Effectiveness of Exercise Interventions in Reducing Pain Symptoms Among Older Adults With Knee Osteoarthritis: A Review

Brian C. Focht

Knee osteoarthritis (OA) affects approximately one third of all older adults in the United States. The pain accompanying its progression reduces quality of life and leads to activity restriction and physical disability. Evidence suggests that exercise represents a promising treatment for pain among older knee-OA patients. The article provides an overview of the extant research examining the effectiveness of exercise interventions in reducing pain symptoms among older adults with knee OA. Critical evaluation of the literature reveals that aerobic training, strength training, and combination aerobic and strength training result in improvements in pain. The magnitude of pain reduction accompanying exercise interventions varies considerably across studies, however. In addition, most trials have focused on short-term (<6 months) interventions, and the limited number of long-term (>6 months) trials have been plagued by high attrition and poor postintervention maintenance of treatment effects. Given the variability in the effectiveness of exercise interventions, future research is necessary to determine the individual differences that influence older OA patients’ responsiveness to exercise interventions and identify more efficacious strategies for promoting the maintenance of long-term exercise.

Key Words: arthritis, elderly, physical activity

Knee osteoarthritis (OA) is a chronic, progressive degenerative disease that affects approximately one third of all older adults in the United States (Centers for Disease Control and Prevention, 2001). Pain is one of the principle adverse symptoms of knee OA. The pain accompanying the onset and progression of symptomatic knee OA has a profound effect on older patients’ physical functioning and health-related quality of life (Felson et al., 2000; Rejeski & Shumaker, 1994). Pain is cited as a primary cause of activity restriction and physical disability among older adults with arthritis (Leville, Fried, McMullen, & Guralnik, 2004). Furthermore, inactivity secondary to pain results in muscle weakness, atrophy, and deconditioning, which have been hypothesized to exacerbate pain symptoms and accelerate the progression toward physical disability in arthritic patients (Dekker,
Pharmacologic and surgical interventions are frequently applied in the treatment of knee OA. These therapeutic strategies have yielded mixed success, however, and are associated with adverse long-term side effects. Accordingly, in the absence of a cure for knee OA, current approaches to treatment have increasingly focused on identifying and developing more effective behavioral pain-management strategies. In accordance with this goal, there is growing interest in the efficacy of exercise therapy in the treatment of knee OA. Findings from this line of inquiry suggest that exercise interventions result in significant improvements in pain symptoms and physical function in older adults with OA of the knee (Baker et al., 2001; Ettinger et al., 1997; Petrella & Bartha, 2000). Consistent with these findings, recent treatment guidelines advocate including exercise as an integral component of the medical management of knee OA (Minor, Stenstrom, Klepper, Hurley, & Ettinger, 2003).

In spite of increased recognition of the benefits of regular exercise participation, most older adults with knee OA remain sedentary. Inactivity contributes to the functional limitations associated with symptomatic knee OA (Minor, 2004). In addition, physical activity interventions targeting older adults with knee OA continue to be plagued with high attrition rates (Brawley, Rejeski, & King, 2003). The disturbingly low adherence rates illustrate the considerable challenges that need to be addressed in order to successfully integrate physical activity into the management of OA pain. Accordingly, the primary purpose of the present article is to provide an overview of research examining the effect of exercise interventions on pain symptoms in older adults with knee OA.

**Study Characteristics**

Studies were included in the present review if they met the following criteria: randomized controlled design, mean sample age of at least 50 years, and use of an intervention involving exercise, defined as consistent participation in a regular, structured, repetitive exercise program several weeks to several months in duration. Studies that did not report mean sample age or randomization procedures were excluded from the review. Investigations including participants in the sample without OA or with other rheumatic diseases or chronic pain conditions were also excluded. Studies were obtained through computer and manual searches. Computer searches were conducted using MEDLINE, PsychLIT, ERIC, and SPORTDiscus. Manual searches were also conducted using the reference lists from other narrative and meta-analytic reviews of the exercise–OA literature (Baker & McAlindon, 2000; Minor, 2004; Petrella, 2000; VanBaar, Assendelft, Dekker, Oostendorp, & Bijlsma, 1999), as well as the reference lists of each study included in the review.

Eighteen randomized controlled trials met the inclusion criteria and are summarized in the present review. Summaries of the trials are provided in Tables 1–4. The aerobic-training intervention trials are summarized in Table 1. The strength-training intervention trials are summarized in Table 2. Trials comparing aerobic-training and strength-training interventions are summarized in Table 3. Finally,
## Table 1  Effects of Aerobic-Training Intervention Trials

<table>
<thead>
<tr>
<th>Authors</th>
<th>Participants</th>
<th>Interventions</th>
<th>Measures</th>
<th>Duration</th>
<th>Major results</th>
</tr>
</thead>
</table>
| Kovar et al. (1992)| 102 older adults (mean age = 69 years); 17 men, 85 women | 1. Walking + patient education  
2. Usual-care control | AIMS     | 8 weeks | Significant between-groups difference in pain ($ES = 0.41$) |
| Mangione et al. (1999) | 39 older adults (mean age = 71 years); 13 men, 26 women | 1. High-intensity cycling  
2. Low-intensity cycling | AIMS-2  | 10 weeks | Decrease in pain with both low-intensity ($ES = 0.21$) and high-intensity ($ES = 0.63$) cycling; no significant differences between groups |

*Note.* AIMS = Arthritis Impact and Measurement Scale; AIMS-2 = Arthritis Impact and Measurement Scale-2.
trials examining interventions involving a combination of aerobic-training and strength-training exercise interventions are summarized in Table 4. Significant between- and within-group effect sizes (ES) accompanying differences in pain that are reported in the text and tables were obtained from previous exercise–OA reviews (Baker & McAlindon, 2000; Minor, 2004; VanBaar et al., 1999) or calculated ($M_1 - M_2/SD_{pooled}$) when sufficient information was provided. If effect sizes could not be calculated, percentage change was estimated when adequate information was presented. Sample sizes in the trials ranged from 20 to 600 older adults, and mean age of the samples ranged from 56 to 73 years. A brief summary of each trial’s results, organized by type of exercise intervention, is provided in the following section of the review.

### Aerobic-Training Interventions

Two trials examined the effects of aerobic training on pain symptoms (Kovar et al., 1992; Mangione et al., 1999). Kovar and colleagues compared the effects of 8 weeks of fitness walking with a usual-care intervention in a sample of 102 older adults. The exercise intervention involved 90-min sessions of supervised walking and psychoeducational training performed three times per week. Participants walked for up to 30 min during each of the three weekly exercise sessions. The intensity prescribed during the walking sessions was not reported. Participants randomized into usual care received standard medical care and weekly telephone contact from clinic staff. Pain was assessed using the arthritis-pain subscale of the Arthritis Impact Measurement Scale (AIMS; Meenan, 1982). Ninety-two (90%) of the participants completed the study. Other measures of adherence to the walking intervention (e.g., number of sessions attended) during the trial were not reported. Results revealed that the fitness-walking intervention resulted in a greater reduction in pain than did the usual-care treatment ($ES = 0.41$). In addition, participants assigned to the walking intervention experienced greater improvement in pain when compared with baseline ($ES = 0.74$) than did those undergoing usual care ($ES = 0.05$). Sixty-one percent of the walking-intervention-group participants and 51% of the usual-care-group participants completed a 1-year follow-up assessment (Sullivan, Allegrante, Peterson, Kovar, & MacKenzie, 1998). Follow-up data revealed that significant reductions in pain observed after the 8-week walking program were not maintained 1 year after treatment. The walking participants’ self-reported physical activity participation also declined across the follow-up period, with no significant differences in total walking volume evident between participants in the walking and usual-care interventions 1 year after the end of treatment.

Mangione et al. (1999) examined the effect of 10 weeks of high- and low-intensity aerobic training in a sample of 54 older knee-OA patients. Participants completed 25 min of stationary cycling at either 70% or 40% of heart-rate reserve three times per week. A total of 39 participants (72%) completed the study. Adherence to the exercise interventions, defined as the number of prescribed cycling sessions attended, was 92% among participants completing the study. Pain symptoms were assessed using the pain subscale of the AIMS-2 (Meenan, Mason, Anderson, Guccione, & Kazis, 1992). There were no differences in attrition or attendance between the high- and low-intensity exercise interventions. Analysis also revealed no significant posttreatment differences in pain ($ES = 0.05$) between the high- and
Table 2  Effects of Strength-Training Intervention Trials

<table>
<thead>
<tr>
<th>Authors</th>
<th>Participants</th>
<th>Interventions</th>
<th>Measures</th>
<th>Duration</th>
<th>Major Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schilke et al. (1996)</td>
<td>20 older adults (mean age = 66 years); 10 men, 10 women</td>
<td>ST Usual care</td>
<td>OASI</td>
<td>8 weeks</td>
<td>Decrease in pain symptoms ($ES = 1.27$) with the ST intervention; no significant differences between groups ($ES = 0.07$)</td>
</tr>
<tr>
<td>Rogind et al. (1998)</td>
<td>28 older adults (mean age = 71 years); 3 men, 25 women</td>
<td>ST No-training control</td>
<td>VAS</td>
<td>12 weeks</td>
<td>Decrease (25%) in pain at night with ST at 3 months and 50% decrease at 12 months; no significant differences between groups</td>
</tr>
<tr>
<td>Van Baar et al. (1998)</td>
<td>201 older adults (mean age = 68 years); 48 men, 153 women</td>
<td>ST Usual care</td>
<td>VAS</td>
<td>12 weeks</td>
<td>Significant between-groups difference in pain ($ES = 0.58$) at 12 weeks; no significant differences between groups at 36-week follow-up</td>
</tr>
<tr>
<td>Maurer et al. (1999)</td>
<td>113 older adults (mean age = 65 years); 66 men, 47 women</td>
<td>ST Patient education Control</td>
<td>WOMAC, AIMS-2, SF-36, VAS</td>
<td>8 weeks</td>
<td>Significant between-groups difference in pain at 8 weeks</td>
</tr>
<tr>
<td>O’Reilly et al. (1999)</td>
<td>191 older adults (mean age = 69 years), men = na, women = na</td>
<td>HB ST Usual care</td>
<td>WOMAC, VAS</td>
<td>6 months</td>
<td>Significant between-groups difference in pain ($ES = 0.31$) at 6 months</td>
</tr>
<tr>
<td>Study</td>
<td>Sample Size</td>
<td>Intervention Details</td>
<td>Measure</td>
<td>Follow-up</td>
<td>Findings</td>
</tr>
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<tr>
<td>Thomas et al. (2002)</td>
<td>600 adults</td>
<td>HB ST, Telephone contact, ST + telephone</td>
<td>WOMAC</td>
<td>2 years</td>
<td>Significant between-groups difference in pain ($ES = 0.25$) at 2 years for both ST interventions</td>
</tr>
<tr>
<td>Petrella &amp; Bartha (2000)</td>
<td>179 adults</td>
<td>HB ST + NSAIDs, NSAIDs only</td>
<td>WOMAC, VAS</td>
<td>8 weeks</td>
<td>Significant between-groups difference in pain ($ES = 1.10$) at 8 weeks</td>
</tr>
<tr>
<td>Baker et al. (2001)</td>
<td>46 adults</td>
<td>HB ST, Nutrition education</td>
<td>WOMAC</td>
<td>4 months</td>
<td>Significant between-groups difference in pain at 4 months</td>
</tr>
<tr>
<td>Topp et al. (2002)</td>
<td>102 adults</td>
<td>Isometric ST, Dynamic ST, No intervention</td>
<td>WOMAC</td>
<td>16 weeks</td>
<td>Significant between-groups difference in pain at 4 months for both ST interventions</td>
</tr>
</tbody>
</table>

Note: ST = strength training; OASI = Osteoarthritis Screening Index; VAS = visual analog scale; WOMAC = Western Ontario and McMaster Universities Osteoarthritis Index; AIMS-2 = Arthritis Impact and Measurement Scale-2; SF-36 = Short Form-36 Health-Related Quality of Life Index; HB ST = home-based strength training; NSAIDs = nonsteroidal anti-inflammatory drugs.
<table>
<thead>
<tr>
<th>Authors</th>
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<th>Duration</th>
<th>Major Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ettinger et al.</td>
<td>439 older adults (mean age = 69 years); 131 men, 308 women</td>
<td>AT, ST</td>
<td>KPS</td>
<td>18 months</td>
<td>Significant between-groups difference in pain with AT ($ES = 0.47$) and ST ($ES = 0.31$)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Health-education</td>
<td>control</td>
<td></td>
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</tr>
<tr>
<td>Evcik &amp; Sonel</td>
<td>90 older adults (mean age = 56 years); 34 men, 56 women</td>
<td>HB ST, AT</td>
<td>WOMAC, VAS</td>
<td>12 weeks</td>
<td>Significant between-groups difference in WOMAC with ST ($ES = 1.20$) and AT ($ES = 1.20$); significant between-groups difference in VAS with ST ($ES = 2.75$) and AT ($ES = 2.66$)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Control</td>
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</tbody>
</table>

*Note. AT = aerobic training; ST = strength training; KPS = Knee Pain Scale; HB ST = home-based strength training; WOMAC = Western Ontario and McMaster Universities Osteoarthritis Index; VAS = visual analog scale.*
### Table 4  Effects of Combination Strength-Training and Aerobic-Training Intervention Trials

<table>
<thead>
<tr>
<th>Authors</th>
<th>Participants</th>
<th>Interventions</th>
<th>Measures</th>
<th>Duration</th>
<th>Major Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deyle et al. (2000)</td>
<td>83 older adults (mean age = 61 years); 34 men, 49 women</td>
<td>PT + AT/ST, Placebo</td>
<td>WOMAC with PT + AT/ST</td>
<td>4 weeks</td>
<td>Significant decrease in pain; no significant differences between groups</td>
</tr>
<tr>
<td>Fransen et al. (2001)</td>
<td>126 older adults (mean age = 67 years); 34 men, 92 women</td>
<td>Individualized PT + AT/ST Group PT + AT/ST, Wait-list control</td>
<td>WOMAC, SF-36, VAS</td>
<td>8 weeks</td>
<td>Significant between-groups differences for both forms of PT relative to control; no significant differences between PT interventions</td>
</tr>
<tr>
<td>Hughes et al. (2004)</td>
<td>150 older adults (mean age = 73 years); 24 men, 126 women</td>
<td>AT/ST, Control</td>
<td>WOMAC</td>
<td>8 weeks</td>
<td>Significant between-groups difference in pain at 6-month follow-up</td>
</tr>
<tr>
<td>Messier et al. (2000)</td>
<td>24 older adults (mean age = 68 years); 7 men, 17 women</td>
<td>AT/ST, AT/ST + diet</td>
<td>KPS</td>
<td>6 months</td>
<td>Significant decrease in pain after AT/ST and AT/ST + diet; no significant differences between groups</td>
</tr>
<tr>
<td>Messier et al. (2004)</td>
<td>316 older adults (mean age = 68 years); 86 men, 230 women</td>
<td>AT/ST, Diet, AT/ST + diet Healthy-lifestyle control</td>
<td>WOMAC, SF-36</td>
<td>18 months</td>
<td>Significant between-groups difference in WOMAC AT/ST + diet relative to control</td>
</tr>
</tbody>
</table>

*Note.* PT = physical therapy; AT/ST = combination of aerobic-training and strength-training interventions; WOMAC = Western Ontario and McMaster Universities Osteoarthritis Index; PT = physical therapy; SF-36 = Short Form-36 Health-Related Quality of Life Index; VAS = visual analog scale; KPS = Knee Pain Scale.
low-intensity exercise groups. Nonetheless, pain symptoms improved significantly when compared with baseline values with both high-intensity ($ES = 0.63$) and low-intensity ($ES = 0.21$) exercise. Changes in acute pain accompanying cycling were also obtained using a visual analog pain scale (VAS). Analysis of VAS responses suggested that neither high- nor low-intensity cycling exercise exacerbated acute knee pain. On the contrary, in a subset of patients acute pain decreased immediately after cycling.

Findings of the two trials examining aerobic training suggest that this type of exercise intervention results in significant, yet small to moderate, improvements in pain among older adults with knee OA. Despite these promising results, however, it should be recognized that because both trials examined relatively short, supervised exercise interventions, the long-term effectiveness of this approach to exercise therapy remains unclear. It is notable that long-term follow-up data (Sullivan et al., 1998) from the Kovar et al. (1992) trial demonstrated that improvements in pain observed at the end of the supervised program were not maintained 1 year post-treatment. Self-reported estimates of physical activity participation at follow-up also indicated that participants in the fitness-walking intervention failed to sustain independent exercise after the end of the supervised intervention. Accordingly, additional research that examines ways to maintain exercise participation after the completion of short-term interventions and that delineates the extent to which maintenance of regular exercise participation might affect long-term changes in pain symptoms is warranted. Because of the limited number of aerobic-training trials, few conclusions can be generated about the optimal mode, frequency, duration, or intensity of aerobic training necessary to elicit improvements in pain. Both walking ($ES = 0.74$) and high-intensity stationary cycling ($ES = 0.63$) resulted in similar improvements in pain. Thus, it appears that both weight-bearing and non-weight-bearing types of aerobic exercise can yield benefits for pain symptoms. It is important to recognize, however, that this might not be true for other relevant OA outcomes such as physical function or the performance of activities of daily living (Minor, 2004). Future research addressing the influence of different doses of aerobic training on changes in pain is necessary.

**Strength-Training Interventions**

Nine trials examined the efficacy of strength-training interventions (Baker et al., 2001; Maurer, Stern, Kinossian, Cook, & Schumacher, 1999; O’Reilly, Muir, & Doherty, 1999; Petrella & Bartha, 2000; Rogind et al., 1998; Schilke, Johnson, Housh, & O’Dell, 1996; Thomas et al., 2002; Topp, Woolley, Hornyak, Khuder, & Kakaleh, 2002; VanBaar, Dekker, Oostendorp, Bilj, Voorn, & Lemmens, 1998). A brief summary of each of the strength-training trials is provided in the following section of the review.

Schilke and colleagues (1996) contrasted the effects of a strength-training program and a usual-care-control intervention in a sample of 20 older adults. The strength-training intervention consisted of 8 weeks of progressive lower body isokinetic resistance exercise completed three times per week. During the strength-training intervention, participants progressed from completing one set of five repetitions during the initial session to completing six sets of five repetitions in Weeks 3–8. Assessments of pain were obtained using the pain subscale of the Osteoarthritis
Screening Index (OASI), a rheumatoid-arthritis-disease inventory the authors modified for use with OA patients. No significant between-groups differences were observed for postintervention pain symptoms ($ES = 0.07$), but participants in the strength-training intervention did report significantly lower pain symptoms when compared with baseline values after the exercise program ($ES = 1.27$).

In a single-blind controlled trial, Rogind et al. (1998) examined the effects of 3 months of strength training and a no-training control group in a sample of 25 older adults with severe bilateral knee OA. Participants completed 10 repetitions of resistance exercises at 70% of their individual capacity for primarily the lower extremity muscles the quadriceps, hamstrings, and hip adductors and abductors using body weight or therapist-provided resistance. Center-based strength training was performed twice per week, and participants were encouraged to do home-based strength training daily. Pain experienced at night and during weight-bearing activity was assessed using a VAS at 3-month and 12-month follow-up assessments. Twenty-three (92%) of the participants completed the trial. Adherence to the 3 months of center-based exercise was 78%, and participants were encouraged to continue exercising at home at the end of the center-based portion of the trial. Adherence to home-based exercise during the follow-up period was not reported. Results of a modified intention-to-treat analysis revealed that the strength-training intervention resulted in significant reductions in pain symptoms at night at 3-month (25%) and 12-month (50%) follow-up.

VanBaar et al. (1999) compared the effects of 12 weeks of center-based exercise therapy and a usual-care treatment in 201 older adults with knee or hip OA. Content, frequency, and intensity of the exercise intervention were individually tailored to each patient’s needs based on the supervising physical therapist’s discretion. Participants exercised one to three times per week for a total of 30 min each session. The specific intensity and content of the exercise sessions were not explicitly stated. Changes in pain were assessed using a VAS after each intervention. A total of 191 (95%) of the participants completed the assessments at the end of the 12-week interventions. Adherence during the center-based phase of the strength-training intervention was not reported. Results from intention-to-treat analyses revealed that strength training produced a significantly greater reduction in pain than did usual care ($ES = 0.58$). Nine-month follow-up data from 183 participants enrolled in this trial were reported in a later publication (VanBaar et al., 2001). Retrospective estimates of adherence to the home-based phase of the exercise program yielded compliance rates ranging from 33% to 66%. Results of follow-up analysis demonstrated that the difference in pain symptoms observed between the strength-training and control groups had declined at the 24-week posttreatment assessment ($ES = 0.36$). The difference in pain continued to dissipate across the follow-up period and was nonsignificant at the 36-week postintervention assessment ($ES = 0.20$).

Maurer et al. (1999) contrasted the effects of 8-week strength-training and health-education interventions on pain in 113 older adults. The strength-training intervention involved three weekly sessions of lower extremity strength training. Each participant completed lower extremity isokinetic resistance exercise involving three sets of three repetitions at three different angular velocities. Multiple assessments of general and specific pain symptoms were obtained before and after 8 weeks of each respective intervention using the AIMS-2, WOMAC (Bellamy, Buchanon, Goldsmith, Campbell, & Sitt, 1988), SF-36 (Ware, Kosinski, & Keller,
1997), and a 10-point category scale for overall pain and pain experienced during walking and stair climbing. A total of 98 participants completed the posttreatment assessments. Adherence during the 8-week exercise intervention was not reported. The strength-training intervention produced greater reductions in the WOMAC pain scale (23%) than was found in the control group (14%). In addition, strength training resulted in more favorable improvement in overall level of self-rated pain (65%) and pain during stair climbing (40%) relative to the control group.

O’Reilly et al. (1999) examined the effects of 6 months of home-based quadriceps strength training and a usual-care treatment among 191 older adults. The strength-training intervention involved progressive isometric and isotonic exercises for the quadriceps and hamstrings that were performed with graded elastic bands. Participants were instructed on how to use the bands during four home visits. Participants were asked to perform a total of 20–30 min of strength training per day. Pain was assessed using the WOMAC and a VAS for walking and stair climbing. A total of 180 participants completed the trial. Estimates of exercise adherence obtained from patients’ daily exercise logs indicated that approximately 70% of the participants completed 75% of the prescribed strength-training sessions. Results of intention-to-treat analyses demonstrated that the strength-training intervention resulted in significantly greater improvements in pain when compared with the usual-care treatment as measured by the WOMAC ($ES = 0.31$). Participants in the strength-training intervention also reported significant improvements in VAS walking and stair-climbing pain scores across the trial. In addition, improvements in pain were related to exercise compliance, with participants demonstrating the highest adherence reporting the most favorable changes in the VAS pain scores.

The efficacy of a home-based strength-training intervention was examined in a recent 2-year single-blind trial (Thomas et al., 2002). A total of 786 older adults were randomly assigned to one of four treatment groups: home-based strength training, monthly telephone contact, home-based strength training and telephone contact, or placebo control in which participants were prescribed a health-food tablet. Similar to the procedures used by O’Reilly et al. (1999), strength training involved isometric and isotonic exercises for the quadriceps and hamstrings that were performed with graded-resistance elastic bands. Pain was assessed using the WOMAC at baseline and every 6 months during the trial. Self-reported estimates of adherence to the home-based exercise intervention were obtained with daily exercise logs that were collected every 6 months. Although 600 participants (76%) completed the study, only 48% of participants randomized into an exercise treatment completed the 2-year follow-up assessment. Intention-to-treat analyses demonstrated that the exercise interventions produced significantly greater improvements in pain than did the nonexercise treatments at 2-year follow-up ($ES = 0.25$). Adherence to the home-based program was also related to improvements in pain. Specifically, participants were classified as having high, moderate, or low adherence based on self-reported compliance with the home-based strength-training program. Results of ancillary analyses revealed that participants reporting high adherence demonstrated more favorable changes in pain ($ES = 0.42$) than did participants with moderate ($ES = 0.34$) or low ($ES = 0.16$) adherence. Nevertheless, although exercise resulted in significant pain benefits, less than half of all participants assigned to an exercise intervention were successfully complying with the exercise prescription at the 2-year follow-up.
Petrella and Bartha (2000) compared the effects of a combination home-based strength-training and nonsteroidal anti-inflammatory drug (NSAID) intervention to NSAID treatment alone in 179 older adults with unilateral knee OA. Strength training involved lower extremity resistance exercises in which participants progressed from completing two repetitions per session three times per week to completing five repetitions per session five times per week. Compliance to home-based exercise sessions and weekly physical activity participation were monitored using exercise logs and the Physical Activity Scale for the Elderly (Washburn, Smith, Jette, & Janney, 1993). Assessments of pain were obtained using the WOMAC, as well as a VAS assessing self-rated pain at rest and during walking and stair-climbing tasks. Intention-to-treat analyses revealed that the combination treatment produced significantly greater improvements in the WOMAC pain subscale at 8 weeks (ES = 1.10). Participants in both the combination and NSAID-alone interventions also reported increased volume of weekly physical activity.

Baker et al. (2001) compared the effects of 4 months of high-intensity home-based progressive strength training with those of a nutrition-education intervention in 46 older adults. Strength training consisted of two functional exercises using body weight for resistance (squats and step-ups) and a series of five isotonic exercises using ankle weights for resistance. Participants performed two sets of 12 repetitions three times per week throughout the intervention. Perceived exertion was used to monitor exercise intensity during the intervention. Participants completed each exercise at a rating of light during the first month of the trial and progressed to completing the exercises at an intensity of hard for the remainder of the trial. Pain was assessed using the WOMAC. A total of 38 of the participants randomized into the study completed the trial. Adherence to the interventions, monitored with exercise and dietary logs kept by the patients and clinic staff, was reported as 84% during strength training and 65% in the nutrition intervention. Results of modified intention-to-treat analyses revealed that the exercise intervention produced significantly greater improvements in pain (38%) than did the nutrition intervention (10%).

Topp et al. (2002) compared changes in pain after dynamic and isometric strength-training interventions and a no-intervention control group in a sample of 102 older adults. Participants assigned to the exercise interventions completed 16 weeks of strength training using Therabands. Participants in the dynamic intervention performed traditional isotonic exercises, and participants in the isometric intervention used bands with resistance sufficient to prevent any movement or change in joint angle during the exercise. Pain was assessed with the WOMAC. Attrition and adherence during the strength-training interventions were not reported. Analysis revealed that improvements in pain were significantly greater after the dynamic (14%) and isometric (12%) strength-training interventions than for the control group (0%).

Taken collectively, the results of these trials suggest that strength-training interventions result in significant improvements in pain symptoms. There was, however, considerable variability in the magnitude of the changes in pain accompanying strength training relative to control interventions, with small (O’Reilly et al., 1999; Schilke et al., 1996; Thomas et al., 2002), moderate (VanBaar et al., 1998), and large (Petrella & Bartha, 2000) between-groups effect sizes reported. Improvements in pain symptoms relative to baseline values in the strength-
training interventions were also quite variable, ranging from 12% (Topp et al., 2002) to 38% (Baker et al., 2001).

Isokinetic (Maurer et al., 1999; Schilke et al., 1996), dynamic (O’Reilly et al., 1999; Rogind et al., 1998; Thomas et al., 2002; Topp et al., 2002; VanBaar et al., 1999), and isometric strength training (Topp et al.) all yielded favorable changes in pain symptoms. Again, the magnitude of the changes varied across mode. The average improvement reported across studies using dynamic exercise was 32%. In contrast, in the single studies reporting percentage improvement, isokinetic exercise (Maurer et al.) resulted in 65% improvement and isometric exercise yielded 32% improvement (Topp et al.).

Although strength training was associated with improvements in pain symptoms, knowledge of the volume and intensity of training necessary to stimulate such improvements remains limited. Intensity differences inherent to completing various modes of strength training used in the trials (i.e., isometric, dynamic, and isokinetic) make it difficult to adequately compare intensity across studies. In addition, when considering that only a limited number of studies explicitly stated the intensity of training used during the intervention, conclusions about the characteristics of strength-training interventions that optimize improvements in pain are premature at the present time. Given that no trials conducted to date have directly compared the effects of different intensities or volumes of strength training on changes in pain, further research examining the dose of strength training necessary to produce improvements in pain symptoms is warranted.

**Aerobic- and Strength-Training Interventions**

Five trials examined changes in pain after exercise interventions consisting of both aerobic- and strength-training components (Deyle et al., 2000; Fransen, Crosbie, & Edmonds, 2001; Hughes et al., 2004; Messier, Loeser, Miller, et al., 2004; Messier, Loeser, Mitchell, et al., 2000). Two trials comparing the effects of aerobic- and strength-training interventions are also summarized in this section of the review (Ettinger et al., 1997; Evcik & Sonel, 2002).

The Fitness and Arthritis in Seniors Trial (FAST), an 18-month, multicenter, single-blind study, compared the effects of aerobic exercise, resistance exercise, and a health-education-control intervention in 439 older adults with symptomatic knee OA (Ettinger et al., 1997). Aerobic training involved 1 hr of walking at 50–70% of heart-rate reserve three times per week. Strength training consisted of two sets of 12 repetitions of each of nine different upper and lower body exercises. Each exercise intervention involved 3 months of center-based training followed by a 15-month home-based training phase. Pain was assessed at baseline and at 6 and 18 months using the Knee Pain Scale (KPS; Rejeski et al., 1995). A total of 364 (84%) patients completed the trial, and participant retention did not differ among the three interventions. Intention-to-treat analyses revealed that both aerobic exercise ($ES = 0.47$) and strength training ($ES = 0.31$) produced significantly greater reductions in pain symptoms than did the health-education intervention. Follow-up analyses also revealed that participants demonstrating the best attendance at exercise sessions exhibited the greatest reductions in knee pain. Adherence progressively decreased across the trial, however, diminishing from 85% at 3 months to 70% at 9 months and 50% at 18 months.
Rejeski, Brawley, Ettinger, Morgan, and Thompson (1997) further examined the influence of exercise compliance on pain symptoms during FAST. Greater attendance at scheduled exercise sessions was linked with superior improvements in pain and physical function. Nonetheless, in contrast to the positive effects observed with greater exercise frequency, pain in participants spending the most time exercising per session (>40 min) did not differ significantly from the health-education intervention. These findings suggest that different measures of adherence (i.e., attendance vs. time spent exercising) demonstrate unique relationships with changes in pain experienced in response to exercise interventions.

Changes in pain during the FAST trial were also found to influence the effect of the exercise interventions on physical function and health status. Rejeski, Ettinger, Martin, and Morgan (1998) observed that improvements in mobility-related self-efficacy and knee pain mediated the effect of exercise therapy on improvement in stair-climb time. Changes in knee pain also mediated the effect of the physical activity interventions on perceived health status. Taken collectively, the findings of the FAST trial demonstrate that both aerobic and resistance exercise result in significant improvements in pain symptoms for older adults with knee OA. In addition, results from FAST underscore the importance of exercise compliance in pain improvements and suggest that changes in pain are salient determinants of the beneficial effect of physical activity on physical functioning.

Deyle and colleagues (2000) compared the effects of 4 weeks of manual physical therapy and supervised exercise with those of a placebo treatment among 83 older adults in a single-blind randomized trial. The manual physical therapy portion of the intervention involved joint movements, muscle stretching, and soft-tissue-mobilization techniques. The exercise portion of treatment consisted of stationary cycling, strength training, flexibility exercises, and manual physical therapy. The physical therapist delivering the supervised intervention tailored the intensity and duration of exercise to each participant’s individual tolerance level. Participants in the placebo treatment received a nontherapeutic ultrasound treatment. Treatment occurred twice per week for 4 weeks for both groups. Changes in pain were assessed 4 weeks, 8 weeks, and 1 year after each treatment, using the WOMAC. A total of 69 patients completed the 4- and 8-week postintervention assessments. The exercise intervention resulted in significant improvements in pain (52%), whereas pain remained unchanged after the placebo intervention (16%). Improvements in pain observed 8 weeks after the exercise intervention had deteriorated considerably at 1-year follow-up. It should also be recognized that, because patients undergoing surgery during the follow-up period were not permitted to participate in the 1-year posttreatment assessment, only 29 participants (69%) in the exercise intervention completed the follow-up assessment.

Fransen et al. (2001) examined changes in pain after 8 weeks of individualized physical therapy, group-based physical therapy, and a wait-list control condition among 126 older adults. The group-based intervention consisted of lower extremity strength training and stretching, as well as 20 min of aerobic training involving either walking or stationary cycling. Group-based therapy was conducted under the supervision of a physical therapist twice per week for 8 weeks and was supplemented with three bouts of home-based aerobic training per week. The characteristics of the individualized intervention were tailored to the specific needs of the patients based on the discretion of the physical therapist delivering the intervention. Pain
was assessed using the WOMAC, the SF-36, and a VAS. A total of 121 patients completed the 8-week trial, and 107 participated in a 16-week posttreatment follow-up assessment. Both interventions produced significantly greater improvements in pain (17%) than did usual care (2%). Changes in pain were not significantly different, however, between the individual and group-based interventions. Improvements in pain were also found to persist at the 16-week follow-up.

Evcik and Sonel (2002) compared 3 months of home-based exercise, supervised center-based exercise, and a usual-care intervention among 90 previously sedentary older adults. The center-based intervention was aerobic training that consisted of walking three times per week. The home-based strength-training intervention consisted of isometric and isotonic quadriceps resistance exercises performed twice per day. Pain was assessed before and after 3 months of each intervention using the WOMAC and a VAS. Although 81 participants completed the trial, adherence during the exercise interventions was not reported. Home-based (ES = 1.20) and center-based (ES = 1.13) interventions produced significantly greater improvements in pain as measured by the WOMAC than did the usual care. In addition, when compared with usual care, the home-based (ES = 2.75) and center-based (ES = 2.66) interventions also produced significantly greater improvements in pain as measured by the VAS. No significant differences in changes in pain were observed between the home-based strength-training and center-based aerobic-training interventions.

Hughes and colleagues examined the effects of a center-based exercise intervention in a sample of 150 older adults with lower extremity OA (Hughes et al., 2004). Assessments of pain were obtained at baseline and 2 and 6 months posttreatment using the WOMAC. Participants performed 1 hr of exercise three times per week during the 8-week intervention. Exercise consisted of 30 min of walking at 40–60% of heart-rate maximum. The strength-training component employed a floor-to-stand progression approach involving lower extremity and upper body resistance exercises performed with Therabands and cuff weights. After each exercise session, participants were provided with 30 min of psychoeducational training adapted from Kovar et al. (1992) designed to enhance their efficacy to adhere to the exercise program. Participants assigned to the control group were provided with arthritis self-care and educational materials. A total of 111 participants completed the 2-month posttreatment assessment, and participants attended an average of approximately 19 of 24 possible exercise sessions during the intervention. The exercise intervention produced a significantly greater improvement in the pain subscale of the WOMAC (ES = 0.42) at 6-month follow-up than did the control group.

Messier et al. (2000) contrasted the effects of 6 months of exercise alone and a combination of diet and exercise in 24 obese older adults. Pain was assessed using the KPS (Rejeski et al., 1995). Exercise was performed for 1 hr three times per week in both interventions. Exercise consisted of 20 min of walking at 50–75% of heart-rate reserve and 30 min of strength training involving one set of 10–12 repetitions of a total of seven resistance exercises targeting both the upper and lower body. Twenty-one participants completed the trial, and adherence during the exercise interventions ranged from 83% in the exercise-alone group to 95% in the combination intervention. Both interventions produced significant improvements in pain during ambulation and transfer at 6 months. Specifically, exercise alone resulted in 40% improvement in pain experienced during ambulation and 46% improvement in frequency of pain during transfer tasks, and the combination of
exercise and diet resulted in 15% improvement in ambulation and 38% improvement in change in transfer. The combination intervention resulted in significantly more favorable changes in weight loss, stair-climb performance, and selected measures of gait mechanics than did exercise alone. Thus, although the exercise-alone and exercise + diet interventions produced significant improvements in self-reported pain, the combination intervention resulted in greater improvements in body weight and mobility-related outcomes that are directly affected by body weight.

Messier et al. (2004) recently reported results from the Arthritis, Diet and Activity Promotion Trial (ADAPT). ADAPT was a single-blind, 18-month, randomized clinical trial comparing the effects of exercise alone, dietary weight loss alone, a combination of exercise and dietary weight loss, and a healthy-lifestyle control intervention on a variety of functional health outcomes in 316 overweight or obese older adults with knee OA. Participants randomized into the exercise-alone and exercise + dietary weight-loss interventions performed exercise three times per week. Exercise consisted of both aerobic and strength training. Aerobic training involved walking for 30 min at 50–75% of heart-rate reserve, and strength training consisted of two sets of 12 repetitions of four lower body resistance exercises. The initial 4-month phase of the intervention involved center-based exercise. For the remainder of the trial, participants could choose to continue center-based exercise or transition to home-based exercise. Participants interested in home-based exercise underwent a 2-month transition phase that alternated between center- and home-based exercise participation. Changes in pain symptoms were assessed at 6 and 18 months using the WOMAC. A total of 252 participants completed the trial, and adherence during the interventions ranged from 60% in exercise only to 64% in the exercise + dietary weight-loss intervention. Results revealed that the combination of exercise and dietary weight loss produced significantly greater improvement in pain relative to the healthy-lifestyle control group. Overall, participants randomized to the combination intervention experienced a 30% decrease in pain.

Changes in pain assessed with the SF-36 (Ware et al., 1997) pain subscale were also reported in an earlier publication focusing on the effects of the ADAPT interventions on health-related quality of life (Rejeski et al., 2002). Compliance with treatment was 75% in the healthy-lifestyle control, 72% in diet only, 60% in exercise only, and 64% in exercise + diet interventions. Results revealed that the exercise + diet intervention produced significantly greater improvements in the bodily-pain subscale of the SF-36 when compared with the healthy-lifestyle control group. Ancillary analyses conducted to examine potential mediators of the treatment effects on health-related quality of life indicated that changes in bodily pain and satisfaction with function were significant independent mediators of improvements in the physical-health composite scale of the SF-36.

Although changes in pain accompanying exercise training have been studied extensively, relatively little is known regarding the pain responses to single bouts of exercise in older adults with knee OA. Focht, Ewing, Gauvin, and Rejeski (2002) recently examined fluctuations in acute pain after single episodes of exercise in a subsample of 32 ADAPT participants. Using an ecological momentary-assessment approach, pain responses were obtained throughout the day for 1 week during the ADAPT trial. Hierarchical linear-modeling analyses demonstrated that pain reports obtained immediately after acute exercise were significantly higher than those obtained at a similar time on a nonexercise day. Pain reports obtained throughout
the remainder of the day after exercise, however, revealed that pain intensity did not differ from pain observed before exercise or pain reported at a similar time on a nonexercise day. Thus, the postexercise elevation was transient and dissipated rapidly after the cessation of activity. Analysis of daily affective responses also revealed that acute exercise resulted in significant elevation in fatigue (Focht, Gauvin, & Rejeski, 2004), but fatigue reports later in the day after exercise were not different from fatigue responses obtained at similar times of day on nonexercise days. Therefore, consistent with the pattern of change observed for pain responses, increases in fatigue after acute exercise do not appear to persist long after the cessation of activity.

In summary, exercise interventions involving both aerobic- and strength-training components resulted in significant reductions in pain symptoms, with improvements ranging from 17% to 46%. Trials comparing aerobic- and strength-training interventions also demonstrated that both types of exercise interventions yielded significant improvements in pain when compared with control interventions, with between-groups effect sizes ranging from small (Ettinger et al., 1997) to large (Evcik & Sonel, 2002). Results from two trials (Messier et al., 2000, 2004) also demonstrate that both exercise alone and exercise in combination with dietary weight loss improve pain in overweight or obese older adults, with significant within-group improvements in pain symptoms ranging from 15% to 46%.

Summary and Discussion

Findings from the randomized controlled trials summarized in the present review suggest that exercise interventions consistently result in improvements in pain symptoms among older adults with knee OA. Aerobic training, strength training, and interventions combining both forms of exercise all were found to improve pain symptoms. Although these findings support the value of exercise as an effective behavioral pain-management intervention, it is important to acknowledge that the effect sizes accompanying the improvements in pain varied considerably across studies. Significant differences in pain between exercise and control interventions were accompanied by between-groups effect sizes that ranged from small ($ES = 0.25$) to large ($ES = 2.75$). Although the reasons for the inconsistency in effect sizes are not clear at the present time, it is likely that this variability partially results from the use of different measures of pain symptoms across trials (Baker & McAlindon, 2000). Despite the considerable variability in the magnitude of the changes, collectively these findings do suggest that exercise interventions result in meaningful reductions in pain symptoms among older adults with knee OA.

In the recently published MOVE consensus statement addressing evidence-based recommendations for exercise in the management of OA (Roddy et al., 2005), it was concluded that a number of basic questions regarding the delivery of exercise interventions to OA patients remain unanswered. The present review of randomized controlled exercise trials allows for further evaluation of some of these important questions. For example, one of the most pressing questions concerns what type of exercise is most effective for reducing pain symptoms in older adults with knee OA. The results of the trials included in the present review suggest that aerobic training, strength training, and interventions combining the two result in improve-
ments in pain symptoms and, thus, are important components of the treatment of knee OA. Accordingly, both are warranted for inclusion in exercise interventions targeting older adults with knee OA. Indeed, as Minor (2004) aptly concluded in a recent review of the effects of physical activity on OA outcomes, “We are not really asking: Do we do strengthening exercises or do we do aerobic exercise? We must talk about how to do both, because both are important to overall health” (p. 81). Also, recent findings from the ADAPT trial demonstrate that integrating dietary weight loss with an exercise intervention involving both aerobic and strength training produced more favorable changes in a number of disablement-process outcomes among overweight and obese older adults with knee OA (Messier et al., 2004). In light of these promising results, further research exploring the benefits of multicomponent lifestyle interventions is needed.

Another important question pertaining to the delivery of exercise interventions is the comparable efficacy of center-based and home-based exercise programs. Results of population-based surveys demonstrate that older men and women prefer exercise programs that can be completed independently but still offer some level of instruction (Wilcox, King, Brassington, & Ahn, 1999). Between-groups effect sizes for home-based exercise interventions ranged from small (O’Reilly et al., 1999; Thomas et al., 2002) to large (Petrella & Bartha, 2000). Similarly, small (Schilke et al., 1996), moderate (VanBaar et al., 1998), and large (Evcik & Sonel, 2002) effect sizes were observed for center-based exercise. In one trial directly comparing home-based and center-based exercise, both were found to result in large improvements in pain symptoms (Evcik & Sonel). Although home- and center-based exercise resulted in significant improvements in pain symptoms, the cost and time required for center-based exercise and cited preference for independent exercise among older adults make home-based programs a desirable approach to exercise therapy for knee OA. Nonetheless, simply advising older knee-OA patients to exercise at home without some form of structured training or education is unlikely to improve participation rates or treatment efficacy (Minor, 2004). Studies incorporating a transition from supervised or center-based to home-based exercise demonstrated significant improvements in pain (Ettinger et al., 1997; Messier et al., 2004). This approach to exercise therapy might represent a promising strategy for integrating the education and support of benefits of structured training with the cost-effectiveness of home-based exercise. Future trials examining effective ways to promote the successful transition from supervised, center-based exercise to independent, home-based training are needed.

Although the present review focused on the effects of exercise interventions on pain, changes in functional limitations and self-reported disability are frequently the primary outcome of exercise trials. Therefore, it is important to acknowledge that the influence of exercise interventions on pain can differ markedly from the effects on other relevant disablement-process outcomes (Keysor, 2003). Several trials reporting estimates of between-groups effect sizes documented differential intervention effects on pain and physical function. The direction of these differences was mixed, however, with some trials reporting greater improvements in physical function (Kovar et al., 1992; Messier et al., 2004; Schilke et al., 1996), some trials demonstrating larger changes in pain (O’Reilly et al., 2000), and others reporting changes that were similar in magnitude (Deyle et al., 2000; Ettinger et al., 1997). Again, the use of different indices to assess pain and physical function
most likely contributes to these differences. Nonetheless, the inconsistency also
demonstrates that the mechanisms through which exercise interventions improve
pain and physical function, or how changes in relevant disablement-process out-
comes might influence each other, have yet to be adequately delineated (Baker & McAlindon, 2000; Minor, 2004). It should be acknowledged, however, that
individual differences in disease status, initial pain level, and capacity to cope
with pain are also likely determinants of responsiveness to exercise interventions,
and further exploration of the extent to which such individual differences might
explain variability in changes in pain symptoms accompanying exercise for knee-
OA patients is necessary.

In addressing the differential responsiveness to exercise across different disable-
ment-process outcomes, Jette and Keysor (2003) recommended that future trials
examining the efficacy of exercise in the treatment of knee OA use established
models of disability to guide the design of the intervention and selection of out-
come measures. In this regard, it is interesting to note that the results of randomized
teach trials in older adults demonstrate that improvements in various
disablement-process outcomes, such as pain symptoms and physical function, should
not be expected to follow a common time course (Rejeski, Brawley, & Shumaker,
1996). Few exercise–OA trials directly examined the relationship between changes
in impairments in strength or aerobic capacity and improvements in pain symptoms.
Therefore, the temporal sequence of change in these outcomes and relationship
between improvements in disease-related impairments and pain symptoms accom-
panying exercise interventions warrant further exploration in future OA trials.

**Methodological Considerations**

Despite the promising results of the exercise trials summarized in the present review,
a number of methodological concerns have yet to be adequately addressed in the
exercise–OA literature. For example, although previous reviews have underscored
the issue of small sample sizes (Baker & McAlindon, 2000; Petrella, 2000; Van-
Baar et al., 1999), most trials lack adequate statistical power to detect meaning-
ful between-groups differences. It should be noted that some recent trials have
employed large sample sizes (Messier et al., 2004; Thomas et al., 2002), and this
trend should continue in future exercise-intervention research. Another important
limitation is that participants randomized into exercise interventions frequently
received more contact during treatment than those in control or comparison groups.
In addition, only a limited number of trials specifically stated that investigators
conducting outcome assessments were blinded to the participants' treatment-group
assignment. Because of these concerns, the potentially confounding influence of
behavioral artifacts cannot be discounted. These limitations threaten the internal
validity of several studies and underscore the need for more rigorous methodology
in future exercise-intervention research.

The number of participants who completed the trial was provided in each of
the trials, but data on adherence were only reported in a limited number of trials.
Several trials attempting to quantify adherence or total volume of physical activity
participation employed nonvalidated measures of physical activity. In addition,
few studies conducted intention-to-treat or dose–response analyses. Adherence is
integral to the effectiveness of physical activity interventions, and it is essential that
future investigations employ psychometrically sound measures of physical activity participation and more sophisticated analytical strategies in an attempt to delineate the role of adherence in treatment efficacy. Therefore, although the available evidence supports the beneficial effects of exercise interventions on pain, a number of methodological limitations detract from the validity of these findings. It is critical that these issues be addressed in the design of future intervention studies.

**Dose–Response Effects on Pain**

There is a paucity of data regarding the dose of exercise that most effectively improves pain symptoms. Few studies have directly examined the effects of different intensities of exercise on pain symptoms. Accordingly, progress toward defining the minimal dose of exercise necessary to produce improvements in pain remains limited. Based on the findings of previous reviews (Baker & McAlindon, 2000; VanBaar et al., 1999), however, some researchers have concluded that higher doses of exercise are most effective for knee-OA patients (Minor, 2004). Nevertheless, results from the FAST trial suggest that this conclusion should be interpreted cautiously with regard to pain outcomes. For example, pain symptoms of participants in FAST accruing more than 40 min of exercise per session were not different from pain reported by patients randomized into the healthy-lifestyle control group (Rejeski et al., 1997). Conversely, participants completing more moderate doses of exercise per session (approximately 30 min) demonstrated significantly more favorable changes in pain symptoms relative to the control group. These findings underscore the fact that the stimulus properties of exercise are important determinants of improvements in pain symptoms. It is equally important, however, to recognize that it is unlikely that any single exercise prescription will prove to be an optimal stimulus for pain reduction in all knee-OA patients. Attempts to identify the most appropriate dose of exercise to produce optimal changes in disablement-process outcomes reflect a passive stimulus–response paradigm that assumes all participants will respond identically to the same exercise stimulus. Participants’ tolerance for and responses to a given dose of exercise are shaped by their interpretation of the activity prescription (Rejeski & Focht, 2002). Therefore, flexible approaches to prescription that attempt to tailor the stimulus properties of the intervention to the individual’s needs should be viewed as important considerations in effective exercise programming in the treatment of older adults with knee OA.

**Challenges to Enhancing Long-Term Efficacy of Exercise Interventions**

Exercise undoubtedly represents a promising behavioral intervention for seniors burdened with knee OA. Twelve of the 18 trials in the present review, however, examined short-term exercise interventions less than 6 months in duration. Few short-term interventions evaluated postintervention maintenance of treatment effects, and those incorporating follow-up assessments often failed to directly assess the intervening processes or behaviors that affected pain symptoms in the interim. Furthermore, trials including follow-up assessments indicate that the significant improvements in pain symptoms dissipate considerably over time (Deyle et al., 2000; Kovar et al., 1992; O’Reilly et al., 1999; Sullivan et al., 1998; VanBaar et
Mounting evidence suggests that the deterioration of pain-relief benefits might be directly related to adherence (Deyle et al., 1997; Ettinger et al., 1997; Kovar et al., 1992; O’Reilly et al., 1999; Rejeski et al., 1997; Sullivan et al., 1998). Indeed, in discussing the potential implications of declining adherence observed during the FAST trial, Ettinger and colleagues suggest, “Long-term compliance may be more important than the type of exercise performed in achieving health benefits in older disabled people. For exercise to be of long-lasting benefit, it probably needs to be continued indefinitely” (p. 30). Unfortunately, exercise interventions for older adults with knee OA are often designed and implemented without targeting the processes underlying exercise-behavior change (Brawley et al., 2003), leaving many participants inadequately prepared to maintain independent, long-term exercise participation. Consistent with this position, recent evidence reveals that integrating training and practice in activity-related self-regulatory skills into exercise interventions and systematically transitioning from supervised center-based exercise to independent home-based exercise enhanced long-term adherence among a sample of older adults with or at high risk for cardiovascular disease (Rejeski et al., 2003). Given the persisting problem of noncompliance, the efficacy of this approach to exercise interventions among older adults with knee OA warrants future investigation.

In summary, results of the trials summarized in the present review support the position that exercise interventions produce significant improvements in pain symptoms among older adults with knee OA. Aerobic training, strength training, and combination interventions all resulted in significant improvements in pain symptoms. Exercise has been shown to be a safe, effective intervention that results in pain relief and beneficial changes in a variety of other relevant disablement-process outcomes. Nonetheless, a number of salient issues warrant attention in future exercise-intervention trials. For example, the mechanisms through which exercise influences pain symptoms are still unclear, and knowledge of the individual differences that might influence patients’ responsiveness to the exercise intervention remains limited. The relationship between changes in pain and other disability-related outcomes also has yet to be adequately defined. Finally, trials examining novel ways to promote long-term maintenance of exercise participation are needed. Further exploration of these problems in future exercise trials will help advance knowledge of how to more effectively integrate exercise interventions in the treatment of older adults burdened with knee OA.

References


