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ORIGINAL ARTICLE

Land-Based Versus Water-Based Rehabilitation Following Total Knee Replacement: A Randomized, Single-Blind Trial

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Objective. **To compare outcomes between land-based and water-based exercise programs delivered in the early subacute phase up to 6 months after total knee replacement (TKR).**
Methods. **Two weeks after surgery (baseline), 102 patients were randomized to participate in either land-based (n = 49) or water-based (n = 53) exercise classes. Treatment parameters were guided by current clinical practice protocols. Therefore, each study arm involved 1-hour sessions twice a week for 6 weeks, with patient-determined exercise intensity. Session attendance was recorded. Outcomes were measured at baseline and at 8 and 26 weeks postsurgery. Outcomes included distance on the 6-Minute Walk test, stair climbing power (SCP), the Western Ontario and McMaster Universities (WOMAC) Osteoarthritis Index (n = 85 English-proficient patients), visual analog scale for joint pain, passive knee range of motion, and knee edema (circumference). Planned orthogonal contrasts, with an intent-to-treat approach, were used to analyze the effects of time and time-group interactions.**
Results. **Compliance in both groups was excellent with 81% attending 8 or more sessions. Loss to followup was 5%. Significant improvements were observed across time in all outcomes at 8 weeks, with further improvements evident in all variables (except WOMAC pain) at 26 weeks. Minor between-group differences were evident for 4 outcomes (SCP, WOMAC stiffness, WOMAC function, and edema) but these appear clinically insignificant.**
Conclusion. **A short-term, clinically pragmatic program of either land-based or water-based rehabilitation delivered in the early phase after TKR was associated with comparable outcomes at the end of the program and up to 26 weeks postsurgery.**

INTRODUCTION

The provision of physiotherapeutic rehabilitation in the weeks immediately following total knee replacement (TKR), either in an outpatient or inpatient facility, has been reported to be common practice, if not routine, in Australia (1), Canada (2), the UK, and the US (3). However, the evidence on which the provision of this service is based is limited and wide variation is evident in the modes of physiotherapy employed (1). The evaluation of rehabilitation after TKR should be a priority, particularly in light of the 2–10-fold global increases in the incidence of TKR over the last 10–20 years (4–7).

Physiotherapy after TKR includes use of modalities to reduce pain and edema, specific exercises to enhance joint range of motion, exercises to improve muscle strength and endurance, and transfer and gait retraining that enhance physical function and quality of life (1,8). Typically outcome measures reflect these priorities. However, the ability of the postsurgical patient to participate in weight-bearing exercise may be limited by pain and edema of the knee joint and by pre-existing comorbid conditions. An exercise medium that can unload the operated knee and other painful joints may allow patients to exercise more effectively with less pain and swelling. Therefore, the inherent buoyancy and increased hydrostatic pressure of water make it a potentially attractive treatment after TKR.

Hydrotherapy appears to provide short-term benefit for patients with knee or hip osteoarthritis, and therefore has been suggested as an initial treatment option, particularly in patients with severe disease (9). It is utilized in isolation

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or to supplement land-based therapy, and is provided as either group or individualized therapy (1) by providers who have access to either an in-house or a community pool. Randomized trials have compared the effectiveness or cost-effectiveness of hydrotherapy versus land-based programs for patients with lower extremity conditions including severe hip (10–14) or knee osteoarthritis (11–14), and juvenile idiopathic arthritis (15). Although associated with improvements in function, pain relief, and/or quality of life (10–15), hydrotherapy has not been shown to offer a clear advantage over land-based programs, especially in view of the expense if provided in house (15). However, if offered in a community pool, hydrotherapy is considered to be a cost-effective treatment option (13,15). This, together with evidence that community dwelling patients with arthritis appear content to continue with hydrotherapy after being exposed to it (16), indicates that research concerning the value of hydrotherapy has clinical application even in a resource-poor health system. Despite the potential benefits of hydrotherapy in the early rehabilitation stage, no randomized trials have investigated the comparative benefits of land-based versus water-based therapy after TKR.

The present study was pragmatically designed, based on current clinical practice in Australia (1), and compared a land-based group exercise program with a water-based group exercise program for patients following TKR. We hypothesized that the unloading of painful, swollen joints in water may assist resorption of edema. Therefore, water-based exercise after TKR will achieve greater improvements in physical function and range of motion than land-based therapy.

PATIENTS AND METHODS

Study design. A randomized single-blind trial of patients undergoing physiotherapy after primary TKR was conducted in a metropolitan public hospital. All patients provided voluntary, written informed consent prior to study enrollment. Outcome measures were assessed at baseline (2 weeks postsurgery), after 6 weeks of rehabilitation treatment, and at 26 weeks postsurgery. Ethical approval for the study was granted by the Institutional Review Board.

Recruitment of participants. Consecutive, eligible patients attending the preoperative clinic were informed of the study. Patients were rescreened for eligibility after surgery, when they returned for the standard review following discharge from acute care. Exclusion criteria included postoperative deep joint infection, bilateral joint surgery or surgery planned for another joint within 6 months, and documented dementia or other neurologic condition that precluded informed consent. Eligible consenting patients were assessed prior to allocation to treatment group. Random allocation (using a random number generator) to either land-based treatment (the hospital physiotherapy gymnasium) or water-based treatment (community pool) was achieved by the drawing of consecutively numbered, sealed envelopes by a person uninvolved in the study. Using data obtained from an earlier TKR rehabilitation trial (17), calculations determined that a sample size of 40 patients per group would provide 80% power to detect a 20% difference between groups in 6-minute walk distance, at a significance level of $P = 0.05$. Therefore, 102 patients were recruited to allow for a 25% dropout rate.

Assessments and outcomes. Patients were assessed by a blinded assessor, but on a few occasions unblinding occurred due to assessor absence. At baseline, demographic and anthropometric data, surgical details, and presence of comorbid conditions were recorded. Anthropometric measurements included body mass (kg) and height (m). Body mass index (kg/m^2) was calculated from these data. Outcomes were selected on the basis of their importance and relevance to patients and clinicians. The primary outcome measured at each assessment was the 6-Minute Walk test. Secondary outcomes were stair climbing power (SCP), the Western Ontario and McMaster Universities (WOMAC) Osteoarthritis Index, a visual analog scale (VAS) for pain in the operated knee, passive knee joint range of motion (ROM), and edema of the knee. The use of walking aids was also recorded to assess the level of gait independence.

The 6-Minute Walk test was conducted on a standard 25-meter track and the distance walked in meters recorded. The 6-Minute Walk test was chosen as the primary outcome because it has excellent test–retest reliability and responsiveness after TKR and permits decision making at an individual patient level (18,19). The time to ascend 18 stairs (flights of 8 and 10 stairs, separated by a small landing) as rapidly as possible, using handrails and walking aids as required, was recorded. SCP was calculated using body mass, total stair height, and ascent time (20). This functional test for mobility-impaired older adults, in whom leg power is more important than strength for mobility, may be an optimal tool for measuring the magnitude of impairment and effects of therapy (20), and SCP has good reliability and responsiveness after TKR (18).

The WOMAC has excellent reliability, validity, and responsiveness when used with patients after TKR (19,21,22). The questionnaire (version LK3.1) was administered by the assessor to ensure completeness of the survey responses. The WOMAC comprises 3 subscales: pain (5 items), stiffness (2 items), and function (difficulty; 17 items) with each item scored on a 0–4 Likert scale. Each subscale is summed (maximum 20 for pain, 8 for stiffness, and 68 for function), with a higher score indicating worse status (23). Raw scores for each subscale were analyzed without transformation. Improvements within this scale are intended to reflect specific joint improvement since the items pertain to specific joint behavior. Patients who were not proficient in English were excluded (8 in the land-based, 9 in the water-based group), therefore WOMAC responses are reported for 85 patients. Patients recorded the highest intensity of pain experienced in their operated knee in the previous 24 hours using a 0–10 cm VAS.

Passive joint range limitations are clinically important, resulting in knee pain and disordered gait (24). Passive knee flexion was measured using a long-arm universal goniometer and the recommended leg landmarks (25) while the patient was seated upright on a standard height chair. Passive knee extension was measured with the patient supine. Knee edema was estimated by circumferential measurements (cm) at 4 locations (apex, midline, superior border, and 4 cm proximal to the superior border of the patella) with the knee in extension. The 4 measures were averaged for each knee and used as the knee edema outcome measure. Additionally, complications were monitored up to 26 weeks postsurgery using a standardized question form administered through patient interview at review clinics or via a followup phone call after discharge.

Treatment. Treatment parameters for both groups were selected so as to reflect the frequency, intensity, and duration of current rehabilitation protocols for such patients (1). Patients attended sessions twice a week for 6 weeks and attendance was recorded at each session. Because all classes were supervised, class attendance was considered equivalent to compliance. Treatment sessions for each mode were 60 minutes long, which included 5-minute warm-up and cool-down periods. Per clinical practice (1), patients controlled the exercise intensity, but were instructed to exercise to their tolerance level. The same physiotherapist conducted all land-based and water-based classes. This, together with a highly prescribed exercise program, was intended to ensure the classes were similar in content and intensity despite the differing media. In addition to the supervised classes, all patients were instructed on a simple home exercise program, which was recommended to be undertaken daily and consisted of general active ROM exercises and walking as tolerated. Home program compliance was not monitored.

Land-based (gymnasium) treatment comprised cycling on a stationary ergometer, walking on a motor driven treadmill, climbing stairs (stationary stepper machine and a set of 5 stairs with handrails), standing isometric, balance and knee ROM exercises at a bar, and sit to stand exercises from chairs of varying heights. Water-based treatment was conducted in a community pool that ranged from 0.5–1.6 meters deep, which allowed the water level to be approximately waist high for each participant. The water was heated to a mean ± SD temperature of 25 ± 3°C. A waterproof dressing was applied to the surgical site on each patient's knee immediately before immersion. Each session included repetitions of walking forward and backward, stepping sideways, step-ups, jogging, jumping, kicking, knee ROM exercises, lunges, and combined squats and upper extremity exercises.

Statistical analysis. Between-group differences for baseline demographic, anthropometric, and surgical data were analyzed using independent *t*-tests for continuous data or chi-square test for independent dichotomous data. The primary and secondary outcome measures were analyzed using planned orthogonal contrasts for repeated measures. Statistical Package for the Social Sciences software, version 14 (SPSS, Chicago, IL) was used. Contrasts were performed with a Helmert comparison (baseline compared with 8 and 26 weeks, 8 weeks compared with 26 weeks) and yielded effects for time, time-by-group interaction, and an overall effect of group. All analyses were performed per intent-to-treat. Compliance (attendance at treatment sessions) was dichotomized into those who attended less than 8 sessions (noncompliant) and those who attended 8 or more sessions (compliant). *P* values less than 0.05 were considered significant and were further assessed by confidence interval analysis where appropriate. The odds ratio (OR) of requiring a walking stick for ambulation at 26 weeks was calculated. Data were reported as mean ± SD or as mean difference (95% confidence interval [95% CI]).

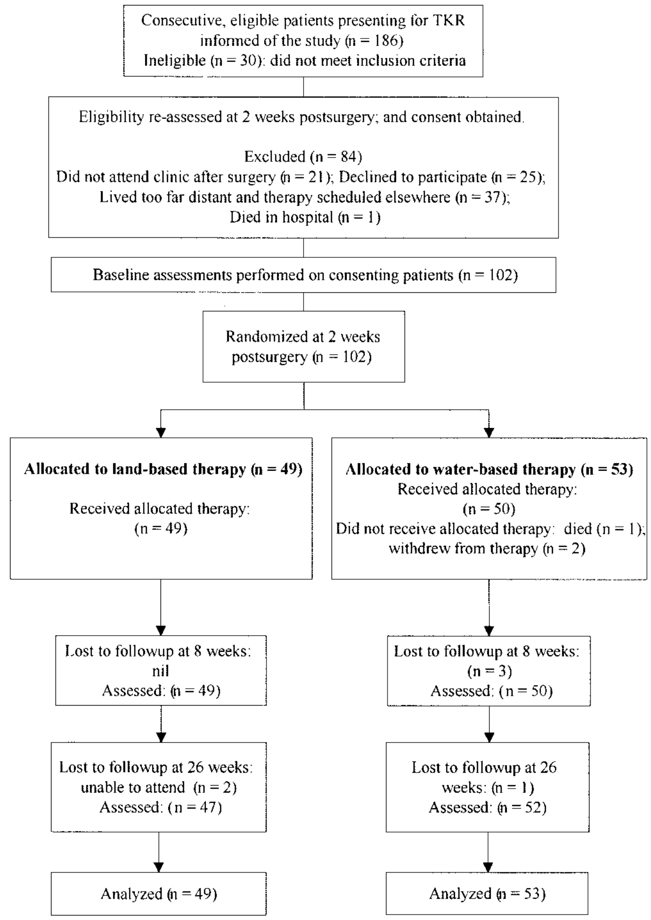

Figure 1. Participant flow in land-based and water-based rehabilitation groups after total knee replacement (TKR) surgery.

RESULTS

Participant recruitment. Of the 216 patients who underwent surgery between November 2005 and November 2006, 102 (47%) consented and, therefore, were available for randomization (Figure 1). Of these, 1 patient from the water-based group died from a cardiac event 4 weeks postsurgery. Two patients from the water-based group withdrew from the intervention during the treatment phase and declined the 8-week assessment; however, they returned for the final assessment. Two patients were unable to attend the final assessment (one was admitted to the hospital with a deep surgical site infection and the other relocated).

Table 1. Baseline demographic, anthropometric, comorbidity, and surgical details*

	Land-based (n = 49)	Water-based (n = 53)
Age, mean ± SD years	67.8 ± 6.3	68.7 ± 9.1
Women	28 (57)	30 (57)
Body mass, mean ± SD kg	81.0 ± 13.7	84.0 ± 16.0
Height, mean ± SD meters	1.63 ± 0.09	1.63 ± 0.11
BMI, mean ± SD kg/m^2	30.6 ± 5.0	31.6 ± 5.8
Obese	25 (51)	28 (53)
Comorbidities		
Endocrine	13 (27)	21 (40)
Gastrointestinal	9 (18)	15 (28)
Heart disease†	18 (37)	9 (17)
Hypertension	37 (76)	35 (66)
Other joint disease	6 (12)	12 (23)
Respiratory	12 (24)	16 (30)
≥3 comorbidities	25 (51)	27 (51)
Surgical details		
Surgery time, mean SD minutes	108 ± 17	114 ± 21
Cement used	49 (100)	51 (96)
Patella resurfaced	12 (25)	13 (25)

* Values are the number (percentage) unless indicated otherwise.
† $P < 0.05$; 95% confidence interval 3–36.

Baseline data. No between-group differences were evident at baseline, except for a higher frequency of heart disease in the land-based group (Table 1). Comorbidity was common, with hypertension (71%) and obesity (52%) featuring most frequently. Eight percent of the cohort were morbidly obese (BMI > 40), and 51% had ≥3 comorbid conditions. Cement fixation of the prosthesis was almost universal.

Numbers analyzed. Consistent with the intent-to-treat analyses employed, missing data for the 5 patients who missed assessments (Figure 1) were handled by carrying forward the previous value for that patient. For 1 patient, the 6-Minute Walk test, the SCP test, and joint ROM tests were not conducted at baseline and the group mean was used to estimate baseline values. Three patients did not perform the SCP test at baseline due to resting tachycardia (2 in the land-based and 1 in the water-based group). These patients were assigned the mean baseline power for the group. Nine patients could only complete 1 flight of stairs at baseline. For these patients, stair ascent time for the complete test (2 flights) was estimated from a regression equation of all paired single flight times versus double flight times, from which each patient's power was then calculated. Analyses for SCP included and excluded these 9 patients, and there was no difference in the results. Data for all 102 patients are presented.

Compliance. Compliance did not differ between treatment groups (mean difference 0.18 sessions, 95% CI −0.7, 1.1). Overall, 81% of patients attended ≥8 of 12 sessions (mean ± SD 9.3 ± 2.3).

Outcomes. The distance walked during the 6-Minute Walk test increased significantly up to 26 weeks postsurgery (201 meters, 95% CI 184, 218 meters; $P < 0.000$), with no between-group differences (mean difference 3 meters, 95% CI −32, 38 meters) (Figure 2A).

SCP continued to improve up to 26 weeks postsurgery (91 watts, 95% CI 81, 101 watts; $P < 0.000$) (Figure 2B). The water-based group improved more than the land-based group between 8 and 26 weeks postsurgery ($P = 0.005$).

For the WOMAC subscales (n = 85), WOMAC pain was reduced at 8 weeks postsurgery (−6.5 points, 95% CI 5.6, 7.5 points) and reached a plateau thereafter, with no group differences (0.4 points, 95% CI −0.5, 1.3 points) (Figure 3A). WOMAC stiffness was reduced up to 26 weeks postsurgery (−2.9, 95% CI −3.2, −2.5 points; $P < 0.000$), with the land-based group reporting less stiffness overall than the water-based group (−0.5 points, 95% CI −0.1, −1.0

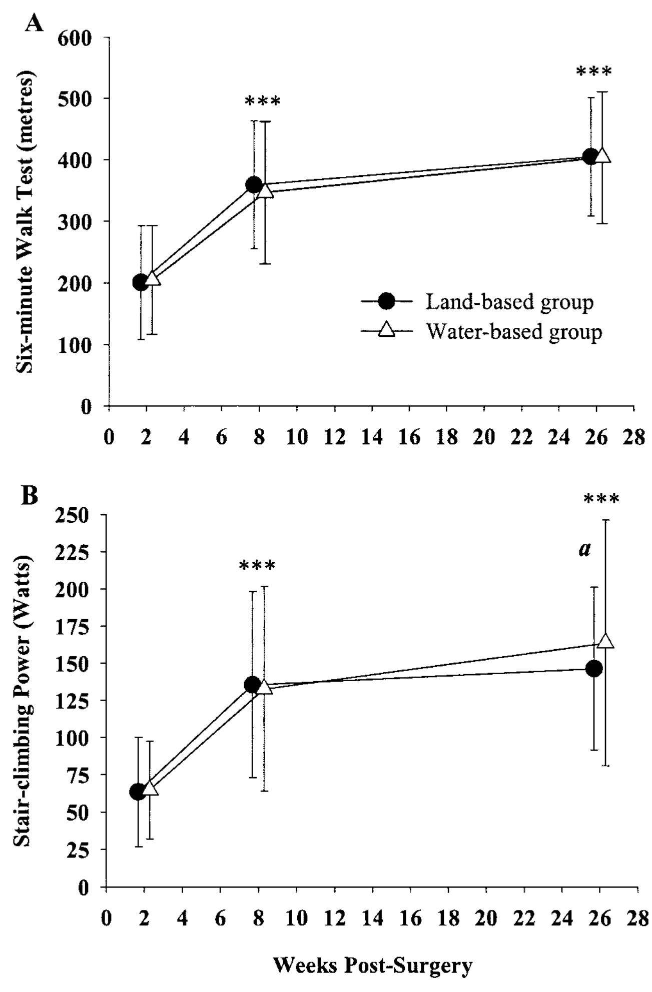

Figure 2. Physical performance tests for land-based (circles) and water-based (triangles) rehabilitation groups at 2, 8, and 26 weeks after total knee replacement surgery in **A,** 6-Minute Walk test and **B**, Stair climbing power. The land-based group is slightly offset to the left, the water-based group to the right at each time point to allow a clear representation of the mean. *** = Main effect for time, 8 and 26 weeks combined >2 weeks, and 26 >8 weeks; $P < 0.001$. *a* = interaction effect, 8 vs. 26 weeks, water-based > land-based; $P = 0.005$.

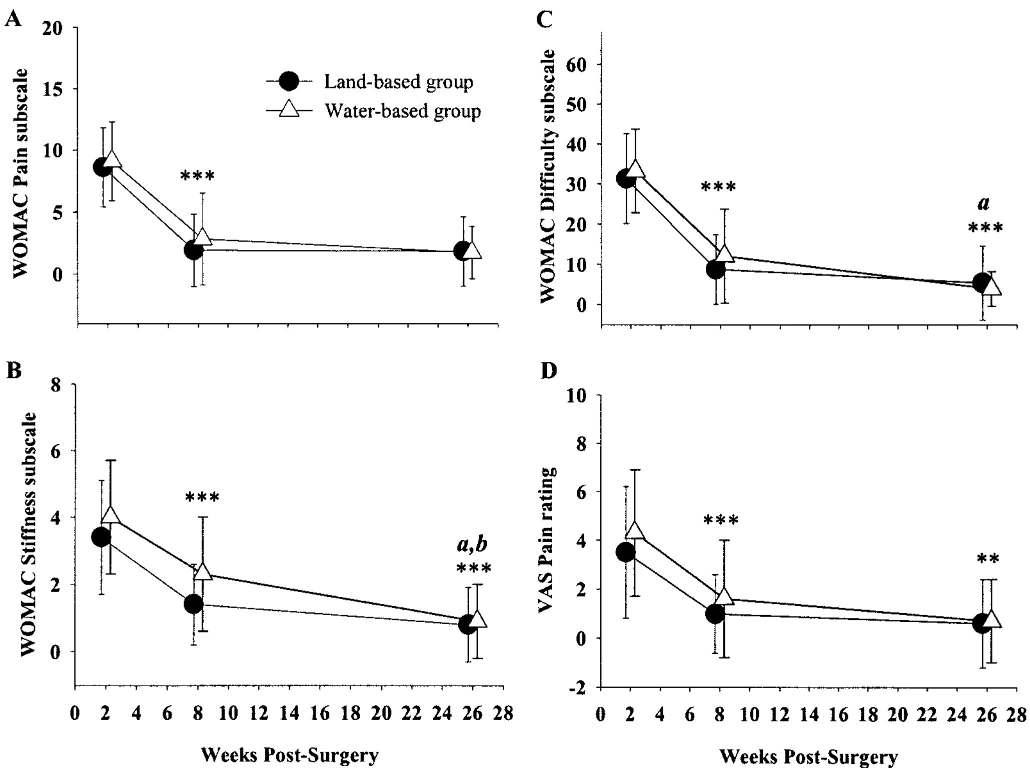

Figure 3. A–C, Western Ontario and McMaster Universities (WOMAC) Osteoarthritis Index subscale scores (n = 85), and **D,** visual analog scale (VAS) pain score for land-based (circles) and water-based (triangles) rehabilitation groups at 2, 8, and 26 weeks after total knee replacement surgery. **A**, WOMAC pain. *** = main effect for time, 8 and 26 weeks combined <2 weeks; $P < 0.001$. **B,** WOMAC stiffness. *** = main effect for time, 8 and 26 weeks combined <2 weeks, and 26<8 weeks; $P < 0.001$. *a* = interaction effect (time-by-group) 8 vs. 26 weeks, improvement greater in water-based group; $P = 0.02$. *b* = group effect, water-based > land-based; $P = 0.038$. **C,** WOMAC difficulty (function). *** = main effect for time, 8 and 26 weeks combined <2 weeks, and 26<8 weeks; $P < 0.001$. *a* = interaction effect (time-by-group) 8 vs. 26 weeks, improvement greater in water-based group, $P = 0.04$. **D,** VAS pain in operated knee over preceding 24 hours. *** = main effect for time 8 and 26 weeks combined < 2 weeks; $P < 0.001$. ** = 26<8 weeks; $P < 0.01$.

points; $P = 0.02$), but improving less from 8 to 26 weeks ($P = 0.02$) (Figure 3B). WOMAC function (difficulty) decreased up to 26 weeks postsurgery (−27.6 points, 95% CI −30.0, −25.2 points; $P < 0.000$) with the water-based group showing more improvement from 8 to 26 weeks compared with the land-based group ($P = 0.04$) (Figure 3C).

Reported VAS pain intensity in the operated joint continued to decrease up to 26 weeks postsurgery (−3.2 points, 95% CI 2.7, 3.8 points; $P < 0.000$) with no between-group differences evident (0.5 points, 95% CI −0.2, 1.1 points) (Figure 3D).

Knee joint flexion ROM continued to improve to 26 weeks postsurgery (24°, 95% CI 21, 27°; $P < 0.000$), with no group differences evident (3°, 95% CI −1, 7°) (Figure 4A). Knee extension also continued to improve to 26 weeks postsurgery (−7°, 95% CI −5, −9°; $P < 0.000$), with no group differences (1°, 95% CI −1, 3°) (Figure 4A).

For knee edema, mean circumference of the nonoperated knee (41.4 cm, 95% CI 40.6, 42.3 cm) did not change over time and did not differ between groups (0.1 cm, 95% CI −1.9, 1.6 cm, $P = 0.89$) (Figure 4B). Edema in the operated knee continued to decrease up to 26 weeks postsurgery (−2.8 cm, 95% CI −3.2, −2.3 cm; $P < 0.000$) with a slightly greater reduction in the water-based group between 8 weeks and 26 weeks ($P = 0.03$) (Figure 4B).

At baseline, 97% of patients required a walking aid at any time. By 26 weeks, 27% required an aid. There was a small increase in risk of requiring a walking aid at 26 weeks in the water-based group (OR 1.2, 95% CI 0.5, 2.9). However, this was not significant on chi-square test.

Adverse events and complications. One patient died of a cardiac event that appeared to be unrelated to rehabilitation treatment (the event occurred over the weekend between the second and third treatment sessions). Thirty-two patients experienced 34 complications during the year and 18 of those complications occurred after discharge from acute care (Table 2). Six patients were readmitted to the hospital; 4 of the 6 required manipulation under anesthetic, 1 had a deep surgical site infection, and 1 had a documented hemarthrosis.

DISCUSSION

This is the first randomized trial comparing land-based and water-based therapy after TKR. The value of water-

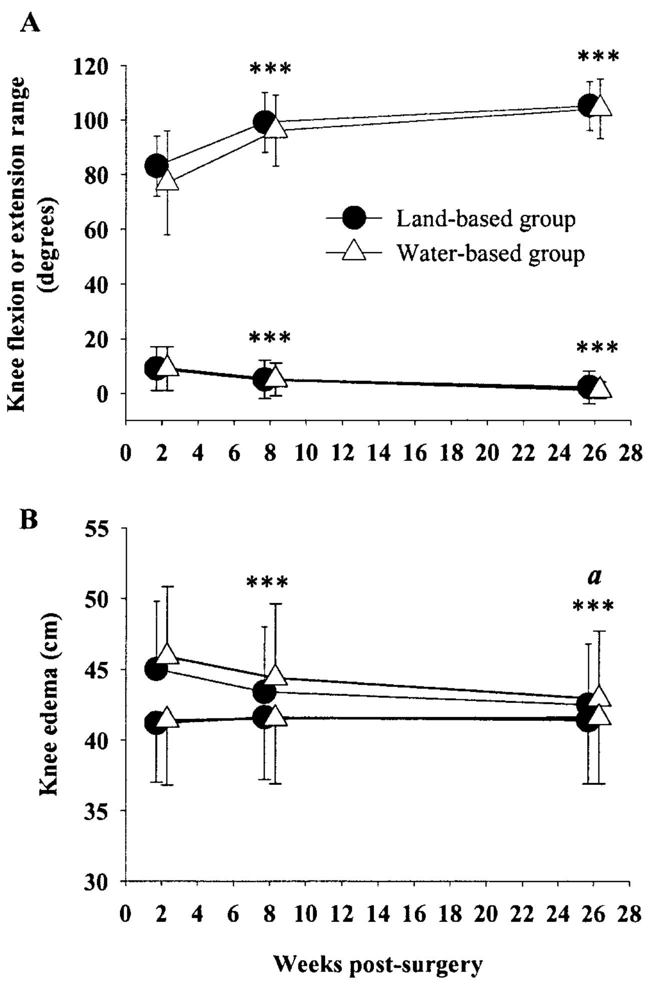

Figure 4. Passive knee joint flexion and extension range of motion and knee edema for land-based (circles) and water-based (triangles) rehabilitation groups at 2, 8, and 26 weeks after total knee replacement. **A,** Knee flexion (upper data set) and extension (lower data set). *** = main effect for time, 8 and 26 weeks combined >2 weeks, and 26>8 weeks; $P < 0.001$. **B**. Knee edema (mean circumference) on the operated leg (upper data set) and nonoperated leg (lower data set). *** = main effect for time in operated leg, 8 and 26 weeks combined >2 weeks, and 26>8 weeks; $P < 0.001$. a = interaction effect for group-by-time between 8 and 26 weeks; $P = 0.03$.

based therapy is particularly interesting since this treatment is associated with comparatively high in-house operational costs. Patients in the 2 groups improved equally well in most outcome measures with few apparent between-group differences. Therefore, neither mode was clearly superior to the other. Contemporary health care relies heavily on cost-neutral service enhancement, therefore if water-based therapy cannot be provided without higher underlying costs, patient access to this medium may remain limited to facilities already utilizing onsite pools for multiple purposes, facilities supported by user-pay systems (such as private hospitals), or facilities in close proximity to community-based pools.

Exercise after TKR is effective in improving function (17,26) and in our study, land-based and water-based exercise programs were associated with comparable improvements in timed walk distance, joint pain, and range of motion, immediately after the program and up to 6 months postsurgery. Improvements were also evident in stair climbing power, stiffness, function (difficulty), and edema, albeit with minor between-group differences. Results of the 6-Minute Walk test at 26 weeks were similar to those achieved in other trials of land-based therapy after TKR (26,27) and approached that (448 meters) of age-matched controls (28). However, SCP results were below those of a comparable age-matched, mobility-limited cohort (284 watts) (20). Our cohort's knee flexion range remained well below age-matched controls (143°) (29) at 6 months postsurgery but was consistent with other ranges of post-TKR cohorts (26,30–32). This may affect the potential for further improvement in the WOMAC difficulty subscale, as could the presence of severe other extremity or lumbar dysfunction (33). To date, there are no published Australian age-matched normative data for WOMAC outcomes. However, our patients reported low levels of pain and stiffness 6 months after surgery, therefore, only minor further gains would be possible. Nevertheless, we acknowledge that although the WOMAC results accurately reflect recovery, the absolute scores may be an over-estimate of patient perceptions given the survey was observer-administered. The potential for further improvement in our cohort, based on the WOMAC scores, is arguably uncertain.

The clinical relevance and mechanisms underlying the minor between-group differences we detected are unclear. Water-based therapy elicited greater improvements in stair climbing power and edema resolution at 6 months postsurgery, but these effects were not evident immediately after treatment cessation. Further, these improvements did not translate into better function or timed mobility, or less reliance on walking aids. Therefore, even if the water medium could accelerate resolution of lower extremity edema or temporarily unload pain-sensitive structures (and we are unable to provide evidence that confirms this), it did not translate into perceptible clinical gains. The

Table 2. Number of complications and adverse events in land-based and water-based rehabilitation groups

Event	Land-based	Water-based
Death	–	1
Manipulation under anesthetic	2	2
Deep surgical site infection	–	1
Hemarthrosis	–	1
Thromboembolism	1	2*
Superficial surgical site infection	5	6
Symptomatic anemia	1	2
Cardiac	1	1
Respiratory	1	1
Urinary tract infection	1	–
Hematuria	–	1
Prolonged febrile state of undefined cause	2	2
Electrolyte disturbance	1	–

* 1 patient had both a deep venous thrombosis and a pulmonary embolus.

lesser improvement beyond 8 weeks in SCP in the land-based group may be attributable to functional limitations secondary to cardiac disease which was more frequent in this group. Land-based therapy produced greater improvements in patient-perceived stiffness overall; however similar end points were achieved and ROM improved similarly in both groups.

The broad inclusion criteria of the present study enhance the generalizability of our results to other TKR populations. Patients were not excluded on the basis of significant comorbidity, age, or surgical approach. The high level of compliance achieved is also noteworthy and compares favorably with other TKR rehabilitation trials (17,26,30). This is in part attributable to phone call followup by the treating physiotherapist when a patient failed to attend. Replication of this compliance may depend on the ability to monitor attendance. Although we employed intent-to-treat analysis, the high compliance added further robustness. The pragmatic design of the interventions was deliberate so that results would be immediately applicable to, and the programs easily adoptable by, rehabilitation providers.

This study followed our usual protocol for rehabilitation after TKR and compared the outcomes associated with 2 different interventions in the absence of a control arm. Consequently, although we have demonstrated that neither program appears to result in superior outcomes at 6 months, the contribution attributable to natural recovery after surgery cannot be determined. It is not typical in the vast majority of facilities for patients to receive unsupervised rehabilitation after TKR (1,2). We acknowledge, however, that a control arm would help partition the effects of natural recovery from any supplementary effects from rehabilitation. Since we did not monitor engagement in regular physical activity after treatment cessation, it is not clear if the continued improvement in all outcomes was due to the programs instilling favorable exercise habits in the cohort or a manifestation of natural recovery. It is conceivable that the outcome measures we assessed had not stabilized (e.g., knee edema) by 6 months postsurgery, and that improvements may have been greater had we followed patients at 1 year, or if patients had been exposed to more protracted rehabilitation. It is unlikely, however, that given the similar trajectory of recovery in both groups up to 6 months postsurgery that clinically relevant differences between groups would emerge at 1 year.

Consistent with current clinical practice in Australia, we did not formally measure exercise intensity or compliance with the home program. Therefore we cannot be certain that the exercise dosage was similar between the land-based and water-based groups or even of sufficient dosage to generate physiologic change. A criticism of most studies to date evaluating the value of rehabilitation after TKR and hip replacement is that the intensity of the prescribed exercise programs may fall short of what is necessary to induce meaningful adaptations (17,34). Nevertheless, every effort was made to ensure the intensity of both programs was similar by employing the same therapist for both groups and providing the same instructions to all patients regarding working to their tolerance level.

The temperature of the pool we used was cooler (25°C) than the temperature generally utilized (32–36°C) for hydrotherapy for patients with knee and hip arthritis (35) and recommended for reducing musculoskeletal stiffness (36). It is theoretically possible that hydrotherapy could have produced more favorable results if the pool temperature was warmer, but previous trials involving arthritis patients (10–15) that used warmer water have not shown hydrotherapy to be superior to land-based alternatives. An in-depth cost-effectiveness analysis was not conducted given the earlier comprehensive studies by Epps et al (15) and Cochrane et al (13).

In conclusion, in both the land-based and water-based rehabilitation groups, improvement was evident in nearly all outcome measures up to 6 months after TKR. Because our original hypothesis was not supported, this study adds to the body of work demonstrating that hydrotherapy, although associated with clinically relevant improvements, does not generally provide superior outcomes when compared with alternative treatments for lower extremity arthritis.

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AUTHOR CONTRIBUTIONS

Dr. Harmer had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study design. Harmer, Naylor, Crosbie.
Acquisition of data. Naylor.
Analysis and interpretation of data. Harmer, Naylor, Crosbie.
Manuscript preparation. Harmer, Naylor, Crosbie, Russell.
Statistical analysis. Harmer, Naylor.
Conducted exercise interventions. Russell.

REFERENCES

1. Naylor JM, Harmer AR, Fransen M, Crosbie J, Innes L. The status of physiotherapy rehabilitation following total knee replacement in Australia. Physiother Res Int 2006;11:35–47.
2. The Medical Advisory Secretariat. Physiotherapy rehabilitation after total knee or hip replacement: health technology literature review. Ontario: Ministry of Health and Long-Term Care; 2005.
3. Lingard EA, Berven S, Katz JN, and the Kinemax Outcomes Group. Management and care of patients undergoing total knee arthroplasty: variations across different health care settings. Arthritis Care Res 2000;13:129–36.
4. Australian Orthopaedic Association National Joint Replacement Registry: annual report. Adelaide: Australian Orthopaedic Association; 2007.
5. Dixon T, Shaw M, Ebrahim S, Dieppe P. Trends in hip and knee joint replacement: socioeconomic inequalities and projections of need. Ann Rheum Dis 2004;63:825–30.
6. Sokka T, Kautiainen H, Hannonen P. Stable occurrence of knee and hip joint replacement in Central Finland between 1986 and 2003: an indication of improved long-term outcomes of rheumatoid arthritis. Ann Rheum Dis 2007;66: 341–4.
7. Katz BP, Freund DA, Heck DA, Dittus RS, Paul JE, Wright J, et al. Demographic variation in the rate of knee replacement: a multi-year analysis. Health Serv Res 1996;31:125–40.

8. Brander VA, Stulberg SD, Chang RW. Rehabilitation following hip and knee arthroplasty. Phys Med Rehabil Clinics North Am 2004;5:815–36.
9. 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 Sys Rev 2007; 4:CD005523.
10. 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;20:179–85.
11. 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;32:812–5.
12. 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;57:407–14.
13. 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;9:1–114.
14. 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;62:1162–7.
15. 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: 1–59.
16. Lineker SC, Badley EM, Hawker G, Wilkins A. Determining sensitivity to change in outcome measures used to evaluate hydrotherapy exercise programs for people with rheumatic diseases. Arthritis Care Res 2000;13:62–5.
17. Moffet H, Collet JP, Shapiro SH, Paradis G, Marquis F, Roy L. Effectiveness of intensive rehabilitation on functional ability and quality of life after first total knee arthroplasty: a single-blind randomised controlled trial. Arch Phys Med Rehabil 2004;5:546–56.
18. Kennedy DM, Stratford PW, Wessel J, Gollish JD, Penney D. Assessing stability and change of four performance measures: a longitudinal study evaluating outcome following total hip and knee arthroplasty. BMC Musculoskelet Disord 2005;6:3.
19. Parent E, Moffet H. Comparative responsiveness of locomotor tests and questionnaires used to follow early recovery after total knee arthroplasty. Arch Phys Med Rehabil 2002;83:70–80.
20. Bean JF, Kiely DK, LaRose S, Alian J, Frontera WR. Is stair climb power a clinically relevant measure of leg power impairments in at-risk older adults? Arch Phys Med Rehabil 2007;88:604–9.
21. Bellamy N, Buchanan WW, Goldsmith CH, Campbell J, Stitt LW. Validation study of WOMAC: a health status instrument for measuring clinically-important patient-relevant outcomes following total hip or knee arthroplasty in osteoarthritis. J Orthop Rheumatol 1988;1:95–108.
22. Hawker G, Melfi C, Paul J, Green R, Bombardier C. Comparison of a generic (SF-36) and a disease specific (WOMAC) instrument in the measurement of outcomes after knee replacement surgery. J Rheumatol 1995;22:1193–6.
23. Bellamy N. WOMAC osteoarthritis index user guide. VII. Queensland (Australia): 2004.
24. Brander VA, Stulberg SD. Rehabilitation after hip- and knee-joint replacement: an experience- and evidence-based approach to care. Am J Phys Med Rehabil 2006;85(Suppl 11): S98–118.
25. Edwards JZ, Greene KA, Davis RS, Kovacik MW, Noe DA, Askew MJ. Measuring flexion in knee arthroplasty patients. J Arthroplasty 2004;19:369–72.
26. Kramer JF, Speechley M, Bourne R, Rorabeck C, Vaz M. Comparison of clinic- and home-based rehabilitation programs after total knee arthroplasty. Clin Orthop Relat Res 2003;410: 225–34.
27. Moffet H, Collet JP, Shapiro SH, Paradis G, Marquis F, Roy L. Effectiveness of intensive rehabilitation on functional ability and quality of life after first total knee arthroplasty: a single-blind randomized controlled trial. Arch Phys Med Rehabil 2004;85:546–56.
28. Steffen T, Hacker TA, Mollinger L. Age- and gender-related test performance in community-dwelling elderly people: Six-Minute Walk test, Berg Balance Scale, Timed Up & Go Test, and gait speeds. Phys Ther 2002;82:128–37.
29. Shumway-Cook A, Brauer S, Woollacott M. Predicting the probability for falls in community-dwelling older adults using the Timed Up and Go Test. Phys Ther 2000;80:897–903.
30. Frost H, Lamb SE, Robertson S. A randomized controlled trial of exercise to improve mobility and function after elective knee arthroplasty: feasibility, results and methodological difficulties. Clin Rehabil 2002;16:200–9.
31. Rajan RA, Pack Y, Jackson H, Gillies C, Asirvatham R. No need for outpatient physiotherapy following total knee arthroplasty: a randomized trial of 120 patients. Acta Orthop Scand 2004;75:71–3.
32. Codine P, Dellemme Y, Denis-Laroque F, Herisson C. The use of low velocity submaximal eccentric contractions of the hamstrings for recovery of full extension after total knee replacement: a randomized controlled study. Isokinet Exerc Sci 2004;12:215–8.
33. Naylor JM, Harmer AR, Heard RC. Severe other joint disease and obesity independently influence recovery after joint replacement surgery: a prospective, observational study. Aust J Physiother 2008;54:57–64.
34. Suetta C, Magnusson SP, Rosted A, Aagard P, Jakobsen AK, Larsen LH, et al. Resistance training in the early postoperative phase reduces hospitalization and leads to muscle hypertrophy in elderly hip surgery patients: a controlled, randomized study. J Am Geriatr Soc 2004;52:2016–22.
35. 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.
36. Elkayam O, Wigler I, Tishler M, Rosenblum I, Caspi D, Segal R, et al. Effect of spa therapy in Tiberias on patients with rheumatoid arthritis and osteoarthritis. J Rheumatol 1991;18: 1799–803.