Arthritis & Rheumatism (Arthritis Care & Research)
Vol. 57, No. 3, April 15, 2007, pp 407–414
DOI 10.1002/art.22621

ORIGINAL ARTICLE

Physical Activity for Osteoarthritis Management: A Randomized Controlled Clinical Trial Evaluating Hydrotherapy or Tai Chi Classes

MARLENE FRANSEN,[1] LILLIAS NAIRN,[1] JULIE WINSTANLEY,[2] PAUL LAM,[3] AND JOHN EDMONDS[4]

Objective. **To determine whether Tai Chi or hydrotherapy classes for individuals with chronic symptomatic hip or knee osteoarthritis (OA) result in measurable clinical benefits.**

Methods. **A randomized controlled trial was conducted among 152 older persons with chronic symptomatic hip or knee OA. Participants were randomly allocated for 12 weeks to hydrotherapy classes (n = 55), Tai Chi classes (n = 56), or a waiting list control group (n = 41). Outcomes were assessed 12 and 24 weeks after randomization and included pain and physical function (Western Ontario and McMaster Universities Osteoarthritis Index), general health status (Medical Outcomes Study Short Form 12 Health Survey [SF-12], version 2), psychological well-being, and physical performance (Up and Go test, 50-foot walk time, timed stair climb).**

Results. **At 12 weeks, compared with controls, participants allocated to hydrotherapy classes demonstrated mean improvements (95% confidence interval) of 6.5 (0.4, 12.7) and 10.5 (3.6, 14.5) for pain and physical function scores (range 0–100), respectively, whereas participants allocated to Tai Chi classes demonstrated improvements of 5.2 (−0.8, 11.1) and 9.7 (2.8, 16.7), respectively. Both class allocations achieved significant improvements in the SF-12 physical component summary score, but only allocation to hydrotherapy achieved significant improvements in the physical performance measures. All significant improvements were sustained at 24 weeks. In this almost exclusively white sample, class attendance was higher for hydrotherapy, with 81% attending at least half of the available 24 classes, compared with 61% for Tai Chi.**

Conclusion. **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 OA.**

KEY WORDS. Osteoarthritis; Hydrotherapy; Tai Chi; Exercise.

INTRODUCTION

Regular moderate physical activity provides a wide range of health benefits (1). Unfortunately, a large proportion of individuals with osteoarthritis (OA) involving the hips or knees are sedentary (2). Graded exercise programs are effective interventions for patients with knee OA (3), with both strength training (4) and aerobic exercise (5) demonstrating significant improvements in pain, physical function, and general health status. However, ongoing adherence to exercise programs is poor (6).

Hydrotherapy is frequently recommended because the weight-relieving properties of water allow for easier joint movement. However, a systematic review of randomized studies conducted up to 2000 identified only 4 studies involving patients with OA and concluded that the evidence for effectiveness was weak due to the poor quality of these studies (7). A recent randomized study of 105 patients with OA found no significant improvements in joint pain or physical function (8). However, almost 50% of

ClinicalTrials.gov identifier: NCT00123994

Supported by a National Arthritis and Musculoskeletal Conditions Improvements grant, the University of New South Wales, the St. George Division of General Practice, and the Central Sydney Division of General Practice.

[1]Marlene Fransen, MPH, PhD, Lillias Nairn, DipPhysio: The George Institute for International Health, University of Sydney, Sydney, Australia; [2]Julie Winstanley, PhD: University of the Sunshine Coast, Queensland, Australia; [3]Paul Lam, MBBS: University of New South Wales, Sydney, Australia; [4]John Edmonds, MBBS: The St. George Hospital, Kogarah, New South Wales, Australia.

Dr. Lam received royalties from the sale of Tai Chi for Arthritis video/DVD and a book titled *Overcoming Arthritis*.

Address correspondence to Marlene Fransen, MPH, PhD, PO Box M201 Missenden Road, Camperdown, New South Wales, Australia 2050. E-mail: mfransen@thegeorgeinstitute.org.

Submitted for publication June 4, 2006; accepted in revised form August 25, 2006.

these study participants were on the orthopedic surgery waiting list. Previous research has clearly demonstrated limited responsiveness to graded exercise among patients with severe structural disease (9).

In recent years, Tai Chi has been gaining popularity. Tai Chi consists of slow, continuous movements that incorporate elements of strengthening, balance, postural alignment, relaxation, and concentration. Although many claims have been made about the health benefits afforded by Tai Chi, there are few randomized studies specifically directed at individuals with chronic OA. Two small studies reported some improvements in quality of life indicators and functioning; however, both studies had methodologic problems likely to inflate estimates of treatment effect (10,11).

The goal of the present study was to determine whether hydrotherapy or Tai Chi classes for individuals with chronic symptomatic OA of the hips or knees are acceptable physical activity options that can provide measurable improvements in joint pain and physical function. If hydrotherapy or Tai Chi classes were shown to be as effective as traditional land-based exercise in reducing pain and improving physical function, such classes could prove to be effective, inexpensive, attractive, and accessible treatment and regular physical activity options for older persons with OA.

PARTICIPANTS AND METHODS

A randomized controlled clinical trial with blinded outcomes assessment was conducted among community-dwelling older persons with symptomatic OA of the hips or knees. This study was conducted in compliance with the Helsinki Declaration and was approved by the South Eastern Sydney Area Health Service Human Research Ethics Committee. Written informed consent was obtained from all participants prior to randomization. The study was registered with the National Institutes of Health.

Participants. Participants were recruited via advertisement in local newspapers, through presentations at local social clubs for older persons, and through referral from local general practitioners and rheumatologists. The inclusion criteria were age 59–85 years, a diagnosis of OA involving the hip or knee as per American College of Rheumatology criteria (12,13), and current and chronic (>1 year) hip or knee pain. Exclusion criteria were current participation in recreational physical activity more than twice per week; inability to walk indoors without a walking aide; unstable cardiac conditions or severe pulmonary disease; incontinence, fear of water, or uncontrolled epilepsy; low back pain referred to the lower limbs; joint replacement surgery in the previous year; arthroscopic surgery or intraarticular injections within previous 3 months; and current participation in Tai Chi or hydrotherapy.

Randomization. A computerized randomization schedule, in blocks of 30, was generated at an offsite location, from which participants were informed of their allocation by telephone after completing their baseline assessment. Participants were randomized to 1 of 3 groups: hydrotherapy classes, Tai Chi classes, or a waiting list control group (12 weeks) prior to randomization to hydrotherapy or Tai Chi. Class size was restricted to a maximum of 15, and classes were conducted at St George Public Hospital between January 2004 and October 2005. Participants were required to make a single donation of $35 to assist with study costs.

Interventions. Participants were required to attend classes for 1 hour, twice a week for 12 weeks. While class attendance was recorded, home practice was not monitored.

Four different registered physiotherapists conducted hydrotherapy classes over the study period. The hydrotherapy program (Appendix A) was designed by the senior rheumatology physiotherapist.

Four different Tai Chi instructors trained in a specially designed Tai Chi program (*Tai Chi for Arthritis* video, Paul Lam) conducted classes over the study period. This program is a modification of 24 forms from the Sun style of Tai Chi and includes a preliminary 10-minute warm-up session. Participants were able to purchase, if they desired, a Tai Chi video to assist with home practice.

Outcomes. The study project manager, who remained blind to participants' group allocation, carried out all outcomes assessments. Assessments were conducted at baseline (pretreatment), 12 weeks (posttreatment), and 24 weeks (followup). Controls were assessed following the same schedule after completion of the 12-week waiting list period. Baseline participant characteristics included a validated evaluation of comorbidity (14). Participants were asked to identify a signal (most painful) hip or knee joint for all further assessments.

The primary outcome measures were pain and physical function measured by the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC; Likert version) (15). Scores were standardized to a 0–100 range, with higher scores indicating greater pain or physical disability.

Secondary outcomes included general health status, psychological well-being, patient's global assessment of treatment effectiveness for the signal joint, patient's global assessment of current status of the signal joint, and physical performance measures. General health status was assessed with the Medical Outcomes Study Short Form 12 Health Survey (SF-12), version 2 (16). From the 8 domains of general health status evaluated by the SF-12, 2 scores were computed: physical component summary (PCS) and mental component summary (MCS) (16). The PCS and the MCS are transformed to have a mean ± SD score of 50 ± 10 in the general US population. Psychological well-being was measured with the Depression, Anxiety and Stress Scale (DASS21) (17). Each of the 3 subscales has a score range of 0–42, with higher scores indicating poorer psychological well-being. Patients' global assessment of treatment effectiveness for the signal joint is a 5-level categorical scale ranging from "much better" to "much worse." Patients' global assessment of current status of the signal joint is a 5-level scale ranging from "excellent" to "poor"

(18). Physical performance measures included the timed 50-foot walk test (19), stair climb test, and Up and Go test (20).

Statistical analysis. The primary statistical analysis was per intent-to-treat with a priori planned comparisons of 1) hydrotherapy classes against controls and 2) Tai Chi classes against controls. Participants lost to followup were assigned scores as per their last assessment but adjusted for any systematic changes as ascertained in the control group. An overall significance level of 2-sided $P = 0.05$ was set and adjustments were made for multiple comparisons relating to secondary outcomes using the Bonferroni correction. For all change scores, positive scores were improvements. Unadjusted and adjusted analyses were performed, with unadjusted analyses consisting primarily of paired *t*-tests and chi-square analysis. The standardized response mean (SRM; mean change divided by the standard deviation of change) was calculated for those outcomes demonstrating significant improvement. The SRM 95% confidence intervals (95% CIs) were estimated assuming a normal distribution of the SRM (21).

For improved clinical relevance, analyses were conducted according to the Outcome Measures in Rheumatology Clinical Trials (OMERACT)/Osteoarthritis Research Society International (OARSI) responder criteria (scenario D) for OA (22). As such, responders were defined as participants achieving ≥50% improvement in pain or physical function scores (and an absolute change of ≥20) or ≥20 improvement in both pain and physical function scores (and an absolute change of ≥10%) on the WOMAC subscales.

Sample size. Sample size estimates were based on the primary outcome measure, the WOMAC pain and physical function scores. Evidence from the literature suggests that 12 mm (0–100-mm scale) represents a clinically significant difference, with an SD of 22 mm (23). To provide the study 80% power to detect such an effect, and allowing for up to a 25% dropout rate, a total sample size of 150 participants was required (24). The study would also have 80% power to demonstrate a 2.5 increased risk of being an OMERACT/OARSI responder (22).

RESULTS

Of the 637 individuals initially screened by telephone, more than one-third (n = 254 [40%]) did not meet the inclusion criteria and more than one-third (n = 231 [36%]) were not interested or not available (Figure 1). The most common reasons for not meeting the inclusion criteria were health or surgical reasons (n = 68 [27%]), asymptomatic for the past year (n = 49 [19%]), pain referred from the lumbar spine (n = 43 [17%]), too young or too old (n = 33 [13%]), too active (n = 33 [13%]), having other physical treatments or corticosteroid injection in the past 3 months (n = 21 [8%]), and unable to participate in hydrotherapy (n = 7 [3%]). The reasons provided by the other 231 potential participants were unavailable to attend classes at the provided times (n = 80 [35%]), not interested in exercise classes (n = 55 [24%]), unwilling to accept randomization (n = 50 [22%]), problems with transportation and mobility (n = 33 [14%]), and unknown reason (n = 13 [6%]). A total of 152 participants were randomized (Figure 1).

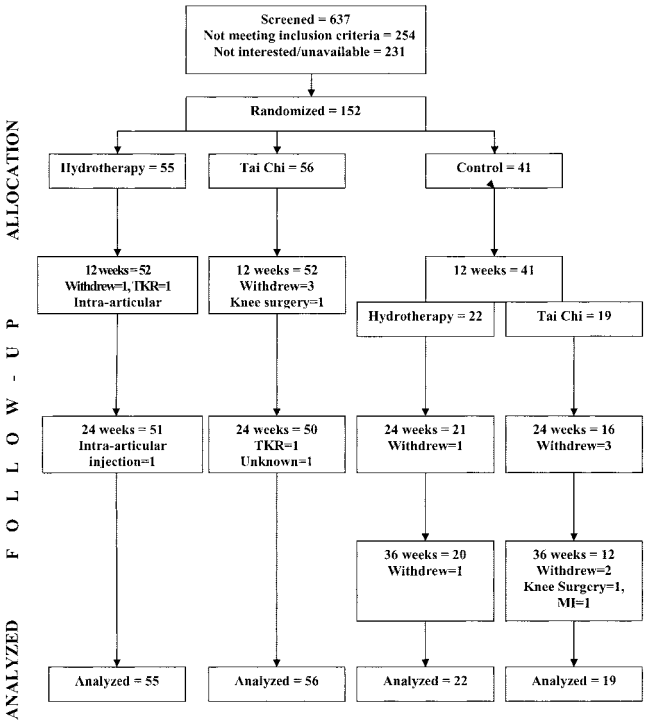

Figure 1. The Physical Activity for Osteoarthritis Management study flow chart. TKR = total knee replacement; MI = myocardial infarction.

Posttreatment assessments were completed for 141 participants (93%) and followup assessments were completed 12 weeks later for 133 participants (88%). Of the 11 participants who withdrew from the study, 3 had been allocated to hydrotherapy (transportation difficulties, classes held too late in the afternoon, not willing to forego physical treatment during the control period) and 8 had been allocated to Tai Chi (disliked Tai Chi classes [n = 2], exacerbation of knee pain [n = 2], wanted hydrotherapy, lost interest, prohibitive family commitments). Apart from differences in study signal joint and the DASS21 stress subscale scores, there were no other significant differences between the 3 allocation groups at baseline (Table 1).

Primary outcome (WOMAC). Posttreatment, significant improvements were evident in pain and function for both the hydrotherapy group and the Tai Chi group (Table 2). The magnitude of the treatment effect for physical function was moderate for both hydrotherapy and Tai Chi classes (SRM 0.62; 95% CI 0.49, 0.75 and SRM 0.63; 95% CI 0.50, 0.76, respectively) compared with the control group (Table 3). Only the hydrotherapy classes resulted in significant improvement in pain scores, with a small treatment effect (SRM 0.43; 95% CI 0.30, 0.56) compared with the control group (25).

At the 12-week assessment, 27 participants (49%), 19 participants (34%), and 6 participants (15%) allocated to

Table 1. Baseline personal characteristics and disease severity measures*

	Hydrotherapy (n = 55)	Tai Chi (n = 56)	Control (n = 41)
Female sex, no. (%)	40 (73)	38 (68)	34 (83)
Age, years	70.0 ± 6.3	70.8 ± 6.3	69.6 ± 6.1
BMI, kg/m^2	30.0 ± 5.0	29.6 ± 5.9	30.7 ± 5.0
Comorbidity score (0–16)	4.5 ± 3.0	4.4 ± 2.7	5.2 ± 2.3
EuroQol 5D (0–1)	0.62 ± 0.20	0.63 ± 0.20	0.56 ± 0.26
Symptom duration, no. (%)			
<6 years	17 (31)	26 (46)	9 (22)
6–10 years	19 (35)	15 (27)	19 (46)
>10 years	19 (35)	14 (25)	12 (29)
Both knees involved, no. (%)	41 (74)	34 (61)	33 (80)
Both hips involved, no. (%)	11 (20)	16 (29)	12 (29)
Signal joint knee, no. (%)	51 (93)	41 (73)	36 (88)
Signal joint hip, no. (%)	4 (7)	15 (27)	5 (12)
Joint surgery, no. (%)	17 (31)	14 (33)	14 (34)
History of joint trauma, no. (%)	11 (20)	14 (33)	11 (27)
At least daily oral analgesia, no. (%)	27 (49)	23 (41)	19 (46)
Global assessment joint: poor/fair, no. (%)	52 (95)	48 (86)	35 (85)
WOMAC (0–100)			
Pain	38.2 ± 17.4	40.3 ± 19.0	44.4 ± 17.0
Function	46.3 ± 20.4	47.2 ± 20.6	50.8 ± 19.3
SF-12 (mean ± SD 50 ± 10)			
PCS	31.9 ± 8.5	35.6 ± 9.6	33.2 ± 10.1
MCS	53.4 ± 11.1	50.9 ± 11.4	47.7 ± 12.4
DASS21 (0–42)			
Depression	6.8 ± 6.8	7.4 ± 8.5	9.5 ± 10.3
Anxiety	4.9 ± 6.3	5.5 ± 5.7	6.9 ± 7.7
Stress	9.5 ± 8.2	9.3 ± 8.4	13.7 ± 9.7
Performance, seconds			
Up and Go	8.9 ± 2.0	9.1 ± 2.4	8.9 ± 2.0
50-foot walk	11.2 ± 2.3	11.3 ± 2.3	11.3 ± 2.1
Stair climb	15.6 ± 5.3	15.3 ± 6.3	16.0 ± 4.7

* Values are the mean ± SD unless otherwise indicated. BMI = body mass index; WOMAC = Western Ontario and McMaster Universities Osteoarthritis Index; SF-12 = Medical Outcomes Study Short Form 12 Health Survey; PCS = physical component summary; MCS = mental component summary; DASS21 = Depression, Anxiety and Stress Scale.

hydrotherapy, Tai Chi, and the control group, respectively, were treatment responders according to OMERACT/OARSI responder criteria D (22). The difference in treatment responder rate between the 3 allocation groups was significant (χ^2 = 12.4, 2 df, P = 0.002).

Secondary outcome measures. The hydrotherapy group improved significantly in the SF-12 PCS, 2 DASS21 subscales, and all 3 physical performance measures (Up and Go, 50-foot walk time, and stair climb), whereas the Tai Chi group only improved significantly in the timed stair climb (Table 2). Only the hydrotherapy group demonstrated significant improvements, above the control group, for the SF-12 PCS and all 3 measures of physical performance (Table 3) (25).

Globally, 37 participants (67%), 26 participants (46%), and 6 participants (15%) in the hydrotherapy, Tai Chi, and control groups, respectively, reported that their signal hip or knee joint was much better or better compared with 3 months earlier. Similarly, 27 participants (49%), 19 participants (34%), and 4 participants (10%), respectively, reported that their signal hip or knee was excellent, very good, or good. The percentage of patients with at least daily analgesia use remained relatively unchanged at week 12 compared with baseline (Table 1): 49%, 36%, and 51% for the hydrotherapy, Tai Chi, and control groups, respectively.

Followup assessment. The followup assessment was conducted for all participants on the basis of their active treatment allocation, i.e., the results included those achieved by the control participants after completion of the hydrotherapy or Tai Chi classes (Figure 1). The significant improvements achieved at 12 weeks were generally sustained for 3 months after cessation of classes (Table 4). In this active treatment cohort, 32 (42%) and 23 (31%) participants in the hydrotherapy and Tai Chi groups, respectively, were OMERACT/OARSI treatment responders at 12 weeks. Among these 12-week responders, 21 (66%) and 18 (58%) participants in the hydrotherapy and Tai Chi groups, respectively, were still treatment responders at 24 weeks.

Treatment adherence. Of participants allocated to hydrotherapy and Tai Chi, 62 (81%) and 46 (61%) partici-

Table 2. Mean ± SD score and mean change (95% CI) at 12 weeks*

	Hydrotherapy (n = 55)	Tai Chi (n = 56)	Control (n = 41)
WOMAC (0–100)			
Pain			
Mean ± SD	27.3 ± 18.7	30.7 ± 18.9	40.0 ± 16.2
Change (95% CI)	10.9 (6.5, 15.3)	9.6 (5.4, 13.7)	4.4 (0.2, 8.6)
Function			
Mean ± SD	34.8 ± 23.7	36.6 ± 20.9	49.9 ± 19.0
Change (95% CI)	11.4 (6.3, 16.6)	10.6 (5.6, 15.7)	0.9 (−3.6, 5.4)
SF-12 (mean 50)			
PCS			
Mean ± SD	35.7 ± 9.8	37.6 ± 11.2	33.1 ± 10.6
Change (95% CI)	3.8 (0.6, 7.0)	1.9 (−0.4, 4.2)	−0.2 (−2.4, 2.0)
MCS			
Mean ± SD	54.6 ± 8.9	50.9 ± 10.7	48.0 ± 11.4
Change (95% CI)	1.2 (−0.9, 3.3)	−0.0 (−2.7, 2.6)	0.2 (−3.1, 3.6)
DASS21 (0–42)			
Depression			
Mean ± SD	4.7 ± 6.1	7.0 ± 8.3	9.0 ± 11.0
Change (95% CI)	2.2 (0.9, 3.4)	0.4 (−1.9, 2.7)	0.5 (−1.6, 2.6)
Anxiety			
Mean ± SD	4.6 ± 5.2	5.1 ± 6.0	7.3 ± 7.8
Change (95% CI)	0.3 (−1.0, 1.5)	0.3 (−1.1, 1.8)	−0.4 (−2.1, 1.3)
Stress			
Mean ± SD	7.1 ± 8.0	8.1 ± 8.6	12.6 ± 10.9
Change (95% CI)	2.4 (0.9, 3.8)	1.1 (−0.6, 2.8)	1.1 (−1.6, 3.6)
Performance, seconds			
Up and Go			
Mean ± SD	8.2 ± 1.7	8.8 ± 3.0	9.2 ± 2.2
Change (95% CI)	0.7 (0.3, 1.1)	0.2 (−0.2, 0.7)	−0.3 (−0.6, 0.1)
50-foot walk time			
Mean ± SD	10.3 ± 2.2	11.0 ± 3.3	11.1 ± 2.1
Change (95% CI)	0.9 (0.6, 1.3)	0.3 (−0.2, 0.8)	0.2 (−0.3, 0.6)
Stair climb			
Mean ± SD	13.8 ± 5.1	14.2 ± 6.5	15.8 ± 5.4
Change (95% CI)	1.8 (0.9, 2.7)	1.1 (0.4, 1.8)	0.2 (−0.5, 1.0)

* 95% CI = 95% confidence interval; see Table 1 for additional definitions.

pants, respectively, attended ≥12 of the available 24 classes.

Adverse events. During the study period, 11 participants reported a serious adverse event requiring hospitalization. None of these events took place during class attendance or could be related to the interventions. One participant withdrew from hydrotherapy and one withdrew from Tai Chi due to exacerbation of low back pain.

DISCUSSION

This randomized trial demonstrates that access to 12 weeks of hydrotherapy or Tai Chi classes for older community-dwelling individuals with OA of the hip or knee joints will produce measurable improvements. At the end of the available classes, joint pain and physical function clearly improved. These improvements were sustained for most participants for a further 12 weeks.

Due to an absolute paucity of well-conducted clinical trials with comparable samples of patients with OA, it is not useful to compare the results of this study with those of previous studies evaluating hydrotherapy or Tai Chi classes. However, the treatment effect sizes for joint pain achieved by the hydrotherapy classes (Table 3) were within the 0.30 to 0.47 95% CI demonstrated in a recent meta-analysis of randomized trials evaluating land-based formal graded exercise programs among patients with knee OA (3). Interestingly, the treatment effect sizes for physical function demonstrated by the hydrotherapy or Tai Chi classes (Table 3) were significantly higher than the 0.23 to 0.39 95% CI demonstrated in the same meta-analysis. This larger beneficial effect on physical function may be related to the focus on whole body movement in both hydrotherapy and Tai Chi programs compared with traditional graded therapeutic exercise (3). Although the significant self-reported improvements in physical function were accompanied by significant moderate to large improvements in all 3 physical performance measures for hydrotherapy, Tai Chi classes did not result in any significant improvements in these objective measures (Table 3).

In contrast to the SF-12 PCS, there were no significant improvements in the SF-12 MCS for either treatment allocation. This finding may be related to the influence of a

Table 3. Effect size (0–12 weeks) compared with control group*

	Hydrotherapy above control		Tai Chi above control	
	Change (95% CI)	SRM (95% CI)	Change (95% CI)	SRM (95% CI)
WOMAC (0–100)				
Pain	6.5 (0.4, 12.7)	0.43 (0.30,0.56)	5.2 (−0.8, 11.1)	NS
Function	10.5 (3.6, 14.5)	0.62 (0.49,0.75)	9.7 (2.8, 16.7)	0.63 (0.50,0.76)
SF-12 version 2 (mean 50)				
PCS	4.0 (0.8, 7.2)	0.34 (0.21,0.47)	2.1 (−0.2, 4.4)	0.25 (0.12,0.38)†
MCS	0.9 (−1.2, 3.0)	NS	−0.03 (−2.9, 2.3)	NS
DASS21 (0–42)				
Depression	1.7 (−0.6, 4.0)	NS	−0.1 (−3.6, 3.1)	NS
Anxiety	0.7 (−1.3, 2.7)	NS	0.7 (−1.5, 2.9)	NS
Stress	1.3 (−1.5, 4.0)	NS	0.01 (−3.0, 3.0)	NS
Performance (seconds)				
Up and Go	1.0 (0.4, 1.5)	0.76 (0.63,0.89)	0.5 (−0.2, 1.2)	0.32 (0.19,0.45)
50-foot walk time	0.8 (0.2, 1.4)	0.49 (0.36,0.62)	0.1 (−0.6, 0.8)	NS
Stair climb	1.6 (0.4, 2.8)	0.55 (0.42,0.68)	0.8 (−0.2, 1.9)	0.36 (0.23,0.49)

* 95% CI = 95% confidence interval; SRM = standardized response mean; NS = nonsignificant change; see Table 1 for additional definitions.
† Borderline significant change.

ceiling effect, with baseline MCS scores in this patient sample being comparable with population norms. However, the DASS21 provided a more detailed questionnaire on psychological well-being, with 21 questions evaluating depression, anxiety, and stress. Interestingly, there was a trend towards significant improvements in the depression and stress subscales for patients allocated to hydrotherapy, but not for patients allocated to Tai Chi (Tables 3 and 4).

This study aimed to evaluate both the clinical effectiveness and the acceptance of hydrotherapy and Tai Chi classes for individuals with chronic symptomatic OA. Class attendance rates were lower for Tai Chi. In addition, 4 Tai Chi class participants withdrew from the study because they disliked the classes or believed the classes exacerbated their knee pain. The lower adherence rates may simply reflect the almost exclusively white ethnicity of the study sample (only 1 Asian participant) or the less than optimal gym environment. However, while the slow movements involved in Tai Chi result in a low-impact form of exercise, Tai Chi is mostly performed with bent knees in a semisquat position requiring sustained lower-limb muscle control. Of the 152 study participants, 84% indicated a knee joint as the signal (most painful) joint. This weight-bearing position is likely to be difficult and painful for persons with knee OA, particularly if arthritic changes are present in the patellofemoral joint. Future studies should evaluate the temporary incorporation of patella taping to potentially allow pain-free Tai Chi practice (26). Water-based Tai Chi may also provide a less painful avenue for physical activity; however, the clinical benefits for patients with knee OA have yet to be evaluated.

Many participants with severe structural joint disease are likely to have been recruited because most had been symptomatic for 6 years or more (Table 1). Inclusion of

Table 4. Active treatment cohort: short-term effects (0–12 weeks) and sustainability (12–24 weeks)*

	Hydrotherapy (n = 77)		Tai Chi (n = 75)	
	0–12 weeks	12–24 weeks	0–12 weeks	12–24 weeks
WOMAC (0–100)				
Pain	9.5 (5.8, 13.2)	−1.1 (−4.4, 2.1)	7.5 (3.7, 11.2)	−1.4 (−4.7, 1.9)
Function	11.2 (7.0, 15.4)	−2.2 (−5.6, 1.1)	8.4 (4.1, 12.7)	−0.6 (−3.9, 2.7)
SF-12 version 2 (mean 50)				
PCS	4.6 (2.1, 7.1)	2.2 (0.2, 4.2)	2.3 (0.2, 4.3)	1.3 (−0.1, 2.6)
MCS	0.7 (−1.1, 2.5)	−2.9 (−4.3, −1.5)	−0.1 (−2.3, 2.0)	−1.1 (−2.6, 0.5)
DASS21 (0–42)				
Depression	2.5 (1.2, 3.7)	0.7 (−0.5, 1.9)	0.0	−0.6 (−1.9, 0.7)
Anxiety	0.7 (−0.4, 1.8)	0.2 (−0.7, 1.1)	0.0	0.2 (−0.9, 1.3)
Stress	3.4 (1.7, 5.2)	−1.1 (−2.5, 0.3)	0.4 (−1.1, 1.9)	−0.5 (−1.8, 0.9)
Performance (seconds)				
Up and Go	0.8 (0.4, 1.1)	0.0	0.2 (−0.2, 0.6)	0.0
50-foot walk time	0.7 (0.4, 1.0)	0.0	0.3 (−0.1, 0.7)	0.0
Stair climb	1.5 (0.8, 2.3)	0.1 (−0.4, 0.6)	0.7 (0.1, 1.5)	0.3 (−0.2, 0.7)

* Values are the mean change (95% confidence interval). Positive changes are improvements. See Table 1 for definitions.

many participants with severe structural disease may have diluted treatment effects as we have shown previously that severe structural disease, in terms of markedly reduced tibiofemoral joint space width, is associated with reduced responsiveness to exercise (9). Unfortunately, funding limitations precluded baseline radiographs to quantify radiographic disease severity in this study. The small number of participants indicating a hip joint as the signal joint also did not allow subgroup analysis of treatment effectiveness according to specific joint involvement.

This clinical trial involved a physical intervention; therefore, participants were not blinded to treatment allocation, possibly inflating treatment effect sizes. However, all participants were aware that the study staff conducting the outcomes assessments were both blinded to their treatment allocation and had no interest in promoting the superior benefits of either of the 2 treatment options.

In addition to blinding of outcomes assessment, this study had several other strengths. The randomization procedure was rigorous and was conducted offsite, followup was excellent, the main outcomes were specified a priori, several therapists were involved in the supervision of the hydrotherapy and Tai Chi classes, and patient-relevant outcomes were collected with well-validated questions and supported by objective measures of physical performance. In addition, the project manager was an experienced clinical physiotherapist able to effectively screen participants prior to randomization, reducing the number of participants with self-reported hip and knee joint pain referred from the lumbar spine.

In conclusion, this study demonstrated that access to 12 weeks of hydrotherapy classes or Tai Chi classes for fairly sedentary older individuals (>59 years of age) with chronic symptomatic knee or hip OA resulted in clinical benefits that were sustained a further 12 weeks. Both types of classes resulted in large improvements in self-reported physical function, greater than improvements demonstrated for traditional land-based exercise. In this almost exclusively white sample, hydrotherapy classes appeared to be more acceptable (higher attendance), appeared to provide greater relief of joint pain, and resulted in larger improvements in objective measures of physical performance.

ACKNOWLEDGMENTS

We thank the hydrotherapy physiotherapists (Guni Hinchey, Kim Walker, Cathy Brand, and Khim Kwan) and the Tai Chi trainers (Joan Peters, Pat Weber, Fiona Black, and Jenny Alfonso). Lai-Hoong Wong kindly allowed the use of the physiotherapy department facilities at St George Hospital.

AUTHOR CONTRIBUTIONS

Dr. Fransen 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. Fransen, Nairn, Lam, Edmonds.
Acquisition of data. Fransen, Nairn, Edmonds.
Analysis and interpretation of data. Fransen, Nairn, Winstanley, Edmonds.
Manuscript preparation. Fransen, Nairn, Winstanley, Edmonds.
Statistical analysis. Winstanley.
Train Tai Chi instruction. Lam.

REFERENCES

1. Macera CA, Hootman JM, Sniezek JE. Major public health benefits of physical activity. Arthritis Rheum 2003;49:122–8.
2. Hootman JM, Macera CA, Ham SA, Helmick CG, Sniezek JE. Physical activity levels among the general US adult population and in adults with and without arthritis. Arthritis Rheum 2003;49:129–35.
3. Fransen M, McConnell J, Bell M. Exercise for osteoarthritis of the hip or knee [review]. Cochrane Database Syst Rev 2003;3: CD003071.
4. Pelland L, Brosseau L, Wells G, MacLeay L, Lambert J, Lamothe C, et al. Efficacy of strengthening exercises for osteoarthritis. Part I. A meta-analysis. Phys Ther Rev 2004;9:77–108.
5. Brosseau L, Pelland L, Wells G, Macleay L, Lamothe C, Michaud G, et al. Efficacy of aerobic exercises for osteoarthritis. Part II. A meta-analysis. Phys Ther Rev 2004;9:125–45.
6. Munro JF, Nicholl JP, Brazier JE, Davey R, Cochrane T. Cost effectiveness of a community based exercise programme in over 65 year olds: cluster randomised trial. J Epidemiol Community Health 2004;58:1004–10.
7. Verhagen AP, Bierma-Zeinstra SM, Cardoso JR, de Bie RA, Boers M, de Vet HC. Balneotherapy for rheumatoid arthritis. Cochrane Database Syst Rev 2003;4:CD000518.
8. 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.
9. Fransen M, Crosbie J, Edmonds J. Physical therapy is effective for patients with osteoarthritis of the knee: a randomized controlled clinical trial. J Rheumatol 2001;28:156–64.
10. Hartman CA, Manos TM, Winter C, Hartman DM, Li B, Smith JC. Effects of T'ai Chi training on function and quality of life indicators in older adults with osteoarthritis. J Am Geriatr Soc 2000;48:1553–9.
11. Song R, Lee EO, Lam P, Bae SC. Effects of Tai Chi exercise on pain, balance, muscle strength, and perceived difficulties in physical functioning in older women with osteoarthritis: a randomized clinical trial. J Rheumatol 2003;30:2039–44.
12. Altman R, Alarcon G, Appelrouth D, Bloch D, Borenstein D, Brandt K, et al. The American College of Rheumatology criteria for the classification and reporting of osteoarthritis of the hip. Arthritis Rheum 1991;34:505–14.
13. Altman R, Asch E, Bloch D, Bole G, Borenstein D, Brandt K, et al. Development of criteria for the classification and reporting of osteoarthritis: classification of osteoarthritis of the knee. Arthritis Rheum 1986;29:1039–49.
14. Sangha O, Stucki G, Liang MH, Fossel AH, Katz JN. The Self-Administered Comorbidity Questionnaire: a new method to assess comorbidity for clinical and health services research. Arthritis Rheum 2003;49:156–63.
15. 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 to antirheumatic drug therapy in patients with osteoarthritis of the hip or knee. J Rheumatol 1988;15:1833–40.
16. Gandhi SK, Salmon JW, Zhao SZ, Lambert BL, Gore PR, Conrad K. Psychometric evaluation of the 12-item short-form health survey (SF-12) in osteoarthritis and rheumatoid arthritis clinical trials. Clin Ther 2001;23:1080–98.
17. Lovibond PF, Lovibond SH. The structure of negative emotional states: comparison of the depression anxiety stress scales (DASS) with the Beck Depression and Anxiety inventories. Behav Res Ther 1995;33:335–43.
18. Bellamy N, Kirwan J, Boers M, Brooks P, Strand V, Tugwell P, et al. Recommendations for a core set of outcome measures for future phase III clinical trials in knee, hip, and hand osteoarthritis: consensus development at OMERACT III. J Rheumatol 1997;24:799–802.
19. Grace EM, Gerecz EM, Kassam YB, Buchanan HM, Buchanan

WW, Tugwell PS. 50-foot walking time: critical assessment of an outcome measure in clinical therapeutic trials of antirheumatic drugs. Br J Rheumatol 1988;27:372–4.
20. Piva SR, Fitzgerald GK, Irrgang JJ, Bouzubar F, Starz TW. Get Up and Go test in patients with knee osteoarthritis. Arch Phys Med Rehabil 2004;85:284–9.
21. Beaton DE, Hogg-Johnson S, Bombardier C. Evaluating changes in health status: reliability and responsiveness of five generic health status measures in workers with musculoskeletal disorders. J Clin Epidemiol 1997;50:79–93.
22. Pham T, van der Heijde D, Altman RD, Anderson JJ, Bellamy N, Hochberg M, et al. OMERACT-OARSI initiative: Osteoarthritis Research Society International set of responder criteria for osteoarthritis clinical trials revisited. Osteoarthritis Cartilage 2004;12:389–99.
23. Bellamy N, Carette S, Ford PM, Kean WF, le Riche NG, Lussier A, et al. Osteoarthritis antirheumatic drug trials. III. Setting the delta for clinical trials: results of a consensus development (Delphi) exercise. J Rheumatol 1992;19:451–7.
24. Kirby A, Gebski V, Keech AC. Determining the sample size in a clinical trial. Med J Aust 2002;177:256–7.
25. Cohen J. Statistical power analysis for the behavioral sciences. Revised ed. New York: Academic Press; 1977.
26. Hinman RS, Crossley KM, McConnell J, Bennell KL. Efficacy of knee tape in the management of osteoarthritis of the knee: blinded randomised controlled trial. BMJ 2003;327:135–40.

APPENDIX A: HYDROTHERAPY PROTOCOL (Water temperature 34°C).
Patients exercise with the water at approximately waist height. Patients are required to bring a bottle of water and the classes pause between blocks for a drink.

WALKING	Each direction 6 laps minimum
Forward, backward, sideways	Large steps, arms draw through the water, bent knees
Forward	With board (after 4 weeks)
Forward running	2 minutes
BAR WORK: One hand hold	Upright posture maintained throughout
Swinging outside leg forward/backward	Straight knees, picking up speed
Hip abduction 20 reps bilateral	Straight knees, picking up speed, big toe shows down
BAR WORK: Both hands on bar	
Hip abduction 20 reps; bilateral	Abducted leg flexed
Hip rotations 10 reps; bilateral	Flexed knee, small circle, forward, side, back, down
Tipping	Big toe touches to side, straight leg
Push ups	Knee/hip extensors activated, lift elbows out of water
Push ups	As before right leg, left knee forward
Walking up the wall on toes	Knees fully flexed
Knees open and close	Knees fully flexed
Both knees together to right and left	Knees fully flexed
Bend and straight knees	Rhythmic swinging forward and backward
Heel raise to squat	Emphasize quadriceps and gluteus activation
Side to side lunges	On the floor or feet under the bar
Squats 10 reps	Back to wall, touching wall with buttocks
Running backward	2 minutes
SEATED	
Lift legs × 20, right then left	Keep thighs on seat, increase speed with improvement
Lift legs alternatively × 40	Really pumping
DEEP WATER NOODLE	
Scissors	Legs swing forward and backward
Cycling	
Knees to chest	Leg flexion
Open/cross	Leg abduction/adduction
STEP	Activate correct posture
Step up then over, turn and repeat	Picking up speed with improved skill
Step up and down sideways	Holding on only if necessary
BAR WORK WITH RINGS/NOODLES	
Push noodle/large ring underwater with foot	10 times each, assist patients from outside of pool
Hook small ring over foot, extend knee	
FREE STANDING	Advanced: closed eyes, closed arms
Swinging one leg forward and backward	Standing on 1 leg, both knees straight
Circle ankle, knee, and hip and reverse	Standing on 1 leg, other knee is bent to 90°
Trunk rotations	The Hula
Twist	Knees bent
Alternate cross leg lifts slow change into	Touch knee with opposite hand
RUNNING	
On the spot	Advance through waist high water, gaiters
Sideways	1–2 minutes
Forward/backward/quick successions	After week 4
STAIRS	
Entry/exit pool ×3–10	Practice, increase repetition and speed as able