EXTENDED REPORT

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

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Objective: To compare the effects of a hydrotherapy resistance exercise programme with a gym based resistance exercise programme on strength and function in the treatment of osteoarthritis (OA).

Design: Single blind, three arm, randomised controlled trial.

Subjects: 105 community living participants aged ≥50 years and over with clinical OA of the hip or knee.

Methods: Participants were randomised into one of three groups: hydrotherapy (n = 35), gym (n = 35), or 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).

Results: In the gym group both left and right quadriceps significantly increased in strength compared with the control group, and right quadriceps strength was also significantly better than in the hydrotherapy group. The hydrotherapy group increased left quadriceps strength only at follow up, and this was significantly different from the control group. The hydrotherapy group was significantly different from the control group for distance walked and the physical component of the SF-12. The gym group was significantly different from the control group for walk speed and self efficacy satisfaction. Compliance rates were similar for both exercise groups, with 84% of hydrotherapy and 75% of gym sessions attended. There were no differences in drug use between groups over the study period.

Conclusion: Functional gains were achieved with both exercise programmes compared with the control group.

Osteoarthritis (OA) is the most common form of arthritis, affecting about 5–10% of the total Australian population. The development of OA is determined by age, genetic predisposition, previous injury, chronic stress across the joint, and abnormal mechanical forces caused primarily by obesity. Isolated quadriceps weakness has been associated with radiographic knee OA in older adults without a history of knee pain, and one descriptive study has demonstrated that decreased lower extremity strength was clearly associated with increased disability in people with OA. This suggests that muscle atrophy is either a consequence of, or a risk factor for, OA and is not simply due to patients avoiding loading painful osteoarthritic knee joints.

Land based exercise regimens and strengthening exercise programmes have reported positive improvements in functional performance and reduction of the pain of OA. A systematic review by Van Baar and colleagues evaluating the effectiveness of exercise therapy in patients with OA of the hip or knee concluded that exercise therapy is effective for this patient group as a range of beneficial effects were seen, including improved pain levels, physical function, and self reported disability. However, of the 11 randomised controlled trials identified, a wide variety of interventions were investigated, and overall, the quality of the studies was poor.

Hydrotherapy is often recommended to patients with arthritis as water provides a range of benefits, including the reduction of oedema, pain relief, and reduced loading on damaged arthritic joints. A systematic review of randomised controlled trials investigating hydrotherapy for the treatment of rheumatoid arthritis and OA found that all the studies had methodological flaws, with only three of the 10 studies reviewed scoring more than half of the maximum score available for methodological quality. Positive findings were detected in most of the trials, but the scientific evidence was considered weak and a conclusion about the efficacy of hydrotherapy for patients with arthritis could not be reached.

Only three of the studies reviewed had studied patients with OA. Methodological flaws of the studies appraised in the systematic reviews included lack of blinding of outcome assessors, and no intention to treat analysis.

Owing to the clinical importance of muscle strength in the development and progression of OA, and the inconclusive evidence about the effectiveness of hydrotherapy for these patients, the current trial has directly compared standardised strengthening programmes in a hydrotherapy pool (water based) and gym (land based).

The direct comparison of these two forms of exercise is important in order to determine the efficacy of hydrotherapy, and further, to determine which method of exercise is more effective in strengthening the quadriceps muscles and improving functional performance in this patient group.

METHODS

The study was a randomised controlled trial, with blinded outcome assessment of 105 community living adults aged 50 and over with radiological diagnosis of OA of the hip or knee, or both. Eligible participants had to be able to independently read, write, and speak English, give informed consent,
provide their own transport, and attend the Repatriation General Hospital three times a week for six consecutive weeks.

Participants were excluded if they had received physiotherapy or hydrotherapy in the past six weeks, were attending community exercise classes, had joint replacement surgery within the past 12 months or it was scheduled within the next 12 weeks, or if there was an indication of cognitive impairment. Participants were recruited from the physiotherapy, orthopaedic, and rheumatology departments of the Repatriation General Hospital (RGH), the orthopaedic department of the Flinders Medical Centre, and from the community through an advertisement.

Potential participants were sent information about the study, screened for eligibility, and invited to participate. A senior physiotherapist assessed the patients’ capability of starting exercise in the gym or pool safely, and obtained written informed consent before baseline assessment. A computer generated randomisation list was created by a person external to the study and was managed by an external department. After baseline assessment, a person from the pharmacy department assigned participants to treatment group according to sequentially numbered, sealed, opaque envelopes, and the investigator was advised of group allocation by telephone. The intervention was started within five days of randomisation.

The exercise interventions consisted of either three water based, or three gym based exercise sessions a week for six weeks. Each 30 minute exercise session included a short warm up period, lower limb stretches, and a standardised set of resistance exercises with individually tailored progression of intensity. The control group received fortnightly telephone calls to record any changes in their condition, drug use, or injuries and were offered free exercise treatment at the RGH at the end of the study period.

All outcome measures were collected at baseline by a single trained investigator before randomisation, and at six weeks by a single “blinded” outcome assessor at the RGH. Clinical outcome measures included quadriceps strength and a six minute walk test. A series of self reported outcome questionnaires were also completed at baseline and at six weeks. The series of questionnaires included the Western Ontario and McMaster Universities (WOMAC) OA Index, consisting of three subscales including pain, stiffness, and physical function, with higher scores indicating greater disease severity. The Adelaide Activities Profile is categorised into four subscales, including domestic chores, household maintenance, social activities, and service to others, with higher scores indicating a higher level of daily activity. The Short Form-12 (SF-12) Health Survey measures quality of life and is divided into a physical and mental component, with higher scores indicating better physical and mental health. And the Arthritis Self-Efficacy Questionnaire consists of four subscales: pain, function, symptoms, and satisfaction, and higher scores here also indicate better health.

Data on demographics, medical history, and drugs were collected directly from the participants at baseline and used to describe the sample. Any injuries sustained during the study were recorded at six weeks and any changes in drug use were categorised as either; “change not related to OA”, “increase in OA drug”, or “decrease in OA drug”.

The study was granted ethical approval by the RGH research and ethics committee.

**Quadriceps strength test protocol**

Isometric quadriceps strength was measured using a hydraulic leg extension machine modified to restrict leg extension at an angle of 110 degrees. Subjects were instructed to push the force gauge pad with their lower leg as hard as they could for five seconds. This was repeated three times on each leg within a 30 seconds rest between each effort, the final score being the mean of the three measures of peak force. Participants were familiarised with the test procedures and received vigorous verbal encouragement. Further details on the strength testing protocol are available from the first author upon request. Both intra- and intertester reliability for quadriceps strength were determined. The test-retest correlations for the baseline and follow up assessor were 0.758 and 0.897, respectively and interrater reliability was also high: 0.761.

**Exercise interventions**

The warm up in the water based exercise group consisted of walking forwards, sideways, and backwards through the water. The strengthening exercises included hip flexion and extension, hip adduction and abduction, knee flexion and extension, and knee cycling. One set of 10 repetitions was increased to three sets of 10 repetitions for each exercise, usually within the first week. Once three sets of 15 repetitions could be performed, weighted gaiters were fastened around the ankles to provide additional resistance. At this point, repetitions were dropped back to 10 and then increased to 15 as tolerated.

The warm up in the gym based exercise group involved about four minutes of stationary cycling. The strengthening exercises included seated bench press, hip adduction and abduction, knee extension, and double leg press. Participants started the programme working at either their 10 repetition maximum or just below their maximum, depending upon pain experienced during and after the initial exercise session. The same protocol for increasing exercise intensity in the water was also applied in the gym.

**Statistical analysis**

Statistical analysis was performed with SPSS version 10. An “intention to treat” approach was used in all analyses, and the last observation carried forward was used to impute data missing at follow up. Data are presented as medians and interquartile ranges, unless otherwise stated. An α level of 0.05 was used in statistical analyses.

Because most of the data followed non-normal distributions, non-parametric tests were used in all statistical analyses. The Kruskal-Wallis test was used to test for differences in outcome measures at baseline by treatment group, and the χ² test was used to test for differences in baseline descriptors by treatment group. The effect of the intervention on the outcomes was determined using the Kruskal-Wallis test, and the Mann-Whitney test with a Bonferroni correction was used for subsequent post hoc pairwise comparisons. Wilcoxon signed ranks tests were used to determine within group changes from baseline to follow up.

To detect a change of 20% in the pain and physical functioning scales of the WOMAC OA Index between the two intervention groups, a sample size of 66 subjects was required (22 in each group). The sample size calculation was based on the assumption of an effect size of 1.0 with an α level of 0.05 and 90% power. To allow for drop outs and injuries, this sample was increased to 35 people in each group, a total of 105 participants.

**RESULTS**

Recruitment started on 1 April 2001 and was completed by the 25 March 2002. Of the 429 people who were contacted to take part in the trial, 165 (38%) were considered eligible. Of the eligible participants, 112 (68%) consented, but it was considered unsafe for seven (6%) to start an exercise programme. The remaining 105 participants were randomly recruited.
allocated to the hydrotherapy \((n = 35)\), gym \((n = 35)\), or control group \((n = 35)\) (fig 1).

Participants randomly allocated to the hydrotherapy and gym groups attended 84% and 75% of the exercise sessions, respectively. Six participants in each treatment group discontinued the intervention for a variety of reasons (fig 1). A small number of participants were lost to follow up in each group (fig 1).

Of the 105 participants, 52 (49.5%) were women. The mean (SD) age of the sample was 70.9 (8.8) years. All participants in the study reported at least one comorbid condition other than OA. There was no significant difference between the groups for any of the baseline sample descriptors (table 1).

Table 1 also shows physical function, quadriceps strength, and self reported pain at baseline. There was no significant difference between the three groups at baseline for any of the clinical or self reported outcome measures, with the exception of self reported pain measured using the WOMAC OA Index. WOMAC pain scores were significantly higher in the hydrotherapy group than the gym group at baseline \((p = 0.015)\). However there was no difference between groups for self reported pain using the Arthritis Self-Efficacy Scale.

Walking speed and distance improved significantly from baseline to follow up in both the hydrotherapy \((p < 0.001)\) and gym groups \((p < 0.001)\), but not in the control group. Pairwise comparisons of change scores showed that the hydrotherapy group was significantly better than the control group for distance walked and the gym group was significantly better than the control group for walking speed (fig 2).

The gym group significantly increased both left and right quadriceps strength from baseline to follow up \((p < 0.001)\), and the hydrotherapy group significantly increased strength in the left quadriceps only \((p = 0.010)\). No change was seen in the control group for strength. Pairwise comparisons of change scores found that the gym group was significantly stronger than the control group for both left and right quadriceps strength, and significantly stronger than the hydrotherapy group for right quadriceps strength. The hydrotherapy group was significantly stronger than the control group for left quadriceps strength only (fig 2).

At follow up, the WOMAC pain score significantly declined from baseline in the hydrotherapy group, but the change in pain was not significantly different between groups (table 2). There were no significant changes from baseline or between groups for WOMAC function or stiffness. At follow up, no significant differences were found from baseline or between groups for self efficacy pain or function. The self efficacy satisfaction score significantly improved from baseline in the gym group, and there was a significantly greater improvement in satisfaction in the gym group compared with the control group (table 2). There were no significant differences from baseline scores, and there was also no significant difference between the groups for any of the Adelaide Activities subscales at follow up. At follow up, the hydrotherapy group showed a significant improvement from baseline in the SF-12 physical component score, and the gym group showed a significant improvement from baseline in the SF-12 mental component score, but this change did not differ significantly between groups (table 2).

Significant differences in overall drug changes \((p = 0.033)\) between the three groups were evident. However, the changes were such that increases and decreases in OA drug use largely cancelled each other out. The hydrotherapy group showed fewer changes in drug use, with only one participant increasing their OA drug. Four participants increased and five participants decreased their OA drug in the gym group, and
in the control group six participants increased and five decreased their OA drugs.

**DISCUSSION**

This study has shown that both the gym based and water based resistance exercise programmes successfully improved physical function. The gym based intervention was found to be more effective in improving muscle strength.

The significant increases in walking speed and distance found in the hydrotherapy group are supported by previous findings. As far as we are aware, the effect of hydrotherapy on quadriceps strength has not been previously reported in this patient group. However, previous hydrotherapy studies have failed to show any significant changes in strength measured at the hip or in grip strength. The increases in strength and function seen in the gym group are consistent with the findings of previous investigations of land based strengthening exercise programmes.

Improving a patient’s ability to walk is important as it helps in maintaining independence to carry out activities of daily living, and the functional independence of older adults is also associated with decreased mortality and decreased admission into nursing homes and hospitals. Increased muscle strength around affected joints is a clinically important outcome as muscle strength provides increased shock absorbing capacity and improved joint stability to assist in the preservation of the diseased joint.

![Figure 2](http://ard.bmj.com/)

**Figure 2** Medians and interquartile ranges for change scores in strength and physical function measures. For walking distance the hydro group was significantly different from the control group (p = 0.048). No other differences were significant. For walking speed the gym group was significantly different from the control group (p = 0.009). No other differences were significant. For right quadriceps strength the gym group and the hydrotherapy groups were significantly different from the control group (p < 0.001, p = 0.018, respectively). No other differences were significant.
resistance exercise, and electrotherapy and exercise, have walked a fixed distance and gait assessment. We also found no significant difference between intervention these self reported measures.

In summary, this study has shown that both the gym and hydrotherapy interventions produce positive functional outcomes for patients with OA severe enough to warrant referral to an orthopaedic surgeon. It was our intention to match the exercise intensity between the two intervention groups as closely as possible. However, progressive overloading of the musculature and loading through the eccentric phase of muscle contraction is not possible in water as it is on land. Therefore, owing to the nature of hydrotherapy, the exercise intensity would not have been as high in the water based group, hence the greater increases in strength seen in the gym group. However, the hydrotherapy programme had an underlying aerobic training component, as higher and faster repetitions were used to increase the exercise intensity. Furthermore, the hydrotherapy group continuously worked for the full half hour session, moving immediately from one exercise to the next. Owing to these characteristics of the hydrotherapy programme, it is expected that the participant’s heart rate (although not measured) was raised and maintained at a higher level for the duration of each exercise session. Patients with OA typically have low cardiovascular fitness, therefore it is expected that the hydrotherapy programme possibly produced increases in aerobic capacity, explaining the significant increase in physical function without the same increases in strength as observed in the gym group.

One potential limitation of the study is how truly representative the sample is of the OA population in general. Firstly, most subjects entering the trial were keen to take part in the exercise intervention in the hope that they would benefit from the exercise. However, not all patients with OA would be as keen to exercise as regularly or as intensively as the subjects in the current study. Although the recruitment of subjects was based on the presence of hip or knee OA and not fitness, it is believed that research projects involving physical activity will generally attract people who are interested in exercise. Secondly, only participants who could provide their own transport to the RGH three times a week were eligible to take part in the trial. Lastly, changes in drug use were not controlled over the study period. However, documentation of drugs at baseline and follow up showed that participation in land based exercise, water based exercise, or no exercise resulted in no changes that occurred largely cancelled each other out in each group.

In summary, this study has shown that both the gym and hydrotherapy interventions produce positive functional outcomes for patients with OA. However, it seems that hydrotherapy may be more suitable for aerobic based exercise programmes and the gym based exercise more suitable for strengthening programmes. Hydrotherapy provides the optimal environment for patients with OA to exercise aerobically, and at higher intensities than would be possible on land,

### Table 2: Self reported measures: WOMAC OA Index, Arthritis Self-Efficacy Scale, and SF-12 Health Survey

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Baseline</th>
<th>Follow up</th>
<th>Median change</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WOMAC</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Function score (0–68)</td>
<td>Hydro</td>
<td>34.0 (16.0)</td>
<td>33.0 (17.0)</td>
</tr>
<tr>
<td></td>
<td>Gym</td>
<td>28.0 (13.0)</td>
<td>27.0 (12.0)</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>37.0 (17.0)</td>
<td>37.0 (13.0)</td>
</tr>
<tr>
<td>Stiffness score (0–8)</td>
<td>Hydro</td>
<td>5.0 (2.0)</td>
<td>4.0 (3.0)</td>
</tr>
<tr>
<td></td>
<td>Gym</td>
<td>4.0 (2.0)</td>
<td>4.0 (2.0)</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>4.0 (3.0)</td>
<td>4.0 (3.0)</td>
</tr>
<tr>
<td>Pain score (0–20)</td>
<td>Hydro</td>
<td>10.0 (3.0)</td>
<td>10.0 (4.0)*</td>
</tr>
<tr>
<td></td>
<td>Gym</td>
<td>8.0 (4.0)</td>
<td>8.0 (5.0)</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>10.0 (4.0)</td>
<td>10.0 (4.0)</td>
</tr>
<tr>
<td><strong>Self efficacy</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Symptoms score (10–100)</td>
<td>Hydro</td>
<td>65.0 (23.3)</td>
<td>63.3 (26.7)</td>
</tr>
<tr>
<td></td>
<td>Gym</td>
<td>70.0 (26.7)</td>
<td>70.0 (30.0)</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>63.3 (31.7)</td>
<td>58.3 (28.3)</td>
</tr>
<tr>
<td>Satisfaction score</td>
<td>Hydro</td>
<td>50.0 (20.0)</td>
<td>50.0 (25.0)</td>
</tr>
<tr>
<td></td>
<td>Gym</td>
<td>50.0 (25.0)</td>
<td>60.0 (30.0)*</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>55.0 (30.0)</td>
<td>50.0 (40.0)</td>
</tr>
<tr>
<td><strong>SF-12</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical score (16–57)</td>
<td>Hydro</td>
<td>31.4 (7.9)</td>
<td>37.1 (12.7)**</td>
</tr>
<tr>
<td></td>
<td>Gym</td>
<td>30.7 (11.2)</td>
<td>31.4 (12.7)</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>30.9 (11.2)</td>
<td>28.8 (11.0)</td>
</tr>
<tr>
<td>Mental score (25–70)</td>
<td>Hydro</td>
<td>53.4 (15.7)</td>
<td>53.3 (15.5)</td>
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<tr>
<td></td>
<td>Gym</td>
<td>51.8 (21.2)</td>
<td>57.9 (19.5)</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>50.5 (16.9)</td>
<td>50.5 (14.0)</td>
</tr>
</tbody>
</table>

*Data are presented as medians and interquartile ranges. Note: SF-12 scales represent minimum and maximum values of the total sample.*

*Significantly different from baseline (p < 0.05); †significantly different from baseline (p = 0.002); $significantly different from hydrotherapy (p = 0.002); **significantly different from control (p = 0.006).
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owing to the reduction of joint loading. Patients with severe OA who find it painful to weight bear for extended periods may find that water provides the appropriate environment in which they can exercise at intensities that may confer significant health benefits. However, to improve joint stability and shock absorbing capacity through improved muscle strength, land based resistance exercise should be recommended as loading during eccentric muscle contractions and progressive resistance can be more effectively applied on land.

Currently published reports indicate that few high quality trials have been carried out to examine the use of hydrotherapy in the treatment of patients with OA. Further research into hydrotherapy should investigate the long term effects of this form of exercise in patients with OA, and should also aim at measuring the effect of hydrotherapy on cardiovascular fitness.

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REFERENCES


18. Green J. Home exercises are as effective as outpatient hydrotherapy for osteoarthritis of the hip. Br J Rheumatol 1999;38:912–15


20. Alexander M, Butter J, MacDonald PB. Effect of a water exercise programme on walking gait, flexibility, strength, self reported disability and other psycho-social measures of older individuals with arthritis. Physio Canada 2001;53:203–11


