

Do Exercise and Self-Management Interventions Benefit Patients with Osteoarthritis of the Knee? A Metaanalytic Review

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ABSTRACT. *Objective.* Osteoarthritis (OA) is the most prevalent health condition among seniors and it causes significant pain and disability. We assessed the influence of patient education and exercise regimens on the well-being of patients with knee OA.

Methods. A metaanalysis was conducted on 16 studies reporting exercise and/or self-management interventions for patients with knee OA. The effects on physical and psychological well-being were assessed immediately after the interventions.

Results. Compared to control conditions, exercise regimens led to improvement in physical health (by self-report and direct measures) and in overall impact of OA. Perceived psychological health remained unchanged by the exercise programs. Although the effect sizes for the self-management programs were significant for psychological outcomes and for the overall effect of OA, there was a significant difference between self-management and control groups only in psychological outcomes.

Conclusion. Overall, both patient education and exercise regimens had a modest, yet clinically important, influence on patients' well-being. (J Rheumatol 2006;33:744–56)

Key Indexing Terms:

OSTEOARTHRITIS
SELF-CARE

METAANALYSIS

EXERCISE
TREATMENT OUTCOME

The most common health problem among seniors is osteoarthritis (OA). Roughly 50% of people age 65 years or older have OA¹. OA of the knee, the most common form, involves the breakdown of joint cartilage and underlying subchondral bone of the knee; this results in significant pain and disability². In 1994, advanced OA of the knee was responsible for 85% of knee joint replacement surgeries among Medicare recipients³. After advancing age and female sex, the strongest risk factor for knee OA is obesity. Other risk factors include ethnicity and previous injuries². Musculoskeletal conditions cost the US economy nearly \$65 billion per year in direct expenses and lost wages and production¹. According to the Public Health Agency of Canada⁴, in 1998 total healthcare costs were among the highest for those with musculoskeletal diseases (\$16.4 billion), second only to those for cardiovascular diseases (\$18.5 billion). As there is no cure for knee OA, treatments tend to focus on decreasing physical and psychological disability; such treatments include patient education, physical activity, weight reduction, and the use of assistive or orthotic devices⁵.

Several metaanalyses have been conducted to assess the influence of exercise or self-management interventions on the well-being of patients with arthritis. Most metaanalyses included studies of both rheumatoid arthritis (RA) and OA^{6–9}. Hirano and colleagues⁶ found that most education interventions yielded positive behavioral change (e.g., self-care, pain behavior, joint protection) and improvement on psychosocial variables (e.g., depression, helplessness, self-efficacy) and physical health status (e.g., pain, quality of life, physical activity level). However, only 3 of the studies included only patients with OA. Another metaanalysis that assessed the effects of educational interventions on disability, pain, and depression suggested that patient education contributes to improving health status⁸. Overall, compared to control groups, the experimental groups had a 22% improvement in depression, a 16% improvement in pain, and an 8% improvement in disability. However, most patients in that metaanalysis had chronic RA.

OA and RA differ in etiology. OA is characterized by degeneration of the cartilage. RA is an autoimmune disease of unknown cause that results in painful inflammation of the joint lining and progressive deterioration of the joints accompanied by swelling, deformities, and/or rheumatoid nodules. OA and RA patients may differ in their response to treatment, as suggested by a metaanalysis that compared education trials with nonsteroidal antiinflammatory drug (NSAID) treatments¹⁰. The results indicated that the effects were not always similar for RA and OA patients. The effect sizes for pain were similar in the OA and RA studies for the

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Accepted for publication November 24, 2005.

patient education programs and the NSAID trials, but changes in physical disability were more evident in the RA than in the OA studies with both types of interventions.

Because OA may affect different joints, such as knees, hips, or hands, conclusions about the effectiveness of programs targeting patients with OA in one joint may not generalize to other joints. Moreover, many interventions with OA patients have not distinguished between the joints affected. Few studies have investigated the effect of programs designed exclusively for patients with knee OA. To our knowledge, only 2 metaanalyses have included such studies. The first examined the influence of nonpharmacological, pharmacological, and surgical treatment modalities for patients with knee OA¹¹. It provided evidence that the different modalities all helped to alleviate the pain of knee OA. However, no other outcomes were examined in that study. The second metaanalysis assessed the effectiveness of exercise therapy for patients with knee OA⁷. There was evidence for a small beneficial effect of various types of exercise on self-reported disability and walking performance. However, the effect of exercise on psychological well-being was not evaluated.

Our report is based on a metaanalysis examining the effectiveness of exercise and self-management interventions on both the physical and the psychological well-being of patients with OA of the knee. The outcomes of a walking protocol can be quite different from the effects of a coping skills training program. The former may reduce physical disability to a greater extent, and the latter may lead to greater improvements on psychological dimensions. Thus, when assessing the effectiveness of interventions, we considered physical outcomes, psychological outcomes, direct measures of impairment, and overall impact of OA separately.

MATERIALS AND METHODS

Search strategy. We conducted a search of the Medline and PsycInfo databases for English language articles published from January 1966 to May 2005. The search combined the specific words "osteoarthritis" and "knee," with "intervention," "education," "exercise," or "self-care" in any fields. We also performed a manual search of bibliographies from relevant articles and reviews.

Inclusion criteria. Exercise interventions were defined as any form of physical activity or training. These interventions included strength training of the knee muscles, low intensity or medium intensity exercise, and light physical activity such as walking, aerobic exercise, and balance or flexibility exercises. Self-management interventions were defined as programs focusing on education about OA, OA self-management or self-care (for example, the Arthritis Self-Help Course), and pain coping skills, as well as diet self-management. Finally, control groups were defined as no-treatment control, standard care control, attention control, or sham electrical stimulation control.

To be included in our metaanalysis, interventions had to meet the following criteria: (1) be published in a peer-reviewed article, (2) have a target population of patients with OA of the knee exclusively, (3) consist of an exercise or self-management intervention as defined above, (4) contain pre- and post-intervention quantitative assessments of physical and/or psycho-

logical health, (5) treatment did not include medication, (6) had to include a control group or a comparison group, and (7) had to be either a randomized controlled clinical trial or a quasi-randomized controlled clinical trial as defined by the Cochrane Effective Practice and Organization of Care Group's criteria for acceptable study designs¹².

Data abstraction. Using a standardized abstraction form, specific elements describing the study design, population characteristics, sample size, intervention strategies, and effects of the programs on each relevant outcome were collected from articles that passed the article-screening phase.

Metaanalysis. We did not distinguish among the types of exercise programs. These included strength training of the knee muscles, low intensity or medium intensity exercise, light physical activity, aerobic exercise, and balance and stretching exercises. When a study compared 2 exercise programs of different types, the 2 groups were entered separately in the analyses. Several studies compared different kinds of self-management programs and were each entered separately (for example, conventional pain coping skills training, spouse-assisted pain coping skills training, and education combined with spousal support). We excluded from the metaanalysis any group that did not fall into one of these 3 categories. Treatment arms that combined exercise and self-management, or programs that combined exercise or self-management with another form of treatment (e.g., neuromuscular stimulation) were excluded.

Each study assessed the influence of the intervention on multiple outcomes. We distinguished 4 types of outcomes, as follows, and we aggregated within-study effect sizes for measures assessing the same outcome. We identified as (1) physical outcomes, scales of physical disability, physical discomfort, physical functioning, arthritis impact, stiffness, and mobility, as well as measures of pain [general pain, knee pain, pain at rest, pain during motion, pain last week, pain now, or the Arthritis Impact Measurement Scales (AIMS) pain subscale]. (2) Psychological outcomes included scales of psychological disability, mental functioning, self-efficacy (for OA or specific behaviors), or depressive symptoms. (3) We also created a category that we called "direct measures of impairment" (in contrast to the 2 previous categories, which involve more subjectivity). It comprised physiological measures (swelling of the knee, joint effusion, peak oxygen consumption, body weight, or quadriceps muscle strength) and performance tests (walking distance test, timed chair rise, time getting out of a car, balance tests, or gait). Radiographs were excluded because they involve some subjectivity in assessment of change and because they have not been shown to be reliable in detecting changes in the health status of patients with OA. Finally, (4) the overall impact of OA was calculated by aggregating the previous 3 categories with any additional measure of general health that a study included.

The metaanalysis was based on baseline data and the data collected immediately at the end of the intervention. For one intervention delivered in a single session¹³, we included a 4-month assessment because it was the first post-intervention assessment. Later assessments were not included in the metaanalysis because some of the studies did not include them, and because the times at which the followup analyses were conducted varied, which made comparison difficult. Moreover, the number of studies was too small to add time of assessment as a moderator in the analysis.

Effect sizes. First, pre-intervention and post-intervention means and standard deviations (SD) were coded, at the study level, for each measure reported, for each treatment arm and each control group. When standard errors (SE) were reported instead of SD, SE were converted into SD. Multiple formulas are available for the calculation of effect sizes¹⁴. We computed study-level change (after-treatment minus before-treatment means) in each outcome measure by each treatment group, as well as the SD of the difference. The effect size for the difference between pre- and post-intervention scores was then calculated for each outcome measure and each group, using Cohen's *d* for a within-group comparison:

$$d = t/\text{SQRT}(df)$$

$$\text{where } t = [(\text{mean of difference scores})/(\text{SD of difference scores})] \times \text{SQRT}(N).$$

Second, for each study, the effect sizes were averaged across measures within the same outcome category.

We weighted effect sizes by a function of group sample size when computing average effects. When group sample sizes varied across outcomes, we computed the average of the group sample sizes and entered it in the effect size calculations. Because systematic heterogeneity in the effect sizes was to be examined with an independent variable (type of group), a fixed effect model was used. Finally, when interpreting the effect sizes, we referred to the conventional values of $d = 0.20$ for a small effect size, $d = 0.50$ for a medium effect size, and $d = 0.80$ for a large effect size. The data were coded so that a positive effect size indicated improvement and a negative sign indicated worsening, of physical health, psychological health, impairment, or overall effect of OA.

RESULTS

Literature review. Nineteen studies met our inclusion criteria. Of those studies, 2 did not provide means and/or standard deviations^{15,16}, and one reported only post-intervention adjusted means with no pre-intervention values¹⁷, making it impossible to compare it to other studies. The 3 studies were excluded after unsuccessful attempts to obtain the information from their authors. The remaining 16 intervention studies were entered into the metaanalysis. Some studies did not report the necessary statistics for all outcomes. Authors were contacted and asked to provide the missing data. We excluded from analysis the outcomes for which we could not obtain data. All the results were obtained on the 16 interventions entered in the metaanalysis. Table 1 outlines the key characteristics of each study.

The number of participants in each study ranged from 20 to 786, representing a total of 2154 individuals; the attrition rate on average was 14% (range 0–43%). The mean age of participants was 65.8 years. All but 2 studies randomly assigned participants to the groups. The 2 studies that did not^{13,18} used a non-random controlled design in which participants were arbitrarily assigned to the groups based on the availabilities of the interventionists. Because the assignment was still arbitrary and therefore consistent with the Cochrane Effective Practice and Organization of Care Group's criteria for acceptable study designs¹², we included the studies in the metaanalysis, but tested whether removing them from the analyses affected the results (see below).

There was considerable heterogeneity in the study design of the interventions. Three studies compared an exercise regimen, a self-management program, and a control group^{19–21}. Another study compared the outcomes of an exercise protocol to those of a self-management program²². Four interventions compared exercise groups to control groups^{18,23–25}, and 2 interventions compared 2 types of exercise protocols^{26,27}. One intervention compared a self-management program to a control group¹³, while 3 studies compared different programs of self-management^{28–30}; one of them included a control group²⁸. Finally, 2 interventions compared electrical nerve stimulation either to a self-management program³¹ or to an exercise program alone and a combination of both exercise and electrical nerve stimula-

tion³². The intervention arms involving electrical nerve stimulation were excluded from the metaanalysis because such treatment did not fit the inclusion criteria. We also excluded from analysis 2 groups that combined exercise and self-management^{20,21}.

The lengths of the interventions ranged from a single session to multiple sessions over 24 months. Typically, the interventions lasted about 10 weeks, with weekly sessions of 1–2 hours. All but one study that was delivered in a single session¹³ included immediate post-intervention assessments. Several studies also conducted later followup assessments, in some cases up to 10 or 12 months after the end of the intervention.

Examining the effect sizes of exercise programs. Thirteen intervention arms consisted of exercise programs^{18–27,32} that varied in the type and intensity of the workouts. Two interventions consisted of a walking program either alone²³ or in combination with motion exercises of the trunk, arms, and legs²². Stationary cycling was used as aerobic exercise in a couple of studies. The first²⁶ compared high intensity with low intensity stationary cycling for 25-minute training periods that followed warmup exercises (walking and flexibility exercises) and preceded cool-down exercise (slow walking and breathing). The high intensity group exercised at 70% heart rate reserve, the low intensity group at 40%. The second study¹⁸ combined 2 minutes on a static exercise bike with 24 maximum voluntary contractions, 1 minute of isotonic knee extension, and three 1-minute functional exercises (sit-stand, step-ups, step-downs), and three 1-minute balance/coordination exercises (unilateral stance, balance boards). On the other hand, one intervention group completed 6 sets of 5 maximal contractions 3 times per week²⁴. Another regimen¹⁹ consisted of 20-minute sessions twice weekly, during which the patients performed 30 inner-range quadriceps exercises, 30 straight leg-raise exercises, and 30 isometric quadriceps exercises; and one intervention²⁵ focused on resistance training by using graded elastic bands to increase the resistance against which the muscles worked during a 20–30 minute workout. Finally, 2 studies combined aerobic training, strength training, and/or range of motion training. In the first, Rejeski, *et al*²¹ prescribed an exercise regimen including an aerobic phase (walking within a heart rate range of 50–75% of heart rate reserve), a resistance-training phase (24 repetitions of leg curls, heel raises, and step-ups, performed with cuff weights and weighted vests to provide resistance), a second aerobic phase, and a cool-down phase, each lasting 15 minutes. In the second study²⁰, participants engaged in 30 minutes of aerobic training 3 days a week. The intensity of aerobic training started at 50–70% of heart reserve and gradually increased to 70–85% over 12 weeks. The aerobic training sessions included a warmup, low intensity biking or walking, 30 minutes of continuous aerobic activity (walking, biking, or water aerobics) performed at or above a patient's prescribed training

Table 1. Interventions for osteoarthritis of the knee included in the metaanalysis.

Report	Samples	Intervention and Control Groups; Assessment Times	Outcome Measures	Attrition/Adherence
Bautch ²²	34 patients, mean age 69, age ≥ 58 yrs	1. Education (self-management program, SM): on OA, health & exercise; 1 h wkly (N = 17). 2. Exercise (EX): 1 h low intensity motion exercise & walking 3 times wkly (N = 17). Length of intervention: 12 wks. Assessments: baseline/post-intervention	Pain (self-report, VAS); health status (self-report, AIMS); joint effusion (synovial fluid keratin sulfate & synovial fluid hydroxyproline) (for subsample of 5 to 6 participants, therefore not included in the metaanalysis); knee x-rays (for subsample)	Attrition 12%
Callaghan ¹⁹	27 patients, age range 29–80	1. Exercise (EX): lower body muscle strengthening; 20-min session twice wkly (N = 8). 2. Education (SM): education on joint care, medication, pain relief methods, coping strategies, and instruction in exercises (N = 10). 3. Sham electrical stimulation control (CT) (N = 9). Length of intervention: 4 wks. Assessments: baseline/post-intervention	Pain (self-report, VAS); swelling (measure of knee joint circumference); range of motion; quadriceps muscle strength; physical performance: timed 20-m walk	Attrition 0%
Cheing ^{32,47*}	66 patients, mean age 64, age range 50–75	1. Transcutaneous electrical nerve stimulation (TENS–excluded) at 4 acupuncture points, 60 min, 5 days a week (N = 16). 2. Exercise (EX): strengthening exercise, 20 min/5 days a week (N = 15). 3. TENS + EX (Combo, excluded): TENS followed by 20 min rest, followed by EX, 5 days a week (N = 15). 4. Sham electrical stimulation control (CT): 60 min/5 days a week (N = 16). Length of intervention : 4 wks. Assessments: session 1 (baseline)/session 20 (post-intervention)/1-mo followup	Pain before & after stimulation or exercise session (self-report, VAS); isometric peak torques of the knee extensors (at 30°, 60°, & 90°) and flexors (at 90°); gait: stride length, cadence, & velocity; range of motion	Attrition 6%
Hurley & Scott ¹⁸	89 patients, mean age 61, age range 34–82	1. Exercise (EX): medium intensity exercise; 30 min twice weekly (N = 60). 2. No-treatment control (CT) (N = 37); note: 16 patients completed control & then exercise. Length of intervention: 5 wks. Assessments: baseline/post-intervention/6-mo followup performed on 25 participants only	Quadriceps muscle strength; voluntary quadriceps activation; proprioceptive acuity; physical performance: timed 50-ft walk physical disability (self-report, Lequesne index)	Attrition 18%
Keefe ^{28,48}	99 patients, mean age 64	1. Pain coping skills training (SM1): 1.5 h wkly (N = 32). 2. Arthritis Self-Help Course (SM2): 1.5 h wkly (N = 36). 3. Standard care control (CT) (N = 31). Length of intervention: 10 wks. Assessments: baseline/post-intervention/6-mo followup	Pain, psychological, & physical disability (self-report, AIMS subscales); motor pain behavior (video evaluation); medication intake (self-report)	Attrition 6%. Adherence: 81% of SM1 attended 9/10 sessions; 86% of SM2 attended 9/10 sessions
Keefe ^{29,49}	88 patients, mean age 63	1. Conventional pain coping skills training (SM1): 2 h wkly (N = 29). 2. Spouse-assisted pain coping skills training (SM2): 2 h wkly (N = 30). 3. Arthritis Self-Help Course + spousal support (SM3): 2 h wkly (N = 29). Length of intervention: 10 wks. Assessments: baseline/post-intervention/6-mo followup/12-mo followup	Pain, psychological, & physical disability (self-report, AIMS subscales); coping strategies (self-report, CSQ) Arthritis self-efficacy scale (self-report, ASES); motor pain behavior (video evaluation); medication intake (self-report)	Attrition 20%. Adherence: 84–88% sessions attended
Keefe ²⁰	72 patients, mean age 60	1. Spouse-assisted pain coping skills training (SM): 2 h wkly (N = 18). 2. Exercise (EX): endurance, strength, and flexibility training, 1 h 3 times a wk (N = 16). 3. Combination of 1 & 2 (Combo, excluded): pain coping skills training for 2 h weekly + EX for 1 h 3 times a week (N = 20). 4. Standard care control (CT) (N = 18). Length of intervention: 12 wks. Assessments: baseline/post-intervention	Peak oxygen consumption; muscle strength (leg extension, leg flexion, biceps curl); Coping strategies (self-report, CSQ); Arthritis Self-efficacy Scale (self-report, ASES); pain & psychological disability (self-report, AIMS subscales)	Attrition 7%
Kovar ^{23,50,51}	92 patients, mean age 69, age range 40–79	1. Walking program (EX): light physical activity + education (OA, health, & exercise) 1.5 h 3 times wkly (N = 47). 2. Standard care control (CT) (N = 45). Length of intervention: 8 wks. Assessments: baseline/post-intervention/12-mo followup	Physical performance: 6-min walking distance; physical disability, arthritis impact, pain, medication use (self-report, AIMS subscales); pain (self-report, VAS)	Attrition 43%. Adherence: 88% sessions attended

Table 1. Continued.

Report	Samples	Intervention and Control Groups; Assessment Times	Outcome Measures	Attrition/Adherence
Mangione ²⁶	54 patients, mean age 71, age range 52–82	1. High-intensity exercise (EX1): warmup, high intensity stationary cycling, walking; 1 h 3 times wkly (N = 19). 2. Low intensity exercise (EX2): warmup, low intensity stationary cycling, walking; 1 h 3 times wkly (N = 20); note: Group size reported after exclusion & dropout only. Length of intervention: 10 wks. Assessment: baseline/post-intervention	Physical performance: Timed chair-rise, 6-min walking distance; pain, other symptoms (self-report, AIMS2 subscale). Gait: cadence, step length, & speed at slow, free, & fast walking; aerobic capacity; peak oxygen consumption	Attrition 22%; 4 additional patients were excluded by researchers. Adherence: 92% sessions attended
Martire ³⁰	24 patients, mean age 72, age range 61–87	1. Arthritis Self-Help Course, ASHC (SM1): OA self-management targeted at patients only; 60 min wkly (N = 11). 2. Couple Arthritis Self-Help Course (SM2): OA self-management targeted at patient & spouse: ASHC + segments on coping and communicating as a couple; 80 min wkly (N = 13). Length of intervention: 6 wks. Assessments: baseline/post-intervention	Arthritis self-efficacy scale (self-report, ASES pain & other symptoms subscales); pain (self-report, AIMS2 subscale); physical disability (self-report, HAQ subscale); depressive symptoms (CES-D)	Attrition 0%. Adherence: 89% sessions attended
Mazzuca ^{13,43}	211 patients, mean age 62	1. Education (SM): individualized OA self-care instructions on exercise, joint pain control, & joint protection; 1 session of 30–60 min (N = 105). 2. Attention control (CT): audiovisual presentation on types of OA and encouraging to seek medical care; 1 session of 20 min (N = 106). Length of intervention: 30–60 min. Assessments: baseline/4-mo followup/8-mo followup/12-mo followup	Physical disability, discomfort (self-report, HAQ subscales); knee pain at rest (self-report); knee pain when walking (self-report); general health status (self-report, QWB); number of visits to primary care providers (PCP), medical records + diaries; costs associated with PCP visits; no. of uses of ancillary clinical services (ACS), medical records + diaries; costs associated with ACS uses	Attrition 19%
McCarthy ²⁷	214 patients, mean age 65	1. Home exercise program (EX1): strengthening, endurance, & balance exercises of medium intensity; 30 min twice wkly (N = 103). 2. Home & class exercise program (EX2): same as 1 + class program involving progressive resistance training, accelerated walking, stretching, and balance exercises; 45 min twice weekly (N = 111). Length of intervention: 8 wks. Assessments: baseline/post-intervention/6-mo followup/12-mo followup	Aggregate locomotor function score (timed 8-m walk, stair ascent & descent, transferring from sitting to standing); pain (self-report, VAS); pain, stiffness, & physical function (self-report, WOMAC subscales); adherence to home exercise (self-report)	Attrition 11%
Rejeski ²¹	316 patients, mean age 69, age range 60–89	1. Aerobic exercise (EX): 1 h, 3 times wkly (N = 80). 2. Diet (SM): self-management of diet; months 1–4 = 16 weekly sessions (alternating 1 individual & 3 group sessions; months 5–6 = 3 group sessions & 1 individual session, biweekly (N = 82). 3. Aerobic exercise + diet (Combo, excluded): 1 & 2 combined (N = 76). 4. Attention control (CT): sessions on healthy lifestyle; mo 1–3 = 1 session monthly; months 4–6 = 1 phone contact monthly; months 7–18 = 1 phone contact bimonthly (n = 78)	Body weight; physical performance: 6-min walking distance; physical & mental functioning (self-report, SF-36 MOS); satisfaction with physical function & appearance (self-report)	Attrition 20%. Adherence: 68% sessions or scheduled contacts attended
Schilke ²⁴	20 patients, mean age 66, age range 53–85	1. Exercise (EX): strength training of the knee muscles; 3 times wkly (N = 10). 2. Standard care control (CT) (N = 10). Length of intervention: 8 wks. Assessments: baseline/post-intervention	Quadriceps muscle strength; range of motion; physical performance: timed 50 ft-walk; pain, stiffness, & mobility (self-report, OASI); pain, psychological & physical disability (self-report, AIMS subscales)	Attrition 0%
Talbot ^{31,52}	38 patients, mean age 70, age ≥ 60	1. Arthritis Self-Help Course (SM): 1 h wkly (N = 18). 2. Arthritis Self-Help Course + neuromuscular electrical stimulation (NMES) (excluded): ASHC 1 h weekly + NMES 15 min 3 times wkly (N = 20). Length of intervention: 12 wks. Assessments: baseline/post-intervention/24-wk followup	Quadriceps muscle strength; physical performance: Timed 100-ft walk, stair-climb, chair-rise; daily physical activity: accelerometer (velocity) + pedometer (step count); arthritis pain (self-report, AIMS2 subscale); present pain intensity (self-report); pain rating index (self-report, McGill Pain Questionnaire)	Attrition 11%. Adherence: 82% sessions attended 81% sessions of stimulation attended

Table 1. Continued.

Report	Samples	Intervention and Control Groups; Assessment Times	Outcome Measures	Attrition/Adherence
Thomas ²⁵	786 patients, mean age 62, age \geq 45 yrs	1. Exercise (EX): strength training of the knee muscles; individual sessions 20–30 min daily (N = 470). 2. No-treatment control (CT) (N = 273); note: About half of each condition also received phone contact monthly. Data were not reported at that level and were collapsed within each group. Length of intervention: 24 mo. Assessments: baseline/6 mo/12 mo/18 mo/post-intervention	Quadriceps muscle strength; pain, stiffness, & physical function (self-report, WOMAC subscales); physical & mental functioning (self-report, SF-36 MOS); hospital anxiety & depression (self-report)	Attrition 24%. Adherence: 48% patients completed exercise program (1 & 3)

* In some cases, multiple publications were based on a single study. Measures cited: AFI: Allogofunctional Index⁵³, AIMS: Arthritis Impact Measurement Scales⁵⁴, AIMS2: Arthritis Impact Measurement Scales 2⁵⁵, ASES: Arthritis Self-Efficacy Scale⁵⁶, CES-D: Center for Epidemiologic Studies Depression Scale⁵⁷, CSQ: Coping Strategies Questionnaire⁵⁹, HAQ: Health Assessment Questionnaire⁵⁹, KPS: Knee Pain Scale⁶⁰, Lequesne Index⁶¹, OASI: Osteoarthritis Screening Index⁶², QWB: Quality of Well Being Scale⁶³, RAND 36: 36-Item Short Form Health Survey⁶⁴, SF-36 MOS: The 36-item Short Form of the Medical Outcome Study Scales⁶⁵, VAS: visual analog scale⁶⁶, WOMAC: Western Ontario McMaster University Osteoarthritis Index⁶⁷.

range, and a cool-down period. Patients also participated in 30 minutes of strength training 2 days per week.

The effect of exercise was assessed using various measures. All the studies comprising an exercise program assessed physical outcomes using self-reports and/or direct measures of impairment. Only 4 studies^{20,21,24,25} considered the psychological benefits of exercise regimes.

To evaluate the diversity of exercise programs, we assessed for heterogeneity using the Q-statistic on each type of outcome¹⁴. On physical outcomes ($n_{\text{interventions}} = 12$, $n_{\text{participants}} = 808$), the Q-statistic p value was 0.19, indicating no evidence of heterogeneity in the effect sizes. The effect sizes all reflected improvement following the interventions, ranging from 0.15 to 0.80, with a mean of 0.29 (95% CI 0.23, 0.36), indicating a small overall effect. The influence of the exercise programs on physical outcomes was highly significant ($Z = 8.37$, $p < 0.0001$). On psychological outcomes ($n_{\text{interventions}} = 4$, $n_{\text{participants}} = 530$), there was no evidence of heterogeneity in the effect sizes ($p = 0.58$). The effect sizes ranged from -0.11 to 0.13, with a mean of 0.04 (95% CI -0.04, 0.13). The exercise programs had no significant effect on psychological outcomes ($Z = 0.94$, nonsignificant). On direct measures of impairment ($n_{\text{interventions}} = 11$, $n_{\text{participants}} = 740$), the effect sizes were all in the expected direction, ranging from 0.03 to 0.55, with a mean of 0.15 (95% CI 0.08, 0.23). The p value of the Q-statistic indicated significant heterogeneity in the effect sizes ($p < 0.02$); nonetheless, the overall influence of the exercise regimens on direct measures of impairment was significant ($Z = 4.20$, $p < 0.0001$), even though it was small. Finally, when all the reported outcomes were combined into an index of overall impact of OA ($n_{\text{interventions}} = 13$, $n_{\text{participants}} = 824$), the effect sizes were relatively heterogeneous ($p < 0.05$), but all suggested improvement after the interventions (range 0.04, 0.88). The mean effect size was small (0.20; 95% CI 0.13, 0.27), although it reflected an improvement over time that was highly statistically significant ($Z = 5.82$, $p < 0.0001$).

Table 2 presents the sample sizes, along with the effect sizes for each group and type of outcomes.

Examining the effect sizes of self-management programs. Thirteen intervention arms consisted of a variety of self-management programs^{13,19–22,28–31}. While one intervention was focused on health, exercise, and arthritis in general²², others were more structured. Several interventions targeting either patients alone or patients with their spouses^{28–31} used a lecture-discussion format³³, the Arthritis Self-Help Course, and addressed 4 topics: the nature of OA, treatment methods, exercise, and joint protection and maintaining mobility and function (use of assistive devices and importance of proper posture during static and dynamic activities). When the programs targeted spouses as well^{29,30}, the lectures addressed both the pragmatic and the emotional aspects of managing OA as a couple. In their coping skills training, Keefe, *et al*^{20,28,29} presented cognitive and behavioral coping methods as skills that could be learned in training sessions and mastered through regular home practice. Relaxation, imagery, and distraction techniques were introduced as methods for controlling pain through attention diversion. Instruction in activity-rest cycling involved helping patients identify activities they tend to overdo and then teaching them to break the tasks into periods of activity and rest. Pleasant activity scheduling was also encouraged. Cognitive restructuring was used to help patients recognize and modify irrational cognitions related to pain. Patients were encouraged to practice countering irrational thoughts with more positive and realistic coping thoughts. On the other hand, one program¹⁹ combined instruction on joint care, medication, pain relief methods, and coping strategies with tuition in exercises chosen for their functional, weight-bearing position and their use of little equipment. One study¹³ tailored the content of the intervention delivered during a single individual session, based on needs identified in a diagnostic assessment and through preliminary communication with the primary care physician. The core content

Table 2. Group sample sizes and effect sizes for studies included in the metaanalysis.

Study	Group Size*	Physical Outcomes	Psychological Outcomes	Direct Measures of Impairment	Overall Impact of OA
Bautch ²²	EX = 15	0.29	—	—	0.27
	SM = 15	−0.37	—	—	−0.13
Callaghan ¹⁹	EX = 8	0.72	—	0.19	0.46
	SM = 10	0.34	—	0.24	0.29
	CT = 8	0.28	—	0.00	0.14
Cheing ³²	EX = 15	0.51	—	0.21	0.36
	CT = 16	0.92	—	0.12	0.52
Hurley ¹⁸	EX = 59	0.48	—	0.43	0.46
	CT = 34	0.17	—	0.03	0.10
Keefe ²⁸	SM1 = 32	0.15	0.17	—	0.16
	SM2 = 36	−0.08	0.33	—	0.12
	CT = 31	0.07	−0.11	—	−0.02
Keefe ²⁹	SM1 = 26	0.14	0.30	—	0.22
	SM2 = 27	0.21	0.48	—	0.34
	SM3 = 28	0.04	0.02	—	0.03
Keefe ²⁰	EX = 16	—	0.05	0.37	0.21
	SM = 18	—	0.41	0.00	0.21
	CT = 18	—	−0.14	0.01	−0.07
Kovar ²³	EX = 40	0.23	0.13	0.43	0.35
	CT = 37	0.05	−0.01	−0.10	0.05
Mangione ²⁶	EX1 = 18	0.45	—	0.10	0.28
	EX2 = 18	0.15	—	0.06	0.10
Martire ³⁰	SM1 = 11	0.02	−0.19	—	−0.08
	SM2 = 13	0.15	0.23	—	0.19
Mazzuca ¹³	SM = 82	0.04	—	—	−0.02
	CT = 82	−0.02	—	—	−0.07
McCarthy ²⁷	EX1 = 71	0.18	—	0.12	0.15
	EX2 = 80	0.52	—	0.40	0.46
Rejeski ²¹	EX = 69	0.19	−0.11	—	0.04
	SM = 73	0.23	0.10	—	0.17
	CT = 68	0.07	0.06	—	0.06
Schilke ²⁴	EX = 10	0.80	—	0.55	0.88
	CT = 10	0.01	—	0.14	0.05
Talbot ³¹	SM = 16	−0.03	—	−0.04	−0.04
Thomas ²⁵	EX = 405	0.24	0.06	0.03	0.11
	CT = 273	0.01	0.05	−0.08	−0.01

EX: exercise programs, SM: self-management programs, CT: control groups. Positive effect sizes indicate improvement. * When group sample sizes varied across outcomes, the average of the group sample sizes was computed and entered in the effect size calculations.

included quadriceps strengthening, control of joint pain with thermal modalities, and joint protection. Finally, one intervention²¹ focused on diet self-management, an important aspect of OA management, as obesity is one of the strongest predictors of the disease. The goal was to raise awareness of the need to change eating habits to lower caloric intake. Sessions included problem solving, reviewing specific topics, low-fat food tasting, goal setting, and counseling. It is interesting that all studies involving self-management included measures of physical health (self-reports and/or direct measures of impairment); 9 interventions^{20,21,28-30} assessed psychological outcomes, and only 3 of them^{19,20,31} contained direct indicators of physical impairment*.

On physical outcomes ($n_{\text{interventions}} = 12$, $n_{\text{participants}} = 387$), the p value of the Q -statistic was 0.77, indicating no

evidence of heterogeneity in the effect sizes. The effect sizes ranged between −0.37 and 0.34. The mean effect of the self-management programs on physical outcomes was very small (0.09, 95% CI −0.01, 0.19) and failed to reach significance ($Z = 1.69$, $p > 0.09$). On psychological outcomes ($n_{\text{interventions}} = 9$, $n_{\text{participants}} = 264$), there was no evidence of heterogeneity in the effect sizes ($p = 0.52$) and the effect sizes ranged from −0.19 to 0.48. The self-management programs led to significant improvement over time on psychological dimensions ($Z = 3.32$, $p < 0.001$), although the mean effect size was small (0.20, 95% CI 0.08, 0.33). For the

*Two other studies^{28,29} used video evaluation of motor pain behavior. Although such a measure presents some advantages over self-reports, it entails interpretation and subjectivity from the observer; therefore we did not consider that assessment to be a direct measure of impairment.

direct measures of impairment ($n_{\text{interventions}} = 3$, $n_{\text{participants}} = 44$), the effect sizes ranged between -0.04 and 0.24 , and appear to be homogeneous ($p = 0.77$). The mean effect size was almost null (0.04 , 95% CI -0.25 , 0.34) and was not significant ($Z = 0.28$, NS). For the index of overall impact of OA ($n_{\text{interventions}} = 13$, $n_{\text{participants}} = 387$), the effect sizes were homogeneous ($p = 0.92$), and ranged from -0.13 to 0.34 , with a small but significant mean effect size (0.11 , 95% CI 0.01 , 0.21 ; $Z = 2.10$, $p < 0.04$).

Examining the effect sizes of control groups. Of the 16 studies in the metaanalytic review, 10 included a control group. The structure of the control groups varied. Six studies defined their control groups as no-treatment groups^{18,25} or groups receiving standard care^{20,23,24,28}, while 2 studies included attention control groups^{13,21}. Finally, 2 groups received sham electric stimulation^{19,32*}.

All the Q-statistic p values reflected homogeneity in effect sizes and were nonsignificant (physical outcomes: $n_{\text{interventions}} = 9$, $n_{\text{participants}} = 559$, $p > 0.08$; psychological outcomes: $n_{\text{interventions}} = 5$, $n_{\text{participants}} = 427$, $p = 0.85$; direct measures of impairment: $n_{\text{interventions}} = 7$, $n_{\text{participants}} = 396$, $p = 0.96$; overall effect: $n_{\text{interventions}} = 10$, $n_{\text{participants}} = 577$, $p = 0.77$). All the mean effect sizes were almost null and were not significant, showing no change over time on any dimension (physical outcomes: 0.06 , 95% CI -0.03 , 0.14 , $Z = 1.33$, NS; psychological outcomes: 0.03 , 95% CI -0.07 , 0.12 , $Z = 0.56$, NS; direct measures of impairment: -0.06 , 95% CI -0.15 , 0.04 , $Z = 1.10$, NS; overall impact of OA: 0.02 , 95% CI -0.06 , 0.10 , $Z = 0.41$, NS).

Comparing exercise and self-management programs to controls. We examined the extent to which both types of intervention groups combined differed from the control groups. The Q-statistic p values indicated significant heterogeneity between the intervention groups and the control groups on physical outcomes ($p < 0.0008$), direct measures of impairment ($p < 0.002$), and overall impact of OA ($p < 0.003$), but not on the psychological outcomes ($p = 0.26$).

We then tested the extent to which each type of intervention group differed from the control groups. The Q-statistic p values indicated significant heterogeneity between the exercise groups and the control groups on physical outcomes ($p < 0.0001$), direct measures of impairment ($p < 0.0009$), and overall impact of OA ($p < 0.0007$), but not on psychological outcomes ($p = 0.83$). For the comparison between self-management programs and control groups, the Q-statistic for psychological outcomes indicated significant heterogeneity ($p < 0.03$), but the p values failed to reach sig-

nificance on the other outcomes (physical outcomes: $p = 0.64$; direct measures of impairment: $p = 0.54$; overall impact of OA: $p = 0.17$).

Additional analyses excluding studies. The conclusions reached in a metaanalytic review depend largely on the decision to include or exclude studies from the analysis. When a study somewhat deviates from the prototype of what belongs in the metaanalysis, the decision to include or exclude it becomes difficult. In our study, the inclusion of several interventions could be questioned: 2 of them used arbitrary assignment instead of random assignment, which, one could argue, decreases the methodological quality of the studies; some self-management interventions that we included were merely educational, and had no other psychological components; in another case, the use of a single session to deliver an intervention might not provide enough time for behavioral change to occur. Yet removing all those studies from our sample would reduce its size significantly, which would preclude analyses of some outcomes and weaken our conclusions. Therefore, we included them, but performed additional analyses to test the rigorousness of our findings.

Specifically, analyses were performed excluding the 2 studies that did not use random assignment^{13,18}. When these studies were removed, the effect sizes for the control groups on physical outcomes became slightly more heterogeneous ($p < 0.05$), while the effect sizes for the exercise groups on direct measures of impairment and on overall impact of OA became slightly less heterogeneous ($p > 0.05$ and $p > 0.09$, respectively). Nonetheless, removing those studies did not affect the comparisons between exercise or self-management programs and control groups. In other words, the results stayed the same.

In another set of analyses, we excluded self-management programs that did not include psychological strategies to increase coping^{13,19,21,22}. The results did not change. Moreover, there was one study that we included as self-management but that the authors considered as control groups²². This study was excluded when we performed the analyses removing the self-management programs that did not include psychological strategies to increase coping. Finally, one study¹³ used a single session to deliver the intervention. This study was excluded when we ran the analyses without the studies that did not use random assignment. Because the results remained virtually unchanged when we removed studies whose inclusion in the metaanalysis was questionable, we have increased confidence in the validity of our findings.

Publication bias. We investigated the possibility of a publication bias in our sample of studies by generating funnel plots. These graph the effect size of a study group on the horizontal axis and the sample size of that study group on the vertical axis. If no publication bias exists, studies with larger sample sizes would have smaller variations in effects,

*We should note that we classified as "self-management program" instead of "control" an arm that was conceived by the researchers as a "minimal treatment group" to the exercise program that was included in that study. This minimal treatment group consisted of 12 hours of educational content directly related to OA and exercise. Therefore, because of its intensity and relevance to management of OA, we considered it to be more than just an attention control group and to fit our definition of self-management²².

and the effects of smaller studies would range equally above and below this value, therefore the plot would take the shape of an inverted funnel. However, if there is bias against the publication of results indicating a null or adverse effect, the funnel plot would be asymmetric, with fewer values toward the left side. Because large studies might be published even if the findings are not significant, this effect would be especially pronounced for small studies, leading to an absence of studies on the lower left of the funnel plot. Plots for the physical outcomes, for psychological outcomes, for direct measures of impairment, and for the overall effect of OA are displayed in Figure 1. For all the plots there seems to be a reasonable degree of symmetry, which indicates little evidence of publication bias.

DISCUSSION

To our knowledge, no other metaanalysis limited to OA in

the knees has assessed the effect of exercise and self-management programs on physical and psychological dimensions. While the well-being of patients enrolled in control groups generally was unchanged over the course of the studies, participants in intervention groups benefited from participation. Their physical health, assessed with self-reported and direct measures, improved; and the overall impact of OA was lessened.

Exercise programs had a positive, although small, effect on the well-being of participants. More specifically, exercise regimens led to improvement in perceived physical health, on direct measures of impairment, and on the overall impact of OA. Perceived psychological health remained unchanged by the exercise programs. Exercise groups differed from control groups in self-reported physical health, in direct measures of impairment, and in the overall impact of OA, but not in psychological outcomes. The finding that exercise

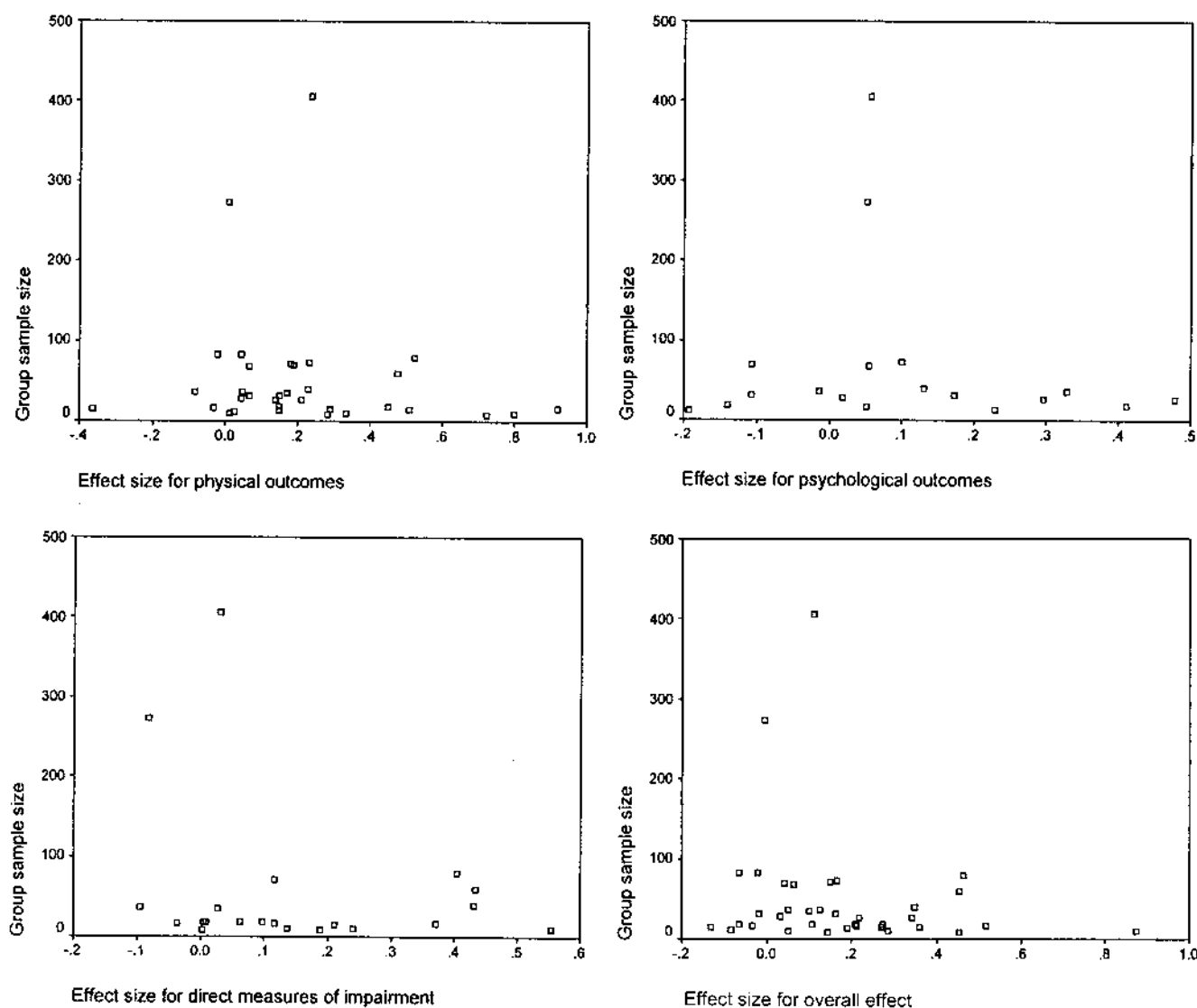


Figure 1. Funnel plots for each type of outcome.

programs did not produce significant improvements in the psychological well-being of participants indicates that exercise interventions need to include additional, or more powerful, intervention components to affect the psychological well-being of participants. OA often takes a toll on the psychological resources of affected persons. Because little can be done to alleviate the impact of OA, individuals may lack self-efficacy and experience helplessness and depression. It is our contention that addressing the mental burden of OA should be a priority of any intervention, because improving participants' psychological well-being may reduce attrition from, and increase adherence to, exercise programs. Affecting the psychological well-being of participants may also increase the longterm (beyond one year) effects of exercise.

The effect sizes for change over time in psychological outcomes and overall impact of OA were significant for the self-management programs, although they were small. However, these programs differed from the control groups only in psychological outcomes. Unfortunately, most studies investigating self-management programs did not include direct indicators of impairment, making it difficult to evaluate their effect on this dimension. That self-management programs did not significantly affect the physical health of patients, while exercise regimens did, suggests that programs for patients with knee OA need to include an exercise component to be effective on this dimension.

To understand why self-management programs did not lead to significant changes in physical outcomes, one ought to look at the mechanisms that underlie health-related change. The literature on patient education has repeatedly identified self-efficacy as a key mediator of behavioral change³⁴⁻³⁶. Self-efficacy can be simply defined as the belief in one's capacity to engage in and/or maintain a specific behavior. Many studies have established this belief as an important determinant of the ability to acquire and maintain new skills and behaviors in coping with chronic illnesses³⁷⁻⁴⁰. It is conceivable that self-management programs that increased psychological well-being nevertheless failed to positively affect patients' belief in the ability to control arthritis or cope with its symptoms, and hence did not improve physical fitness. Because arthritis is a chronic, debilitating illness, self-efficacy for arthritis may be particularly difficult to alter. Only 3 studies included in the meta-analysis reported measures of self-efficacy for arthritis-related behaviors at the post-intervention assessment. The first study suggested that involving spousal support in interventions might enhance self-efficacy for arthritis³⁰. The other 2 interventions examined the role of self-efficacy in the process leading to the outcomes. Keefe, *et al*²⁹ observed that patients in the coping skills training (both spouse-assisted and conventional) reported higher levels of self-efficacy for arthritis-related behaviors than participants who attended the Arthritis Self-Help Course combined with spousal support. Across conditions, patients who reported increases

in self-efficacy over the course of the intervention were more likely to report decreases in pain, psychological disability, and physical disability. In their more recent study of the effects of spouse-assisted pain coping skills training and exercise alone or in combination, Keefe, *et al*²⁰ observed similar results. Overall, patients who showed increases in self-efficacy over the course of the study also showed improvement in physical health.

Our metaanalysis has some limitations that are inherent in such an approach. This metaanalytic review included exercise and self-management programs that were very heterogeneous. The exercise interventions included low intensity or high intensity aerobic exercises, resistance exercises, or other strengthening training, flexibility or balance. Some interventions were clinic-based and some were home-based. The intensity of the exercise interventions also varied from 20 minutes to 3 hours a week, and their duration ranged from 4 weeks to 24 months. The studies that included self-management components were heterogeneous as well. Some self-management interventions focused strictly on educational information about OA and general information about healthy living. Other interventions focused on techniques for pain management and/or coping, while others included information about the value of exercise. Some of the self-management interventions included spouses, but most did not. The intensity of the self-management interventions also varied from a single 30-minute intervention to 2 hours weekly, and their duration ranged from one session to 18 months. Using broad categories such as "exercise programs" and "self-management programs" does not reflect the diversity of intervention techniques included in our review. Refining those categories any further would drastically reduce the already very limited sample of studies (13 intervention arms of each type) and would threaten the validity of the results.

In addition to varying in content, intensity, number of sessions, duration, and comprehensiveness of the interventions, the studies varied in sample size (from 20 to 786), types of measurement, and the overall quality of implementation of the intervention. To control the influence of those limitations on the integrity of our results, several precautions were taken. First, the sample sizes were weighted in the analyses, meaning that interventions with larger sample sizes contributed more in the analyses than interventions with smaller groups. Second, we distinguished among 4 types of outcomes (self-reports of psychological health, self-reports of physical health, direct measures of impairment, and overall impact of OA). Using that categorization yielded differential results: exercise and self-management affected the dimensions in distinct ways. This still resulted in broad categories that one could have focused on specific concepts (e.g., pain) or even specific measures (e.g., AIMS subscale) rather than combining various concepts in the broad category (self-report of physical health). However,

had we adopted that approach, our already limited sample of studies would have been too small to conduct the analyses, as very few studies included identical measures or concepts (see Table 1).

To address some of the limitations, additional analyses were performed excluding studies based on different criteria. These criteria included: not using random assignment (2 instances), not including psychological strategies to increase coping with OA (4 instances), use of a single session (one instance), or educational interventions conceived as control groups by their authors (one instance). In each case, the results remained unchanged. Weighing sample sizes, differentiating among 4 outcome categories that allowed us to shed light on the differential effects of exercise and self-management programs, and obtaining similar results when comparing the analyses before and after exclusion of studies that might be considered as discrepant with the rest, increased our confidence about the integrity of our conclusions.

Our review cannot reveal whether the interventions themselves, the methods of implementation, or methodological limitations were responsible for the modest effects observed. It is also possible that there was a lack of statistical power in the original studies to detect interventions' effects. Half of the studies^{19,20,22,24,26,30-32} included groups of 20 or fewer participants, so it is likely that some sample sizes were too limited to detect small but real changes. Nonetheless, the effect sizes observed in the studies are consistent with what other metaanalytic reviews have found^{8-10,40}.

This modest influence of interventions begs the question of how clinically relevant the findings are. We argue with others^{10,40} that, because most of the participants were already receiving standard care, the gains observed from the treatments are clinically important. Clearly, there are some added benefits of participating in exercise programs and self-management programs, and these results validate the health-promotion efforts of organizations such as the Centers for Disease Control (CDC) and the Arthritis Foundation. Physical activity and self-management programs may not have yet become standards of care: according to the CDC, only one in 10 has taken an arthritis management course⁴¹. However, the CDC and the Arthritis Foundation are working together to change these statistics: they are currently promoting and sponsoring at least one self-management program, Lorig's Arthritis Self-Help Course³³, and they are working to identify additional evidence-based interventions that are safe and beneficial for people with arthritis. The CDC has also developed media campaigns to promote physical activity to relieve the pain and disability associated with arthritis. In addition, the CDC is sponsoring 2 exercise programs offered by chapters of the Arthritis Foundation: (1) the People with Arthritis Can Exercise (PACE), a community-based recreational exercise program; and (2) the Arthritis Foundation Aquatics Program (AFAP), a water exercise program created by the Arthritis

Foundation. Our metaanalysis sheds light on the benefits of integrating physical activity and self-management strategies into the best practices of standard care for OA. It also suggests that new programs combining both types of intervention may produce a wider range of positive outcomes (both physical and psychological).

Finally, when evaluating an intervention, one should assess its cost-effectiveness. Only 2 studies examined the cost-benefit ratio of the interventions. One study found that exercise was more effective and less costly to implement than education⁴². The second study found that an education intervention was more cost-effective than an attention control group⁴³. Thus, both education and exercise programs may be cost-effective. However, the cost-effectiveness of these interventions was small relative to the cost-effectiveness of other interventions with OA patients⁴⁴. Future studies should examine the cost-benefit ratios of intervention programs for people with knee OA to demonstrate to health-care providers that such programs can benefit both the provider and the patient. OA of the knee affects millions of Americans, and the number of people afflicted will increase as the mean age of the population increases. Some evidence suggests that behavioral interventions for people with OA can produce significant cost savings, while also producing increases in health and psychological well-being⁴⁴⁻⁴⁶.

In conclusion, OA of the knee is the most common type, and treatments for patients are limited. Programs that can improve both the psychological and physical well-being of patients are needed. Different interventions and novel combinations of treatments need to be tested. The data suggest that we may need to intensify the interventions and test interventions that include exercise combined with other components if we are to affect both physical and psychological well-being of the patient. Patients in both the self-management and exercise groups manifested improvements over time, but the effects were small.

At the end of this review, the reader may be puzzled by findings that are not very inspiring. This reflects the state of intervention approaches used for knee OA. Although we would not want to undermine the efforts of the researchers, we must acknowledge the difficulty of altering patients' physical and mental health. It is impossible to determine with certainty from a metaanalytic review what directions future research should take. Nonetheless, we would join other authors⁴⁰ in their efforts to formulate recommendations for future intervention research on arthritis. First, power analyses should be conducted prior to studies to determine the sample sizes needed to detect significant effects. Second, means and standard deviations for baseline and post-intervention assessments should be published for all outcomes to allow all studies to be subjected to meta-analysis. Third, future interventions should be designed for patients suffering exclusively from OA in the same joints. Fourth, to be effective, interventions for OA patients should

include an exercise component as well as components directed at improving psychological outcomes. Fifth, assessments should be conducted on multiple physical and psychological health outcomes. Both direct measures and self-reports of physical health should be used. Sixth, researchers need to test individual treatment components as well as combinations of components, so that we may determine which components are efficacious and how they interact. Finally, all studies should report cost-benefit analyses. It is possible that healthcare resources are used more efficiently as a result of interventions, even though a patient's health is not improved significantly.

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