Managing hip and knee osteoarthritis with exercise: what is the best prescription?

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***Abstract*:** Hip and knee osteoarthritis are common, chronic, and disabling. Therapeutic exercise is a component of all major rheumatologic society guidelines, yet the frequency, dose, duration, and therapeutic threshold for exercise are not clearly delineated. This review summarizes current studies of exercise for hip and knee osteoarthritis, discusses issues that influence the design, interpretation, and aggregation of results and how these factors impact the translation of data into clinical practice. A review of databases to identify current randomized controlled trials (2000 to present) of exercise to manage the symptoms of hip and knee osteoarthritis is discussed here. One study enrolling only hip patients was identified. Six studies of outcomes for individuals with hip or knee osteoarthritis and 11 studies of persons with knee osteoarthritis were found. Limited studies focus specifically on exercise for persons with hip osteoarthritis. Exercise is provided as a complex intervention combining multiple modes and provided in various settings under a range of conditions. Regardless of the variability in results and inherent biases in trials, exercise appears to reduce pain and improve function for persons with knee osteoarthritis and provide pain relief for persons with hip osteoarthritis. Given the complexity of exercise interventions and the specific issues related to study design, novel approaches to the evaluation of exercise are warranted.

***Keywords*:** guidelines, hip and knee osteoarthritis, therapeutic exercise

Introduction

Osteoarthritis is a common chronic disabling condition whose primary pathology is cartilage destruction. Epidemiologic data indicate the impact of osteoarthritis on work disability in men over 50 years of age is only second to ischemic heart disease [Arden and Nevit, 2006; D'Ambrosia, 2005]. Some epidemiologic studies rely on radiographic evidence of osteoarthritis, but the correlation between radiographic changes in the joints and symptoms is modest at best [Bedson and Croft, 2008]. While osteoarthritis may present in the spine and hands, the large weight-bearing joints such as the hips and knees are most frequently affected.

Clinical manifestations of osteoarthritis include altered proprioception, muscle weakness and atrophy, pain, stiffness, and limitations in functional activities and social participation [Iversen and Steiner, 2009]. With progressive disease, malalignment and bone-on-bone joint pain may be present. Osteoarthritis management focuses on pain relief and maximizing function and independence. Pharmacotherapeutic options include acetaminophen, anti-inflammatory medications, glucosamine, chondroitin sulfate, capsaicin and opiate derivatives [Zhang *et al.* 2007, 2005; Fraenkel *et al.* 2004; Hochberg *et al.* 1995]. These medications target inflammation and relieve pain. The integration of nonpharmacologic interventions such as therapeutic exercise, manual therapy, splinting, bracing, orthotics and assistive devices are recommended and provide a low-cost and minimal-risk option for patients to manage their disease. Among these nonpharmacologic interventions, therapeutic exercise is the most studied and supported in the literature [Fransen *et al.* 2009a, 2009b; Moe *et al.* 2007; Zhang *et al.* 2007, 2005; Hochberg *et al.* 1995]. In fact, exercise is a component of the management guidelines for hip and knee osteoarthritis among numerous professional rheumatologic and health societies (Figure 1).

While exercise is a recognized component of the management of hip and knee osteoarthritis, specific details regarding exercise prescription are

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variable and vague. The variability and lack of specificity of exercise recommendations is related in part, to the heterogeneous nature of exercise, as well as to issues with the design, implementation and reporting of nonpharmacologic interventions [Iversen and Petersson, 2006]. Much like pharmacologic interventions, exercise produces differing physiologic changes depending on the mode and dose used. Exercise can include but is not limited to: balance and proprioception activities, isometric, isokinetic exercise with or without resistance, flexibility exercises, core stabilization exercises and aerobic/endurance exercises. This inherent heterogeneity of exercise leads to difficulties with attribution issues when reporting the results of clinical trials, as exercise is often not provided in a single mode but as a combination of therapeutic options. Complicating the issue is that fact that exercise interventions require the active participation of subjects, prohibiting the option for double blinding within the design of clinical trials. The requirement for active subject participation leads to a greater likelihood of dropouts, as patients cannot be blinded to treatment allocation. In addition, active participation must be operationally defined, and parameters established for measurement and maintenance of treatment adherence. Efficacy studies of exercise, by definition, require subject supervision and, thus, provider–client interactions may have an impact on adherence and outcomes. Lastly, not all outcomes used in exercise trials have established minimal clinically important differences and may be at risk for floor and ceiling effects, leading to issues of power and clinical relevance [Bedson and Croft, 2008; Iversen and Petersson, 2006; Boutron *et al.* 2003].

Between 1966 and 2005 there have been a reported 34 published clinical practice guidelines for the management of hip and knee osteoarthritis, 15 systematic reviews and numerous Cochrane reviews of exercise for the management of hip and knee osteoarthritis [Bischoff and Roos, 2003; Brosseau *et al.* 2003; Fransen *et al.* 2003; Petrella, 2000; van Baar *et al.* 1999; La Mantia and Marks, 1995; Puett and Griffin, 1994]. Since 2005 additional attempts to summarize and aggregate these data have been conducted [Farrar and Mitchell, 2009; Fransen *et al.* 2009a, 2009b; Hernandez-Molina *et al.* 2008; Mazieres *et al.* 2008; Misso *et al.* 2008; Bartels

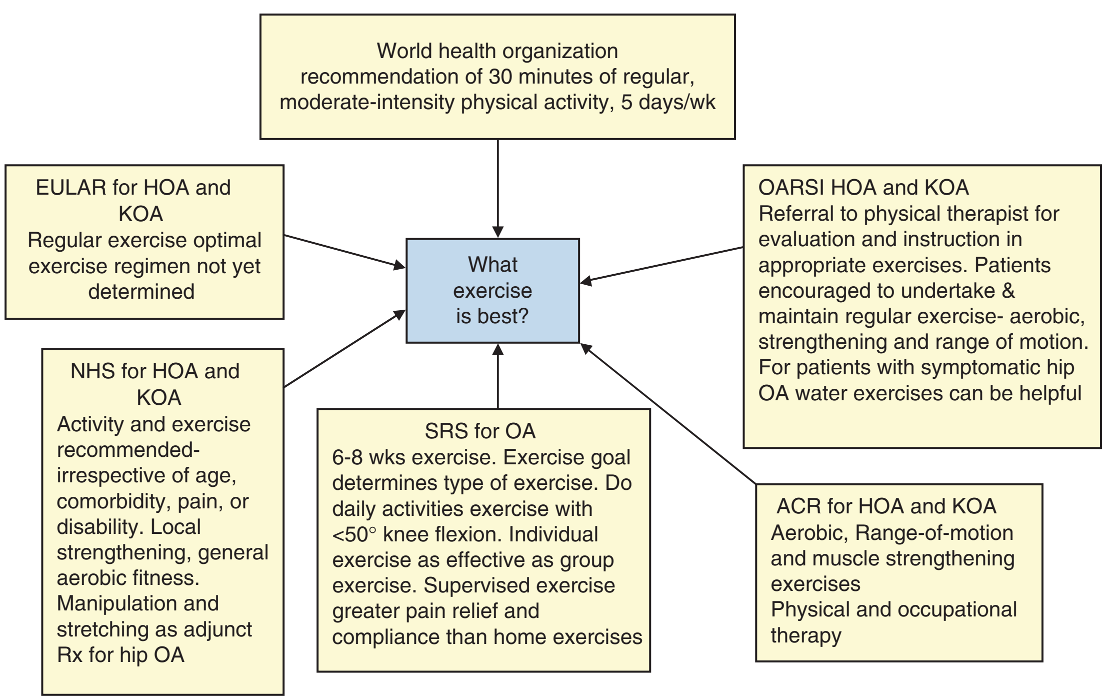

Figure 1. Summary of published guidelines for the use of exercise in the management of hip and knee osteoarthritis. HOA, hip osteoarthritis; KOA, knee osteoarthritis; OA, osteoarthritis; EULAR, European league against rheumatism; OARSI, osteoarthritis research society international; SRS, scoliosis research society; ACR, American college of rheumatology; NHS, national health service. Reproduced with permission from Iversen, MD. Presentation at EULAR meeting, Copenhagen, DK.

et al. 2007; Pisters *et al.* 2007; Vignon *et al.* 2006; Roddy *et al.* 2005] (Table 1). Studies included in these reviews and meta-analyses vary with respect to sample demographics (inclusion/exclusion criteria, sample size, recruitment strategies), and extraction and synthesis of data. A recent meta-analysis [Hernandez-Molina *et al.* 2008] consisting of nine clinical studies of exercise *versus* no treatment for hip osteoarthritis reported a moderate effect size (−0.38) for pain relief. The authors commented there was a high degree of heterogeneity among the interventions. With the removal of one clinical trial, the effect size was greater but still modest. Two recent Cochrane meta-analyses of patients with hip and knee osteoarthritis randomized to land exercise *versus* a nonexercise group have recently been published, one for persons with hip osteoarthritis [Fransen *et al.* 2009a] and one for persons with knee osteoarthritis [Fransen *et al.* 2009b]. The Cochrane meta-analysis of land-based exercise for knee osteoarthritis included 32 randomized controlled trials of exercise for persons with symptomatic osteoarthritis or pain knee, concluded exercise yielded small but significant benefits for self-reported pain (SMD 0.40; 95% CI 0.30–0.50) and function (SMD 0.37; 95% CI 0.25–0.49). These effects are comparable to the results published using analgesics and nonsteroidal anti-inflammatory medications [Fransen *et al.* 2009b]. Similarly, the meta-analyses of five randomized controlled trials of land-based exercise *versus* a nonexercise group to manage hip osteoarthritis [Fransen *et al.* 2009a] demonstrated a moderate treatment effect for pain reduction (ES = −0.49; 95% CI −0.77 to −0.20), but no benefit of exercise in terms of improved self-reported physical function.

To better understand the variability in results and impact across all outcomes, a closer inspection of the attributes of exercise interventions provided in randomized controlled trials of exercise for persons with hip and knee osteoarthritis is warranted. For this review, the following databases were searched: MEDLINE, PEDRO, Cochrane and CINAHL (January 2000 to December 2009). Studies were included if they compared exercise therapy (any mode) with a control, were randomized controlled trials, and were published from 2000 to present. Studies published during the last decade were selected to provide insight into recent research in this area. Studies were excluded if they combined exercise with a therapeutic modality such as transcutaneous electrical nerve stimulation (TENS), ultrasound or taping, combined exercise with medications, did not have an attention control group, or compared exercise alone with medications or with another mode of exercise. The literature search was conducted for knee osteoarthritis and then for hip osteoarthritis. Each study was ranked as to the risk of bias using the framework outlined by Tugwell and colleagues and Jadad and colleagues, which bases the bias risk score on the published methodology with respect to treatment allocation, blinding and

Table 1. Samples of systematic reviews, umbrella reviews and meta-analyses of exercise to manage symptoms of hip and knee osteoarthritis and their summary findings.

Year	Summary
1994	KOA articles from 1966–1993. Exercise reduces pain and improves function [Puett and Griffin, 1994].
1995	KOA 3 RCTs (1980–1994) indicates benefit of aerobic exercise [La Mantia and Marks, 1995].
1999	HOA and KOA RCTs: exercise produces small-to-moderate effects on pain, small effects on disability and moderate effects for self-reported global assessments [van Baar *et al.* 1999].
2000	KOA: 23 studies from 1966–2000 shows short-term benefit of exercise [Petrella, 2000].
2003	KOA: No difference between strengthening and aerobic exercise. Need more data for balance and proprioceptive exercise [Bischoff and Roos, 2003].
2003	HOA and KOA: No formal judgment about optimal mode or dose of exercise can be determined from the evidence [Fransen *et al.* 2003].
2003	KOA: No difference between high- and low-intensity exercise in KOA [Brosseau *et al.* 2003].
2005	HOA and KOA: Some evidence that strengthening exercise may decrease pain but not on disability. Not enough evidence to make a determination about aerobic exercise [Roddy *et al.* 2005].
2008	HOA: low-quality evidence. Some relief from pain [Moe *et al.* 2007]
2008	HOA: moderate pain relief with exercise [Hernandez-Molina *et al.* 2008].
2009	KOA: small impact on self-reported pain and function [Fransen *et al.* 2009b].
2009	HOA: small reduction in pain and no impact on function [Fransen *et al.* 2009a].

KOA, knee osteoarthritis; HOA, hip osteoarthritis.

handling of loss to follow up [Tugwell *et al*. 2004; Jadad *et al*. 1996].

Studies of exercise in persons with hip osteoarthritis

Table 2 identifies the randomized controlled trials of exercise therapy for persons with hip osteoarthritis published between 2000 and 2009 and their exercise program attributes. It is readily apparent that the number of randomized controlled trials recruiting persons with only hip osteoarthritis which compare exercise with a control group is markedly lacking; only one study met this criteria. As such, this review also includes studies that recruited patients with either hip or knee osteoarthritis or both to provide a more rich description of the interventions.

Tak and colleagues recruited and allocated 109 persons who were living independently and who met the American College of Rheumatology criteria for hip osteoarthritis [Hochberg *et al*. 1995] to either: 1 h per week of class-based exercise including light-to-moderate progressive resistive dynamic exercises plus a home program provided over 6 weeks or a wait list control [Tak *et al*. 2005]. The exercise intervention included light-to-moderate resistance dynamic exercises followed by a home exercise program. During the trial 15 subjects dropped out (14%). The results indicated the exercise program had a moderate effect on pain relief and a small effect for improvements in hip function, disability, and timed walks (timed up and go test). The study was assessed as having a low risk of bias. Given the low frequency and short duration of the intervention, one might speculate that a more intense intervention may have produced greater results.

Six studies [Fransen *et al*. 2007; Hinman *et al*. 2007; Wang *et al*. 2007; Cochrane *et al*. 2005; Tak *et al*. 2005; Foley *et al*. 2003; Hopman-Rock and Westhoff, 2000] were included that

Table 2. Program length, frequency, duration and doses of exercise in randomized controlled trials of persons with hip osteoarthritis.

Study	Program length	Exercise frequency and session duration-TOTAL time (min)	Exercise mode
Tak *et al.* [2005]	8 weeks	1 × per week for 60 minutes = 60 minutes	Group 1: Class-based light to moderate progressive dynamic strengthening exercises with resistance plus home program Group 2: wait list control
Studies of persons with hip and knee osteoarthritis			
Hopman-Rock and Westhoff [2000]	6 weeks	1 × per week for 120 minutes = 120 minutes	Group 1: Dynamic exercises with resistance plus static exercises taught by a physical therapist with peer education Group 2: control
Foley *et al.* [2003]	6 weeks	3 × per week for 30 minutes = 90 minutes	Group 1: Dynamic exercises with resistance and range-of-motion Group 2: Aquatic exercise Group 3: Control
Hinman *et al.* [2007]	12 weeks	(first 6 weeks supervised) 2 × per week for 45–60 minutes = 90–120 minutes (second 6 weeks) instructed to perform at same frequency and session duration on their own at local pool	Group 1: Aquatic dynamic exercises of all muscle groups Group 2: Wait list control
Fransen *et al.* [2007]	12 weeks	2 × per week for 60 minutes = 120 minutes	Group 1: Class-based Tai Chi exercises Group 2: Aquatic exercises Group 2: Wait list control
Wang *et al.* [2007]	12 weeks	3 × per day for 50 minutes = 150 minutes	Group 1: Aquatic program for flexibility, strengthening and endurance exercises Group 2: Control
Cochrane *et al.* [2005]	52 weeks	2 × per week for 60 minutes = 120 minutes	Group 1: Aquatic - progressive dynamic, range-of-motion and aerobic exercises Group 2: Usual care control

recruited persons with hip or knee osteoarthritis. Of these, three studies (50%) were 12 weeks in length [Fransen *et al*. 2007; Hinman *et al*. 2007; Wang *et al*. 2007] and the most common number of minutes per week of exercise was 120 minutes (range 60–150 minutes). Four studies assessed the impact of aquatic exercise [Fransen *et al*. 2007; Wang *et al*. 2007; Cochrane *et al*. 2005], two incorporated dynamic resistance [Foley *et al*. 2003; Hopman-Rock and Westhoff, 2000], strength training and one study used Tai Chi [Fransen *et al*. 2007]. Two interventions used a class- or group-based exercise format. Among these randomized controlled trials, four studies were judged to be at low risk of bias and three of moderate risk of bias. The majority used intention-to-treat analysis. The results of these studies suggest exercise for hip osteoarthritis has a frequent positive effect on pain but less-frequent impact on physical function. While not formally addressed in all studies, adherence to allocated treatment differed and this may have impacted study results. In all studies exercise was well tolerated (Table 3).

Studies of exercise in persons with knee osteoarthritis

Studies of exercise in persons with knee osteoarthritis were more prevalent. Among the 11 studies identified [Wang *et al*. 2009; Lund *et al*. 2008; Williamson *et al*. 2007; Thorstensson *et al*. 2005; Gur *et al*. 2003; Song *et al*. 2003; Topp *et al*. 2002; Baker *et al*. 2001; Fransen *et al*. 2001; Deyle *et al*. 2000; Meisser *et al*. 2000], three studies (36%) incorporated an exercise intervention of 8 weeks of exercise duration [Lund *et al*. 2008; Gur *et al*. 2003; Fransen *et al*. 2001]; range 6–16 weeks. The frequency and length of individual

Table 3. Sample characteristics and results of randomized controlled trials of exercise for persons with hip osteoarthritis and knee osteoarthritis.

Study	Subjects	Risk of bias	Results and jaded score
Tak *et al*. [2005]	109 hip OA only mean age = 68 years	Low	ITT: Positive moderate effect for pain relief, small beneficial effects for hip function, disability and timed walk. No change in QOL.
Studies of patients with hip and knee osteoarthritis			
Hopman-Rock and Westhoff [2000]	104* Mean age = 65 years	Moderate	EA: Significant founds found for pain, QOL, strength of the left quadriceps, knowledge, self-efficacy, BMI, physically active lifestyle, and visits to the physical therapist.
Foley *et al*. [2003]	105* Mean age = 70 years	Low	ITT: Land group increased quadriceps strength, walk speed, self-efficacy and satisfaction compared with control subjects. Compared with control subjects the hydrotherapy subjects increased distance walked, left quadriceps strength, and function. Compliance rates were similar for both exercise groups. There were no differences in drug use between groups over the study period.
Hinman *et al*. [2007]	71 mean age = 63	Moderate	ITT: Aquatic group reduced pain by 33% (ES = 0.24) 72% exercisers reported global improvement in pain and 75% in function *versus* 17% of controls for each outcome. Exercisers 12 × more likely to report global pain decrease.
Fransen *et al*. [2007]	152 Mean age = 70 years	Low	ITT: Subjects assigned to aquatic exercises had a 6.5 mean decrease in pain and physical function whereas subjects in the Tai Chi classes demonstrated improvements of 5.2 and 9.7, respectively. Only subjects in the aquatic group achieved statistically significant changes in function. Attendance was higher for the aquatic group.
Wang *et al*. [2007]	42 mean age = 66 years	Moderate	ITT: No adverse effects with exercise. Aquatic participants showed improved knee and hip flexibility, strength and aerobic fitness, but had no effect on self-reported physical functioning and pain.
Cochrane *et al*. [2005]	312	Low	ITT: Small effect size for pain seen in exercise group.

*Radiographic evidence of osteoarthritis.
QOL, quality of life; ITT, intention-to-treat; EA, efficacy analysis.

exercise sessions varied. The total duration of sessions per week ranged from 40 to 120 minutes per week. The mode of exercise also varied considerably. The majority included dynamic strengthening exercise either alone or in combination with another exercise mode. One trial assessed the impact of aquatic exercise [Lund *et al.* 2008], two used Tai Chi [Wang *et al.* 2009; Song *et al.* 2003] and infrequently aerobic exercise was combined with strengthening exercises [Fransen *et al.* 2001]. Two of the studies provided individual sessions with supervision [Gur *et al.* 2003; Deyle *et al.* 2000]. Most studies reported minimal, if any, detail regarding the intensity of effort used while performing the exercise sessions (Table 4).

The results of these trials are equally variable (Table 5). Function, pain and health outcomes (symptoms, timed walk) are assessed in a variety of ways and at differing time points. Both function and pain were positively impacted by the exercise interventions. Figure 2 illustrates the standard mean differences reported for pain in the trials. All studies reported significant improvements in pain relief with the use of exercise but the relative impact of relief differed by trial.

Discussion

Numerous studies, reviews, practice guidelines, systematic reviews, umbrella reviews and meta-analyses have been conducted to determine the effects of exercise for persons with hip and knee osteoarthritis. The evidence for the benefits of exercise to manage the symptoms of knee osteoarthritis is more prevalent than for hip osteoarthritis. Owing to the inconsistency in study reporting (e.g. intensity of exercise, blinding, level of supervision, setting and setting attributes), heterogeneity of study participants, unevenness of comparison/control groups, and quality of some trials (use of blinding, adjustment for drop outs), it is difficult to make firm statements about which single mode or combination exercises are best for these patients. Supervised studies appear to yield greater benefits compared with home exercise, likely due to the fact patients can receive encouragement and are monitored during the supervised exercise sessions. Results from these recent studies of exercise in knee osteoarthritis suggest exercise, predominantly dynamic strengthening exercises, provides small-to-moderate benefits for pain and function. In addition, trials of exercise appear to be well tolerated by patients and present little risk. On the other hand, exercise for persons with hip osteoarthritis appears to reduce pain but the magnitude of the impact on function is less obvious. This conclusion is supported by the well-designed and executed meta-analyses in the literature [Fransen *et al.* 2009a, 2009b; Hernandez-Molina *et al.* 2008] and umbrella reviews [Jamtvedt *et al.* 2008; Moe *et al.* 2007].

It is unclear from the data which intensity, frequency, mode and duration is best for patients with hip and knee osteoarthritis. Recent Cochrane reviews [Fransen *et al.* 2009a, 2009b] have attempted to assess exercise dose by dichotomizing studies as those which employed 12 sessions or greater than 12 sessions. This method is pragmatic but does not account for the physiologic multiplicative effects of more frequent or longer duration of exercise per week. In this paper, the total minutes of exercise per week is provided to give the readers a clearer sense of the exercise dose per week. Perhaps a new strategy to assess the effectiveness of exercise dose would be to multiply the total minutes of exercise per week by the duration of the program (TOTAL DOSE) and then stratify studies by exercise total dose and examine the effect sizes of specific outcomes. In this review, not all studies reported exercise session time but among those that did, the standard mean differences for pain are reported. However, this technique is imperfect and can only be implemented if scientists conducting the clinical trials are clear and detailed in their reporting.

Where can we go from here? Further attention to the reporting and design of clinical trials is warranted to allow for accurate comparisons and evaluations of exercise interventions. The CONSORT framework [Altman *et al.* 2001], a 21-item checklist for detailing the methodology and reporting of clinical trials, has been adopted by numerous scientific journals, educational programs and scientific groups. This framework is recommended for studies of nonpharmacologic interventions [Boutron *et al.* 2008]. As scientists embrace this strategy, there hopefully will be a concurrent increase in the ability of researchers to combine trials in meta-analysis and/or perform desired stratified analyses on specific patient subgroups or intervention characteristics. However, the issue of selecting relevant patient-centered outcomes is not addressed with this approach. Particularly during the last decade, researchers

Table 4. Length of program, frequency, total duration and modes of exercise in randomized controlled trials of persons with knee osteoarthritis.

Study	Program length	Frequency and session duration- TOTAL Time (min)	Exercise mode
Deyle *et al.* [2000]	4 weeks	2 × per week 30 minutes manual therapy plus 40–45 minutes exercise = 80–90 minutes	Group 1: Strengthening exercises plus manual therapy to knees, hips and spine Group 2: Subtherapeutic ultrasound (sham)
Thorstensson *et al.* [2005]	6 weeks	2 × per week for 60 minutes at>60% Max HR = 120 minutes	Group 1: Clinic-based supervised group strengthening exercise Group 2: Wait list control
Williamson *et al.* [2007]	6 weeks	1 × per week for 60 minutes = 60 minutes	Group 1: Acupuncture Group 2: Physical therapist supervised group exercise consisting of isometric and dynamic strengthening and balance exercises Group 3: Standard advice
Lund *et al.* [2008]	8 weeks	2 × per week for 50 minutes = 100 minutes	Group 1: Aquatic-based dynamic, isometric and balance exercises Group 2: Dynamic, isometric and balance exercises Group 3: Control
Gur *et al.* [2003]	8 weeks	3 × per week—time not specified but reps and timing noted (see exercise mode)	Group 1: High-intensity strengthening exercises of knee flexors and extensors – 6 concentric and 6 eccentric for each muscle group using Cybex at angular velocities ranging from 30°/s to 180°/s with 30°/s intervals, for both legs. 5 minute rest between legs and 2 minutes between muscle groups Group 2: Control—no treatment
Fransen *et al.* [2001]	8 weeks	2 × per week for 60 minutes = 120 minutes	Group 1: Strengthening and aerobic exercises Group 2: Wait list control
Song *et al.* [2003]	12 weeks	Minimum 3 sessions per week of Tai Chi for 20 minutes = 60 minutes. First two weeks all sessions supervised, after 2nd week came to class 1 × per week and expected to do at home 2 × per week	Group 1: Tai Chi Group 2: Control
Wang *et al.* [2009]	12 weeks	Both groups 2 × per week for 60 minutes = 120 minutes	Group 1: Tai Chi Group 2: 40 minutes of education plus 20 minutes of gentle stretching
Messier *et al.* [2000]	16 weeks	Exercise 3 × per week for 60 minutes = 180 minutes	Group 1: Class-based strengthening exercises plus aerobic walking followed by telephone monitored home exercise program plus diet Group 2: Information on weight loss and healthy lifestyle, total of 3 meetings with approximately 8 follow-up calls Group 3: Information on diet
Baker *et al.* [2001]	16 weeks	2 sets of 12 repetitions, 3 × per week for each of 7 exercises	Group1: Home-based strengthening exercises plus 12 visits Group 2: Attention control—nutrition education
Topp *et al.* [2002]	16 weeks	Group: 1 × per week for 40 minutes = 40 minutes Group 2: 2 × per week for 40 minutes	Group 1: Clinic-based dynamic and isometric strengthening exercises with theraband Group 2: Home exercise program of isometric exercises Group 3: Control—no treatment

HR, heart rate; ASMP, arthritis symptom management program.

Table 5. Sample characteristics and results of randomized controlled trials of exercise for persons with knee osteoarthritis.

Study	Subjects	Risk of bias	Results
Deyle *et al.* [2000]	83 mean age = 61 years	Moderate	EA: Among treatment group there was a clinically significant increase in 6-minute walk and WOMAC score at 4 weeks and 8 weeks. At 8 weeks, mean 6-minute improved by 13.1% and WOMAC scores improved by 55.8% over baseline. After statistical adjustment, average 6-minute walk in the treatment group was 170 m (more than that in the placebo group)
Thorstensson *et al.* [2005]	61*mean age = 56 years age	Moderate	EA: No significant differences pain, function in daily life or in sport and recreation between exercisers and controls. Among exercisers self-reported quality of life improved at 6 weeks compared with control participants and this persisted at the 6-month evaluation.
Williamson *et al.* [2007]	181 awaiting TKR		Improvements seen in ROM and walk time in both groups. Aquatic group less pain.
Lund *et al.* [2008].	79 mean age = 68 years	Low	ITT: At 3-month follow-up land exercise group showed reduced pain, no difference in other outcomes, more adverse effects in land group.
Gur *et al.* [2003]	23 * Mean age = 56 years	Moderate	ITT: Subjects in both exercise groups reduced pain and improved functional capacity and functional training directly impacted stair climbing. No improvements in control group. Pain reduction was greater in concentric exercise group than eccentric group.
Fransen *et al.* [2001]	126 mean age = 66	Moderate	ITT: at 8 weeks, exercisers demonstrated large improvements in pain relief compared to controls (SRM = 0.65), moderate improvements for function (SRM = 0.49) and for strength (SRM = 0.46).
Song *et al.* [2003]	72 mean age = 63 years	Moderate	EA: Significant improvements in pain, stiffness, abdominal strength, balance, and function. Control: Slight deterioration in function.
Wang *et al.* [2009]	40 mean age = 65 years	Low	ITT: Tai Chi group reported decreased pain, improved function, decreased chair stand time and decreased depression. No severe adverse events.
Messier *et al.* [2000]	316 obese* mean age = 69 years	Low	ITT: Subjects in the combined diet and exercise group had significant gains in physical function, 6-minute walk and reductions in knee pain compared with healthy lifestyle group. The exercisers improved in the 6-minute walk. Weight loss was greater in the two groups than the healthy lifestyle groups. No changes in joint space width seen among groups
Baker *et al.* [2001]	46 * mean age = 69 years	Moderate	ITT: Self-reported pain decreased by 36% and physical function increased by 38% in the exercise group compared with 11 and 21%, respectively, in the control group. Exercisers who completed the trial had a 43% mean decrease in pain, a 44% mean increase in self-reported physical function, and improvements in physical performance, quality of life, and self-efficacy when compared with the control group.
Topp *et al.* [2002]	102 mean age = 63 years	High	EA: Among the group allocated to isometric exercise, time to perform tasks decreased by 16% to 23%. In the dynamic group, time to descend and ascend stairs decreased by 13% to 17%. Both exercise groups decreased knee pain during functional activities. Improvements in outcomes were not significantly different between exercise groups.

*Radiographic evidence of osteoarthritis.
ITT, intention-to-treat; EA, efficacy analysis; WOMAC, Western Ontario and McMaster Universities OA Index; ROM, range of motion; TKR, total knee replacement; SRM, standardized response mean.

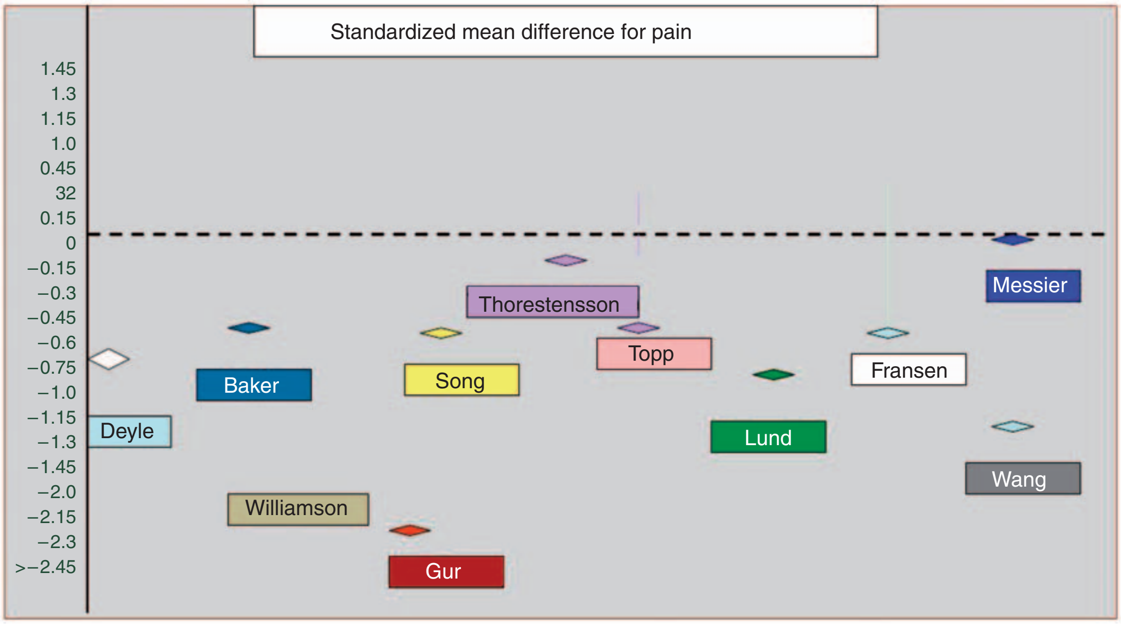

Figure 2. Effects of exercise dose *versus* no exercise for persons with knee osteoarthritis.

have employed techniques to integrate patient perspectives in the design of trials, and the selection and development of clinical outcomes [Kirwan *et al.* 2005]. These techniques include eliciting patient values for specific outcomes, calculating relative weights for specific functional activities and reverting back to qualitative methodologies to embrace the rich experiences and perspectives of patients when developing outcome measures. These activities are influencing CORE outcome measures and have resulted in patient engagement in scientific conferences (EULAR, CARE Nonpharmacologic Conferences). The full impact of these strategies on outcomes of clinical trials is still to be seen.

Perhaps another approach to studying complex interventions such as exercise therapy may be effective in yielding the desired outcome. It is well recognized that the randomized controlled trial is not the gold standard for complex interventions such as exercise programs which require individual tailoring to meet the needs of each subject. A potential approach to evaluating the efficacy and effectiveness of exercise may be to ask patients to list their top five priorities (pain relief, ability to maintain work productivity, engage in intimate relations, etc.) and to examine whether these priorities were achieved following an individually tailored exercise intervention. This approach would allow for the integration of patient perspectives into outcome assessment and enable researchers the opportunity to provide exercise programs that target outcomes that are patient driven and relevant.

Conclusion and recommendations

Exercise interventions are complex and published studies lack the level of detail necessary to ascertain exercise dose and its impact on health outcomes. Few studies are designed to recruit only hip patients. Small-to-moderate improvements in hip pain are found with short-term exercise of various modes, intensities, frequency and duration. Studies of exercise for persons with knee osteoarthritis are belayed with similar issues and lead to small-to-moderate improvements in function and pain. Thus, researchers need to improve reporting mechanisms for the methodology of their clinical trials to ensure data are available to attempt a quantitative assessment of exercise dose. However, as researchers we may need to embrace a new design paradigm when evaluating the outcomes of exercise trials.

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