package and education. Patients randomised to the control group remained at home and did not change their exercise patterns.

The spa resort holiday package included spa-exercise therapy 5 days a week at one of two spa resorts. Therapy programs were standardised for both spa resorts and were performed by trained physiotherapists not involved in the outcome assessment and analyses of the study. Every morning patients started with 1 hour of physical exercises, followed by 30 minutes of walking, and postural correction therapy by lying supine on a bed (initially 14 minutes, but increasing daily by 2 minutes to a final period of 30 minutes a day). Every other afternoon, the patients in Bad Hofgastein visited the Gasteiner Heilstollen. The Gasteiner Heilstollen are former mine galleries with a climate characterised by temperatures from 38.0 to 41.5°C, a humidity of 70% to 98%, and concentrations of radioactive radon in the air. Patients travelled by train to one of the treatment areas situated 2 kilometers inside the mountain, where they rested (naked) in the supine position on a bed for 1 hour. After the stay in the Heilstollen, the patients rested for 30 minutes at room temperature. Instead of visiting the Gasteiner Heilstollen, the patients in Arcen received a similar thermal treatment by visiting the sauna and the thermal baths. Either the Heilstollen or the sauna was visited a total of 10 times within a period of 3 weeks. In the Heilstollen, the radon progeny activity was measured in Working Level using the Instant Radon Progeny Meter (IRPM, Type TN-IR-21, Thomson & Nielsen, Canada). For the total 10-hour stay, patients were exposed to a cumulative dose of 0.536 Working Level Month (WLM). The other afternoons were spent with 30 minutes of intensive hydrotherapy and 30 minutes bathing in thermal water, followed by 1 hour of sports. Individual therapies were not allowed. During the weekends, patients were permitted to visit the thermal baths but were instructed not to exercise.

Hydrotherapy was only a small component of the extensive holiday resort package evaluated. This study cannot serve as a comparison of hydrotherapy (exercise in water) to simple exercise or control.

An economic evaluation (59) of this spa holiday intervention calculated the costs per quality-adjusted life year gained for each resort compared to control as €7,465 (95%

gdoig@med.usyd.edu.au

CI 3,294–14,686) for the spa resort holiday in Bad Hofgastein, Austria, and €18,575 (95% CI 3,678–114,257) for the spa resort holiday in Arcen, The Netherlands.

Hidding et al (57) randomised 149 patients to: 1) twice weekly group physical therapy for 9 months plus home exercises or; 2) home exercise.

The group physical therapy sessions were extensive and consisted of 1 hour of physical training, followed by 1 hour of sporting activities and 1 hour of hydrotherapy. Hydrotherapy was given in heated water (mean, 31^{o} C; range, 29^{o}-32^{o} C) to reduce pain and improve mobility of the spine and peripheral joints *after sporting exercises*. It is not reported whether exercises were conducted during 'hydrotherapy'. Group physical therapy patients were also encouraged to conduct a home exercise program that was directed at the hip joints, peripheral joints, and the entire spine, for 30 min daily over the entire study period.

Control patients were encouraged to conduct a home exercise program that was directed at the hip joints, peripheral joints, and the entire spine, for 30 min daily over the entire study period.

Compared to individually directed home exercises conducted for 30 minutes a day, the addition of a twice weekly comprehensive group exercise program for 9 months resulted in significant improvements in fitness (maximum work capacity by ergometry), thoracolumbar mobility, and overall global health as assessed by the patients ($P < 0.05$). Other measures of functional capacity (Sickness Impact Profile, Health Assessment Questionnaire for the Spondylarthropathies, and Functional Index measures) did not differ between groups.

Helliwell et al (58) randomised 44 patients with ankylosing spondylitis to receive: 1) intensive in-patient physiotherapy, which included hydrotherapy (n=15); 2) hydrotherapy plus home exercises (n=15); or 3) home exercises alone (n=14).

The intensive in-patient treatment consisted of a three-week admission to the Royal Bath Hospital, Harrogate and involved daily (Monday to Friday) one-hour group exercise sessions with stretching exercises and aerobics, a hydrotherapy session at least three times a week, very occasionally supplemented by Vichy massage if back muscle spasm was a prominent feature. Interferential treatments were given to specific peripheral joints where pain in those joints hindered full participation in the exercise classes.

The hydrotherapy plus home exercise group received a six-week period of twice-weekly out-patient hydrotherapy sessions which included exercise for all parts of the body with emphasis on exercises for the back and neck. Patients in this group were also taught a home exercise regime to perform twice a day and were given a diary to check satisfactory compliance with these exercises.

Home exercise patients were instructed in the same home exercise regime as the hydrotherapy patients and were also given the diary to complete.

Not all patients attended outcome follow-up (at six months 87% of patients in the in-patient group, 60% of patients in hydrotherapy and exercise groups and 57% of patients in the home exercise group attended for assessment).

Despite randomisation and stratification, treatment groups differed in their initial baseline measurements: the hydrotherapy group had better cervical rotation and VAS pain scores.

Based on ANOVAs, which assess overall differences between all three groups but do not provide direct comparisons between individual groups, the groups differed significantly immediately after treatment for the visual analogue scores for pain and

gdoig@med.usyd.edu.au

stiffness (F = 10.88, p = 0.001) and for cervical rotation (F = 3.73, p = 0.03). This difference was not maintained even at two months after cessation of treatment.

Neuromotor impairments

One comprehensive systematic review published in 2006 by **Getz et al** (3) addressed research findings in this condition. It identified 11 articles on the topic: one randomised control trial, two quasi-experimental studies, one cohort study, two case control studies and five case reports. The clinical trial (60) was retrieved and appraised individually.

Summary of findings

The study by **Dorval et al** (60) has been identified by other reviewers (3) as being 'randomised' however it used a 'purposive' group allocation process. **Dorval et al** report that "Conventional [aquatic exercise] (*n* = 10) and experimental [aquatic exercise](*n* = 10) groups were formed according to availability of transportation and mobility." This type of 'purposive' group allocation may lead to significant biases. Furthermore, this paper compares two types of aquatic exercise groups.

Despite the positive increase in the subjects' scores in both aquatic intervention groups, the authors conclude that the experimental aquatic programme was not sufficiently powerful to be significantly different from the conventional aquatic program, in terms of gains in self-esteem and functional independence. This non-randomised intervention study does not contain a land-based control group.

Brain Injury

There were two small RCTs on this topic (61;62). Both trials appear very similar and may represent duplicate reports of the same project in various stages of completion.

Summary of findings

Patients who received additional exercise in the hydrotherapy group responded to exercise.

The control patients in these small trials (61;62) participated in an 8-week vocational rehabilitation class, which was based around improving reading and writing skills post-injury.

Patients enrolled into these trials were above level six (confused–appropriate) on the Ranchos Los Amigos Scale and were able to undertake a sub-maximal cycle ergometry test thus they were capable of land-based exercises. A more appropriate comparison group would have been land-based exercises matched for frequency, duration and intensity.

RCT evidence

In 2004, **Driver et al** (62) reported eight participants were assigned to an aquatic exercise group and eight to a control group.

The aquatic exercise group completed an 8-week exercise programme that consisted of 24 exercise sessions (three times a week) each lasting 1-hour. Exercise sessions included both aerobic and resistance training components. Throughout the programme, participants wore Polar Heart rate monitors to ensure that heart rate was kept within 50–70% of the individuals maximum heart rate. Heart rate was determined using the Karvonen method.

Each participant was assigned an instructor who worked with the participant throughout the programme for instructional and safety reasons.

gdoig@med.usyd.edu.au

The control group was assigned an 8-week vocational rehabilitation class. The vocational class was a reading and writing programme based on improving hand and creative writing ability post-injury. The vocational rehabilitation class was a typical programme offered at the rehabilitation centre, although none of the control group had previously completed the class.

The aquatic exercise group responded to exercise. A more appropriate and relevant control group would have been dry land exercise of the same duration and frequency.

In 2006, **Driver et al** (63) reported that eighteen individuals were randomly assigned to an aquatic exercise (n=9) or control group (n=9).

The aquatic exercise sessions were completed three times a week for 8 weeks and each session lasted 1-hour. Exercise sessions included both aerobic and resistance training components. Throughout the programme, participants wore Polar Heart rate monitors to ensure that heart rate was kept within 50–70% of the individuals maximum heart rate. Heart rate was determined using the Karvonen method.

The control group participated in an 8-week vocational rehabilitation class, which was based around improving reading and writing skills post-injury.

The aquatic exercise group responded to exercise. A more appropriate and relevant control group would have been dry land exercise of the same duration and frequency.

Older patients with chronic heart failure

Two RCTs (64;65), one of which is a cross-over trial.

The cross-over RCT by **Michalesen et al** (65) compared six weeks of home 'hydrotherapy' followed by six weeks restriction. In this trial, 'hydrotherapy' consisted of warm baths followed by cold foot and arm pourings / washings. Since no exercises were conducted, the results of this trial are not relevant to this review.

RCT evidence

This small trial by **Cider et al** (64) compared: 1) 15 patients with heart failure who received 45 minute hydrotherapy (pool exercises) sessions 3 times a week for 8 weeks to; 2) 10 *no exercise* control patients.

Cider et al report, "The control group was instructed to live their life as normal for 8 weeks and were not allowed to increase their habitual physical activity during this period."

The group receiving exercise was found to improve measures of exercise tolerance. A more appropriate and relevant control group would have been dry land exercise of the same duration, intensity and frequency.

Chronic Obstructive Pulmonary Disease

One small RCT (66) has been conducted in this patient population.

Summary of findings

High intensity physical group training undertaken in water may result in higher activity levels and physical function scores compared to land based training.

RCT evidence

In 2004, **Waddell et al** (66) reported the results of a trial containing 43 outpatients, with moderate to severe COPD (27 w/16 m), from two local hospitals in northern Sweden.

Patients were randomised to receive high intensity physical group training in water (water group) or on land (land group) performed for 12 weeks, three times per week, 45 min per session.

gdoig@med.usyd.edu.au

Although there were no differences in overall quality of life measures, the water group scored significantly higher in the activity scale of the St. Georges Respiratory Questionnaire and the physical health domain of the SF-36 compared to the land exercise control group.

The authors conclude that high intensity physical group training in water is of benefit for patients with COPD.

Varicose veins

Ernst et al conducted a trial (67) in 1991 that involved 61 patients. Patients were randomised to regular hydrotherapy or control (no intervention). Control patients had better venous competence but the hydrotherapy patients had smaller leg volumes. No long term or quality of life measures were reported.

Cruciate ligament repairs

One pseudo randomised trial was identified (68).

Summary of findings

There was a statistically significant difference in a self-reported symptom scale in favour of hydrotherapy measured at 8 weeks however the clinical importance of the magnitude of the difference observed is not reported (mean=92.2, SD=4.31 vs 82.4, SD=12.36, P=0.03).

RCT evidence

This trial by **Tovin et al** (68) allocated 20 subjects to: 1) land exercise or; 2) water exercise. Both exercise groups began in the first week post-op and continued for eight weeks.

This is a methodologically weak pseudo-randomised trial. Allocation concealment was not maintained.

The analysis is quite complex with attempts to account for measurements taken at multiple time points. There are no notable differences in measures of joint laxity, peak torque recovery, range of motion recovery or mid-patella and above mid-patella girth measurements.

There was a statistically significant difference in a self-reported symptom scale in favour of hydrotherapy measured at week 8 however the clinical importance of the magnitude of the difference observed is not reported or discussed (mean=92.2, SD=4.31 vs 82.4, SD=12.36, P=0.03).

Fracture of Proximal Humerus

One systematic review (69) was identified. The review by **Hodgson et al** concluded that “Electrotherapy or hydrotherapy does not enhance recovery and joint mobilization has limited evidence of its efficacy.” One RCT of hydrotherapy was identified (70).

Summary of findings

Revay et al (70) studied patients with a fractured humerus: two fragment fracture at the level of the surgical neck or three and four fragment fractures (non-displaced) or with less than 1cm displacement or more than 45^{o} angulation. Forty-eight patients were randomised to: 1) self training or 2) self training combined with treatment in a 33^{o}C swimming pool.

The authors conclude, “Both self training and group training in swimming pools gave acceptable results. There were no differences between groups after one year. The

gdoig@med.usyd.edu.au

less resource consuming self training group, however, gave better results after two and three months."

Total hip arthroplasty

In 2003, **Gilbey et al** (71) randomised 76 patients with end-stage hip arthritis who were scheduled for a total hip replacement to: 1) an 8-week customised pre-operative exercise program followed by a 12 week post-surgery exercise program (n=37) or; 2) control (n=31).

The Exercise Intervention Program consisted of two supervised clinic-based and two home-based exercise sessions each week for 8 weeks before surgery. Once their wound had healed, patients continued clinic-based exercise sessions until 12 weeks after surgery. The clinic exercise session was approximately 1 hour with a 30-minute aerobic and strength program followed by a 30-minute program of mobility and gait training in the hydrotherapy pool.

Control subjects received no additional exercise. Both groups received routine in-hospital physical therapy.

The exercise group responded to exercise. Exercise patients demonstrated significantly better strength, range of motion and WOMAC scores compared to no-exercise patients.

Hydrotherapy was only one aspect of the Exercise Intervention Program. The control group did not receive any intervention. It is difficult to draw inferences regarding whether the benefits of the Exercise Intervention Program are attributable to land-based aerobic and strength training or hydrotherapy-based mobility and gait training.

Stroke

In 2004, **Chu et al** (72) randomised 12 community-dwelling people with stroke who had mild to moderate residual motor deficits (residual unilateral weakness) to: 1) group exercise programs for 1 hour, 3 times a week for 8 weeks in chest-deep water at targeted heart rates or; 2) a control group that performed arm and hand exercises while sitting.

The water-based exercise intervention consisted of 10 minutes of land-based stretching, 5 minutes of light aerobic warm-up in the water (marching on the spot, single- and double-legged hopping holding onto the pool edge), 30 minutes of moderate to high aerobic activities (shallow water walking, running, side stepping) at the target heart rate prescribed for that week, 5 minutes of a light cool down (marching on the spot), and 10 minutes of gentle stretching in the water.

The main objective of the control program was to improve upper-extremity function.

The water-based exercise group attained significant improvements over the control group in cardiovascular fitness, maximal workload, gait speed, and paretic lower-extremity muscle strength. The relatively short program (8wk) of water based exercise resulted in a 22% improvement in cardiovascular fitness in a small group of people with stroke compared to sedentary control patients.

It is important to note that the eligibility criteria for this study resulted in a patient population with relatively high function. In preparation for randomisation, all subjects performed a maximal cycle test, and were required to reach maximal effort as defined by the ACSM guidelines. The experimental and control groups differed significantly in the aerobic capacity of the prescribed exercises, with the water exercise group achieving target heart rates of 50% to 70%, 75%, and 80% heart rate reserve ±5 beats/min (as determined by the initial maximal exercise test) for weeks 1 to 2, 3 through 5, and 6 through 8, respectively. As demonstrated by the pre-randomisation cycle test performed at eligibility screening, the control group patients would have been capable of undertaking a

gdoig@med.usyd.edu.au

cycle-based aerobic component to their prescribed exercise class with similar target heart rate goals.

Normal, healthy pregnant women and preventing/reducing back pain

Summary of findings

A comprehensive systematic review of the effects of all types of physical therapy in pregnancy, including water gymnastics, was conducted in 2003 by **Stuge et al** (73)**.** These authors concluded "Because of heterogeneity and the varying quality of the studies no strong evidence exists concerning the effect of physical therapy interventions on the prevention and treatment of back and pelvic pain related to pregnancy. Future studies should meet current methodological standards, and interventions to be evaluated should be based on established theoretical framework."

With regards to the study by **Khilstrand et al** (74), **Stuge et al** conclude, "Water gymnastics show less pain intensity and significantly less sick leave compared with no intervention, but this might be because of an attention effect."

RCT evidence

In 1999, **Kihlstrand et al** (74) randomised normal healthy women during the second half of pregnancy to: 1) participate in water-gymnastics (n=129) once a week or; 2) no intervention control group (n=129).

The water-gymnastics group included ten classes of 12–15 women and took place in a swimming pool with a water temperature of 32–34 degrees Celsius. The exercises were recommended by the Swedish Swimming Society and tested for pregnant women by physiotherapists. The women were offered water-gymnastics 17–20 times (once a week during the second half of pregnancy). Each training session lasted one hour and included relaxing exercises. All classes were led by one specially trained midwife. Another specially trained midwife replaced her during holidays or sickness. Two different exercise programs were used for all women; one with exercises suitable for earlier pregnancy to be used for the first ten training sessions, and one with exercises suitable for later pregnancy for the last ten sessions.

The control group received no additional exercises or attention.

Intensity of back/low back pain increased with advancing pregnancy. There was no excess risk for urinary or vaginal infections associated in the intervention group. Compared to no intervention, water gymnastics during the second half of pregnancy significantly reduced the intensity of back/low back pain. Compared to no intervention, water-gymnastics decreased the number of women on sick-leave because of back/low back pain.

Failure to include an active control group makes it difficult to draw inferences from this study. It is possible the water-gymnastics group benefited from the 'attention' provided by a group program.

Coronary artery disease

Summary of findings

One small trial compared water exercise to land exercise (75). Both programs were found to improve overall fitness but there were no differences between water or land exercise groups.

RCT evidence

In 2007, **Volaklis et al** (75) examined the effects of combined resistance and aerobic training on land versus combined resistance and aerobic training in water. Thirty-

gdoig@med.usyd.edu.au

four subjects with coronary artery disease were randomly assigned to: 1) land exercise (n = 12), 2) water exercise (n = 12), or 3) control (n = 10) groups.

The water exercise program was conducted in a heated pool (depth 1.20 m) at water temperatures between 28°C and 30°C and consisted of 2 weekly aerobic sessions (at 50%-70% of maximal heart rate achieved during symptom limited grade exercise test) and 2 weekly sessions of resistance training (60%-80% of the maximal number of repetitions performed in each exercise at baseline). All sessions lasted 60 min and included a warmup period (10 minutes), the main program (30-40 minutes), and a cool down period (10 minutes).

The land exercise program consisted of 2 weekly aerobic sessions and 2 weekly sessions of resistance training. Both aerobic and strength exercise lasted 60 minutes and included a warm-up period (10 minutes), the main program (30-40 minutes) and a cool down period (10 minutes). The exercise intensity of the aerobic program was 60% to 80% of the maximal heart rate achieved during a symptom-limited grade exercise test.

After 4 months of training, analysis of covariance revealed that body weight and sum of skinfolds were lower for both exercise groups than for the control group. Patients who trained in water improved exercise time and maximum strength in a similar manner compared to the patients who trained on land.

Both exercise groups significantly reduced total cholesterol and triglycerides, but there were no differences among exercise groups.

The results of the present study show that both the water and land exercise programs were effective at increasing exercise time, muscular strength, body composition, and improving lipid profile in patients with CAD.

Indications for which RCTs were NOT available:

It is possible to conduct an RCT in virtually all disease conditions, both acute and chronic.

If there are no established land-based exercise or physiotherapy treatment interventions, patients may be randomised to water-exercise vs. an appropriately designed standard care intervention. An appropriately designed standard care intervention could provide an objective comparison of the benefits of water-exercise against standard care, controlling for changes over time, the psychological effects of the attention provided in a group environment and/or education.

If there are established benefits from land-based exercise or physiotherapy treatment interventions, patients may be randomised to water-exercise or land-based exercise. Such a comparison effectively establishes the benefits of water-exercise against the known benefits of land-based exercise, controlling for other extraneous factors.

The non-randomised interventional study conducted by **Kesiktas et al** (76) provides proof that RCTs can be conducted in all patient populations. This ‘control case matched’ study conducted in spinal cord injury patients compared: 1) passive range of motion exercise twice a day and oral baclofen for 10 weeks to; 2) passive range of motion and oral baclofen, as well as 20 min of water exercises (at 71 °F, full immersion) 3 times per week. However, because investigators personally selected the group to which patients would be allocated to, it is not a randomised trial and may be prone to major biases. Patients could easily have been randomly allocated to treatment groups.

It is beyond the scope of this review to appraise observational or uncontrolled intervention studies.

Despite an extensive search, RCTs have not been identified in the following patient groups:

gdoig@med.usyd.edu.au

Spinal cord injury, cerebral palsy, Guillain-Barre Syndrome, Post-Polio Syndrome, Chronic Regional Pain Syndrome, Rett Syndrome, Autism, Spinal Muscular Atrophy or Breast cancer lymphodema.

Topics and papers identified in the search but NOT included in this review

Methods paper
1 methods paper (not a clinical topic) not retrieved

Crenobalneotherapy / balneotherapy (hot mineral spring spas above 34C, no exercises performed in hot spa)
2 recent systematic reviews identified, retrieved and reviewed for additional RCTs on hydrotherapy (12;77).
4 older systematic reviews [2 French language] identified, not retrieved.
2 RCTs (78;79) and one systematic review on balneotherapy in RA (80).

Paper by **Hall** (79) evaluated the effect of tap water baths.

RCT conducted by **Altan et a**l in 2006 (81), compared exercise on land with exercise on land plus balneotherapy (therapeutic hot spa containing spa water at 39°C for 30 min once a day for 3 weeks hot spa). Both control and balneotherapy patients received instructions on a land-based exercise programme, which they were requested to repeat once a day for 30 min during the study.

Codish et al (82) studied the efficacy of balneotherapy and climatictherapy (climatotherapy) at the Dead Sea area in patients with ankylosing spondylitis. The intervention group received daily treatments consisting of each of the following: 20 minute applications of mud packs heated to 39–40°C to the entire body, 20 minute sessions in a sulfur (mineral) pool at 36–37°C, and bathing in Dead Sea water (in the sea itself or in an indoor pool). Participants in the control group received climatotherapy, but were prohibited from receiving any form of balneotherapy.

Systematic review of adjuvant therapy in subacute back pain (6) identified one trial of balneotherapy, which was not retrieved (no exercises *in* water).

Labour (bath immersions or labour pool)
1 narrative (opinion based editorial) review in Labour – not retrieved
1 systematic review with a focus on bath tub or labour pool immersion (not exercise in a pool).

> Not able to conduct a meta-analysis trials so each publication was reviewed independently. No overall conclusion with regards to 'water immersion' could be reached (83).

One small trial by **Benfield et al** (84) evaluated the impact of a 'tub' of 37C water for 1 hr during early labor compared to no tub.

Burns / Wound Debridement
2 papers. Requires department specific whirlpools.

Heatstroke (requires local cooling baths equipment)
2 reviews and 1 RCT on heatstroke.

gdoig@med.usyd.edu.au

Neuroedocrine disorders of females
1 [Russian language Guideline]

Bluebottle stings
1 RCT of cold vs hot water.

Pressure ulcer healing
RCT (85) evaluating the effects of whirlpool baths on pressure ulcer healing.

Normal healthy vollyball players
Population not included (86).

Normal pregnant women
Participants were not randomised to any intervention. Observational studies not included (87).

Healthy college aged women
Population not included (88).

Well elderly
Population not included (89-91).

Stretching for Ankylosing Spondylitis

This trial by **Bulstrode et al** (92) does not compare hydrotherapy with another intervention. It compares a comprehensive exercise intervention with or without stretching exercises performed on dry land. All patients in this trial received a 15-day intensive physiotherapy courses. Active exercises were given in the gymnasium and hydrotherapy pool to strengthen progressively the anti-gravity and postural muscles and to increase mobility of all the joints of the spine, thorax, hips and shoulders. Stretching exercises were added on top of this base level intervention.

Post menopausal sedentary healthy women

2003 trial by **Ay and Yurtkuran** (93) randomised 46 (but the Abstract states 41) sedentary but healthy women to a controlled aquatic exercise program or sedentary lifestyle. The normal healthy women randomised to exercise responded to exercise. Results of this trial are difficult to interpret since an appropriate gentle land based exercise control group was not provided.

This second trial by **Au and Yurtkuran** (94) randomised a 62 postmenopausal healthy sedentary women to into three Groups: 1) aquatic exercise (*n* = 24); 2) weight bearing exercise (*n* = 24), and 3) control groups (*n* = 23).

The authors conclude: “In this longitudinal study, it was determined that a moderate increase of the regular physical activity, either as aquatic or weight-bearing exercise, is effective to increase calcaneal BUA by 3.1% and 4.2%, respectively, in sedentary postmenopausal women.” Because BUA is an ultrasound measure that may be correlated to bone mineral density, this suggests exercise (of either type) may increase BMD of the calcaneous.

gdoig@med.usyd.edu.au

Post menopausal healthy women with osteoporosis

The purpose of this study by **Devereux et al** (95)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.

The group randomised to receive exercise at a community aquatic centre reported significant improvements in quality of life. Due to the lack of a group-based land exercise control group, it is difficult to draw conclusions from this paper.

Obese healthy women

Paper by **Gappmaier et al** not included (96).

gdoig@med.usyd.edu.au

Reference List

(1) Ribeiro F, Leite M, Silva F, Sousa O. [Physical exercise in the treatment of Ankylosing Spondylitis: a systematic review]. Acta Reumatol Port 2007; 32(2):129-137.

(2) Bartels EM, Lund H, Hagen KB, Dagfinrud H, Christensen R, Danneskiold-Samsoe B. Aquatic exercise for the treatment of knee and hip osteoarthritis. Cochrane Database Syst Rev 2007;(4):CD005523.

(3) Getz M, Hutzler Y, Vermeer A. Effects of aquatic interventions in children with neuromotor impairments: a systematic review of the literature. Clin Rehabil 2006; 20(11):927-936.

(4) Hammond A. Rehabilitation in rheumatoid arthritis: a critical review. Musculoskeletal Care 2004; 2(3):135-151.

(5) Sim J, Adams N. Systematic review of randomized controlled trials of nonpharmacological interventions for fibromyalgia. Clin J Pain 2002; 18(5):324-336.

(6) Pengel HM, Maher CG, Refshauge KM. Systematic review of conservative interventions for subacute low back pain. Clin Rehabil 2002; 16(8):811-820.

(7) Dagfinrud H, Kvien TK, Hagen KB. Physiotherapy interventions for ankylosing spondylitis. Cochrane Database Syst Rev 2008;(1):CD002822.

(8) Geytenbeek J. Evidence for effective hydrotherapy. Physiotherapy 2002; 88(9):514-528.

(9) Geytenbeek J. Aquatic Physiotherapy Evidence-Based Practice Guide. 2008. National Aquatic Physiotherapy Group Australian Physiotherapy Association.

(10) Busch AJ, Schachter CL, Overend TJ, Peloso PM, Barber KA. Exercise for fibromyalgia: a systematic review. J Rheumatol 2008; 35(6):1130-1144.

(11) Dziedzic K, Jordan JL, Foster NE. Land- and water-based exercise therapies for musculoskeletal conditions. Best Pract Res Clin Rheumatol 2008; 22(3):407-418.

(12) Forestier R, Francon A. Crenobalneotherapy for limb osteoarthritis: systematic literature review and methodological analysis. Joint Bone Spine 2008; 75(2):138-148.

(13) Hall J, Swinkels A, Briddon J, McCabe CS. Does aquatic exercise relieve pain in adults with neurologic or musculoskeletal disease? A systematic review and meta-analysis of randomized controlled trials. Arch Phys Med Rehabil 2008; 89(5):873-883.

(14) Martin C. Hydrotherapy: Reveiw on the effectiveness of its application in physiotherapy and occupational therapy. 2004. WorkSafe British Columbia, Canada.

(15) Patrick DL, Ramsey SD, Spencer AC, Kinne S, Belza B, Topolski TD. Economic evaluation of aquatic exercise for persons with osteoarthritis. Med Care 2001; 39(5):413-424.

(16) Gusi N, Tomas-Carus P. Cost-utility of an 8-month aquatic training for women with fibromyalgia: a randomized controlled trial. Arthritis Res Ther 2008; 10(1):R24.

gdoig@med.usyd.edu.au

(17) Cochrane T, Davey RC, Matthes Edwards SM. Randomised controlled trial of the cost-effectiveness of water-based therapy for lower limb osteoarthritis. Health Technol Assess 2005; 9(31):iii-xi, 1.

(18) Green J, McKenna F, Redfern EJ, Chamberlain MA. Home exercises are as effective as outpatient hydrotherapy for osteoarthritis of the hip. Br J Rheumatol 1993; 32(9):812-815.

(19) Foley A, Halbert J, Hewitt T, Crotty M. Does hydrotherapy improve strength and physical function in patients with osteoarthritis--a randomised controlled trial comparing a gym based and a hydrotherapy based strengthening programme. Ann Rheum Dis 2003; 62(12):1162-1167.

(20) Stener-Victorin E, Kruse-Smidje C, Jung K. Comparison between electro-acupuncture and hydrotherapy, both in combination with patient education and patient education alone, on the symptomatic treatment of osteoarthritis of the hip. Clin J Pain 2004; 20(3):179-185.

(21) Fransen M, Nairn L, Winstanley J, Lam P, Edmonds J. Physical activity for osteoarthritis management: a randomized controlled clinical trial evaluating hydrotherapy or Tai Chi classes. Arthritis Rheum 2007; 57(3):407-414.

(22) Silva LE, Valim V, Pessanha AP, Oliveira LM, Myamoto S, Jones A et al. Hydrotherapy versus conventional land-based exercise for the management of patients with osteoarthritis of the knee: a randomized clinical trial. Phys Ther 2008; 88(1):12-21.

(23) Wang TJ, Belza B, Elaine TF, Whitney JD, Bennett K. Effects of aquatic exercise on flexibility, strength and aerobic fitness in adults with osteoarthritis of the hip or knee. J Adv Nurs 2007; 57(2):141-152.

(24) Belza B, Topolski T, Kinne S, Patrick DL, Ramsey SD. Does adherence make a difference? Results from a community-based aquatic exercise program. Nurs Res 2002; 51(5):285-291.

(25) Hinman RS, Heywood SE, Day AR. Aquatic physical therapy for hip and knee osteoarthritis: results of a single-blind randomized controlled trial. Phys Ther 2007; 87(1):32-43.

(26) Suomi R, Koceja DM. Postural sway characteristics in women with lower extremity arthritis before and after an aquatic exercise intervention. Arch Phys Med Rehabil 2000; 81(6):780-785.

(27) Soumi R, Lindauer S. Effectiveness of arthritis foundation aquatic program no strength and range of motion in women with arthritis. Journal of Aging and Physical Activity 1997; 5:341-351.

(28) Lund H, Weile U, Christensen R, Rostock B, Downey A, Bartels EM et al. A randomized controlled trial of aquatic and land-based exercise in patients with knee osteoarthritis. J Rehabil Med 2008; 40(2):137-144.

(29) Sylvester K. Investigation of the effect of hydrotherapy in the treatment of osteoarthritic hips. Clinical Rehabilitation 1990; 4(3):223-228.

(30) Wyatt FB, Milam S, Manske RC, Deere R. The effects of aquatic and traditional exercise programs on persons with knee osteoarthritis. J Strength Cond Res 2001; 15(3):337-340.

gdoig@med.usyd.edu.au

(31) Suomi R, Collier D. Effects of arthritis exercise programs on functional fitness and perceived activities of daily living measures in older adults with arthritis. Arch Phys Med Rehabil 2003; 84(11):1589-1594.

(32) Ahern M, Nicholis E, Simionato E, Clark M, Bond M. Clinical and psychological effects of hydrotherapy in rheumatic diseases. Clinical Rehabilitation 1995; 9:204-212.

(33) Minor MA, Hewett JE, Webel RR, Anderson SK, Kay DR. Efficacy of physical conditioning exercise in patients with rheumatoid arthritis and osteoarthritis. Arthritis Rheum 1989; 32(11):1396-1405.

(34) Epps H, Ginnelly L, Utley M, Southwood T, Gallivan S, Sculpher M et al. Is hydrotherapy cost-effective? A randomised controlled trial of combined hydrotherapy programmes compared with physiotherapy land techniques in children with juvenile idiopathic arthritis. Health Technol Assess 2005; 9(39):iii-x, 1.

(35) Stenstrom CH, Lindell B, Swanberg E, Swanberg P, Harms-Ringdahl K, Nordemar R. Intensive dynamic training in water for rheumatoid arthritis functional class II--a long-term study of effects. Scand J Rheumatol 1991; 20(5):358-365.

(36) Eversden L, Maggs F, Nightingale P, Jobanputra P. A pragmatic randomised controlled trial of hydrotherapy and land exercises on overall well being and quality of life in rheumatoid arthritis. BMC Musculoskelet Disord 2007; 8:23.:23.

(37) Sanford-Smith S, MacKay-Lyons M, Nunes-Clement S. Therapeutic benefit of aquaerobics for individuals with rheumatoid arthritis. Physiotherapy Canada 1998; 50(1):40-46.

(38) Bilberg A, Ahlmen M, Mannerkorpi K. Moderately intensive exercise in a temperate pool for patients with rheumatoid arthritis: a randomized controlled study. Rheumatology (Oxford) 2005; 44(4):502-508.

(39) Rintala P, Kettunen H, McCubbin J. Effects of a water exercise program for individuals with rheumatoid arthritis. Sports Med Training Rehabil 1996; 7:31-38.

(40) Gusi N, Tomas-Carus P, Hakkinen A, Hakkinen K, Ortega-Alonso A. Exercise in waist-high warm water decreases pain and improves health-related quality of life and strength in the lower extremities in women with fibromyalgia. Arthritis Rheum 2006; 55(1):66-73.

(41) Vitorino DF, Carvalho LB, Prado GF. Hydrotherapy and conventional physiotherapy improve total sleep time and quality of life of fibromyalgia patients: randomized clinical trial. Sleep Med 2006; 7(3):293-296.

(42) Tomas-Carus P, Hakkinen A, Gusi N, Leal A, Hakkinen K, Ortega-Alonso A. Aquatic training and detraining on fitness and quality of life in fibromyalgia. Med Sci Sports Exerc 2007; 39(7):1044-1050.

(43) Assis MR, Silva LE, Alves AM, Pessanha AP, Valim V, Feldman D et al. A randomized controlled trial of deep water running: clinical effectiveness of aquatic exercise to treat fibromyalgia. Arthritis Rheum 2006; 55(1):57-65.

gdoig@med.usyd.edu.au

(44) Mannerkorpi K, Nyberg B, Ahlmen M, Ekdahl C. Pool exercise combined with an education program for patients with fibromyalgia syndrome. A prospective, randomized study. J Rheumatol 2000; 27(10):2473-2481.

(45) Evcik D, Yigit I, Pusak H, Kavuncu V. Effectiveness of aquatic therapy in the treatment of fibromyalgia syndrome: a randomized controlled open study. Rheumatol Int 2008; 28(9):885-890.

(46) Gowans SE, deHueck A, Voss S, Richardson M. A randomized, controlled trial of exercise and education for individuals with fibromyalgia. Arthritis Care Res 1999; 12(2):120-128.

(47) Jentoft ES, Kvalvik AG, Mengshoel AM. Effects of pool-based and land-based aerobic exercise on women with fibromyalgia/chronic widespread muscle pain. Arthritis Rheum 2001; 45(1):42-47.

(48) Munguia-Izquierdo D, Legaz-Arrese A. Exercise in warm water decreases pain and improves cognitive function in middle-aged women with fibromyalgia. Clin Exp Rheumatol 2007; 25(6):823-830.

(49) Altan L, Bingol U, Aykac M, Koc Z, Yurtkuran M. Investigation of the effects of pool-based exercise on fibromyalgia syndrome. Rheumatol Int 2004; 24(5):272-277.

(50) Sutherland G, Anderson M, Stoov M. Can aerobic exercise training affect health-related quality of life for people with multiple sclerosis? Journal of Sport & Exercise Phychology 2001; 23(2):122-135.

(51) Kool J, de Bie R, Oesch P, Knusel O, van den BP, Bachmann S. Exercise reduces sick leave in patients with non-acute non-specific low back pain: a meta-analysis. J Rehabil Med 2004; 36(2):49-62.

(52) McIlveen B, Robertson VJ. A randomized controlled study of the outcome of hydrotherapy for subjects with low back pain and leg pain. Physiotherapy 1998; 84:17-26.

(53) Sjogren T, Long N, Storay I, Smith J. Group hydrotherapy versus group land-based treatment for chronic low back pain. Physiother Res Int 1997; 2(4):212-222.

(54) Schrepfer R, Fritz J. A comparison of change in visual analogue pain rating of acute low back pain patients following deep water walking or deep water hanging. The Journal of Aquatic Physical Therapy 2008; 8(2):25-28.

(55) Yozbatiran N, Yildirim Y, Parlak B. Effects of fitness and aquafitness exercises on physical fitness in patients with chronic low back pain. The Pain Clinic 2004; 16(1):35-42.

(56) van Tubergen A, Landewe R, van der HD, Hidding A, Wolter N, Asscher M et al. Combined spa-exercise therapy is effective in patients with ankylosing spondylitis: a randomized controlled trial. Arthritis Rheum 2001; 45(5):430-438.

(57) Hidding A, van der LS, Boers M, Gielen X, de Witte L, Kester A et al. Is group physical therapy superior to individualized therapy in ankylosing spondylitis? A randomized controlled trial. Arthritis Care Res 1993; 6(3):117-125.

gdoig@med.usyd.edu.au

(58) Helliwell PS, Abbott CA, Chamberlain MA. A randomized trial of three different physiotherapy regimes in ankylosing spondylitis. Physiotherapy 1996; 82:85-90.

(59) van Tubergen A, Boonen A, Landewe R, Rutten-Van Molken M, van der HD, Hidding A et al. Cost effectiveness of combined spa-exercise therapy in ankylosing spondylitis: a randomized controlled trial. Arthritis Rheum 2002; 47(5):459-467.

(60) Dorval G, Tetreault S, Caron C. Impact of aquatic programmes on adolescents with cerebral palsy. Occupational Therapy International 1996; 3(4):241-261.

(61) Driver S, Rees K, O'Connor J, Lox C. Aquatics, health-promoting self-care behaviours and adults with brain injuries. Brain Inj 2006; 20(2):133-141.

(62) Driver S, O'Connor J, Lox C, Rees K. Evaluation of an aquatics programme on fitness parameters of individuals with a brain injury. Brain Inj 2004; 18(9):847-859.

(63) Driver S, Rees K, O'Connor J, Lox C. Aquatics, health-promoting self-care behaviours and adults with brain injuries. Brain Inj 2006; 20(2):133-141.

(64) Cider A, Schaufelberger M, Sunnerhagen KS, Andersson B. Hydrotherapy--a new approach to improve function in the older patient with chronic heart failure. Eur J Heart Fail 2003; 5(4):527-535.

(65) Michalsen A, Ludtke R, Buhring M, Spahn G, Langhorst J, Dobos GJ. Thermal hydrotherapy improves quality of life and hemodynamic function in patients with chronic heart failure. Am Heart J 2003; 146(4):728-733.

(66) Wadell K, Sundelin G, Henriksson-Larsen K, Lundgren R. High intensity physical group training in water--an effective training modality for patients with COPD. Respir Med 2004; 98(5):428-438.

(67) Ernst E, Saradeth T, Resch KL. A single blind randomized, controlled trial of hydrotherapy for varicose veins. Vasa 1991; 20(2):147-152.

(68) Tovin BJ, Wolf SL, Greenfield BH, Crouse J, Woodfin BA. Comparison of the effects of exercise in water and on land on the rehabilitation of patients with intra-articular anterior cruciate ligament reconstructions. Phys Ther 1994; 74(8):710-719.

(69) Hodgson S. Proximal humerus fracture rehabilitation. Clin Orthop Relat Res 2006; 442:131-138.

(70) Revay S, Dahlstrom M, Dalen N. Water exercise versus instruction for self-training following a shoulder fracture. Int J Rehabil Res 1992; 15(4):327-333.

(71) Gilbey HJ, Ackland TR, Wang AW, Morton AR, Trouchet T, Tapper J. Exercise improves early functional recovery after total hip arthroplasty. Clin Orthop Relat Res 2003;(408):193-200.

(72) Chu KS, Eng JJ, Dawson AS, Harris JE, Ozkaplan A, Gylfadottir S. Water-based exercise for cardiovascular fitness in people with chronic stroke: a randomized controlled trial. Arch Phys Med Rehabil 2004; 85(6):870-874.

gdoig@med.usyd.edu.au

(73) Stuge B, Hilde G, Vollestad N. Physical therapy for pregnancy-related low back and pelvic pain: a systematic review. Acta Obstet Gynecol Scand 2003; 82(11):983-990.

(74) Kihlstrand M, Stenman B, Nilsson S, Axelsson O. Water-gymnastics reduced the intensity of back/low back pain in pregnant women. Acta Obstet Gynecol Scand 1999; 78(3):180-185.

(75) Volaklis KA, Spassis AT, Tokmakidis SP. Land versus water exercise in patients with coronary artery disease: effects on body composition, blood lipids, and physical fitness. Am Heart J 2007; 154(3):560-566.

(76) Kesiktas N, Paker N, Erdogan N, Gulsen G, Bicki D, Yilmaz H. The use of hydrotherapy for the management of spasticity. Neurorehabil Neural Repair 2004; 18(4):268-273.

(77) Pittler MH, Karagulle MZ, Karagulle M, Ernst E. Spa therapy and balneotherapy for treating low back pain: meta-analysis of randomized trials. Rheumatology (Oxford) 2006; 45(7):880-884.

(78) Guillemin F, Constant F, Collin JF, Boulange M. Short and long-term effect of spa therapy in chronic low back pain. Br J Rheumatol 1994; 33(2):148-151.

(79) Hall J, Skevington SM, Maddison PJ, Chapman K. A randomized and controlled trial of hydrotherapy in rheumatoid arthritis. Arthritis Care Res 1996; 9(3):206-215.

(80) Verhagen AP, de Vet HC, de Bie RA, Kessels AG, Boers M, Knipschild PG. Balneotherapy for rheumatoid arthritis and osteoarthritis. Cochrane Database Syst Rev 2000;(2):CD000518.

(81) Altan L, Bingol U, Aslan M, Yurtkuran M. The effect of balneotherapy on patients with ankylosing spondylitis. Scand J Rheumatol 2006; 35(4):283-289.

(82) Codish S, Dobrovinsky S, Abu SM, Flusser D, Sukenik S. Spa therapy for ankylosing spondylltis at the Dead Sea. Isr Med Assoc J 2005; 7(7):443-446.

(83) Tournaire M, Theau-Yonneau A. Complementary and alternative approaches to pain relief during labor. Evid Based Complement Alternat Med 2007; 4(4):409-417.

(84) Benfield RD, Herman J, Katz VL, Wilson SP, Davis JM. Hydrotherapy in labor. Res Nurs Health 2001; 24(1):57-67.

(85) Burke DT, Ho CH, Saucier MA, Stewart G. Effects of hydrotherapy on pressure ulcer healing. Am J Phys Med Rehabil 1998; 77(5):394-398.

(86) Martel GF, Harmer ML, Logan JM, Parker CB. Aquatic plyometric training increases vertical jump in female volleyball players. Med Sci Sports Exerc 2005; 37(10):1814-1819.

(87) Polman R, Kaiseler M, Borkoles E. Effect of a single bout of exercise on the mood of pregnant women. J Sports Med Phys Fitness 2007; 47(1):103-111.

(88) Robinson LE, Devor ST, Merrick MA, Buckworth J. The effects of land vs. aquatic plyometrics on power, torque, velocity, and muscle soreness in women. J Strength Cond Res 2004; 18(1):84-91.

gdoig@med.usyd.edu.au

(89) Simmons V, Hansen PD. Effectiveness of water exercise on postural mobility in the well elderly: an experimental study on balance enhancement. J Gerontol A Biol Sci Med Sci 1996; 51(5):M233-M238.

(90) Lord S, Mitchell D, Williams P. Effect of water exercise on balance and related factors in older people. Aust J Physiother 1993; 39(3):217-222.

(91) Lord S, Matters B, St George B, Thomas M, Bindon J, Chan D et al. The effects of water exercise on physical functioning in older people. Australasian Journal on Ageing 2006; 25(1):36-41.

(92) Bulstrode SJ, Barefoot J, Harrison RA, Clarke AK. The role of passive stretching in the treatment of ankylosing spondylitis. Br J Rheumatol 1987; 26(1):40-42.

(93) Ay A, Yurtkuran M. Evaluation of hormonal response and ultrasonic changes in the heel bone by aquatic exercise in sedentary postmenopausal women. Am J Phys Med Rehabil 2003; 82(12):942-949.

(94) Ay A, Yurtkuran M. Influence of aquatic and weight-bearing exercises on quantitative ultrasound variables in postmenopausal women. Am J Phys Med Rehabil 2005; 84(1):52-61.

(95) Devereux K, Robertson D, Briffa NK. Effects of a water-based program on women 65 years and over: a randomised controlled trial. Aust J Physiother 2005; 51(2):102-108.

(96) Gappmaier E, Lake W, Nelson AG, Fisher AG. Aerobic exercise in water versus walking on land: effects on indices of fat reduction and weight loss of obese women. J Sports Med Phys Fitness 2006; 46(4):564-569.

gdoig@med.usyd.edu.au