

# Meta-Analysis: Exercise Therapy for Nonspecific Low Back Pain

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**Background:** Exercise therapy is widely used as an intervention in low back pain.

**Objective:** To evaluate the effectiveness of exercise therapy in adult nonspecific acute, subacute, and chronic low back pain versus no treatment and other conservative treatments.

**Data Sources:** MEDLINE, EMBASE, PsychInfo, CINAHL, and Cochrane Library databases to October 2004; citation searches and bibliographic reviews of previous systematic reviews.

**Study Selection:** Randomized, controlled trials evaluating exercise therapy for adult nonspecific low back pain and measuring pain, function, return to work or absenteeism, and global improvement outcomes.

**Data Extraction:** Two reviewers independently selected studies and extracted data on study characteristics, quality, and outcomes at short-, intermediate-, and long-term follow-up.

**Data Synthesis:** 61 randomized, controlled trials (6390 participants) met inclusion criteria: acute (11 trials), subacute (6 trials), and chronic (43 trials) low back pain (1 trial was unclear). Evidence suggests that exercise therapy is effective in chronic back pain relative to comparisons at all follow-up periods. Pooled mean improvement (of 100 points) was 7.3 points (95% CI, 3.7 to 10.9 points) for pain and 2.5 points (CI, 1.0 to 3.9 points) for function

at earliest follow-up. In studies investigating patients (people seeking care for back pain), mean improvement was 13.3 points (CI, 5.5 to 21.1 points) for pain and 6.9 points (CI, 2.2 to 11.7 points) for function, compared with studies where some participants had been recruited from a general population (for example, with advertisements). Some evidence suggests effectiveness of a graded-activity exercise program in subacute low back pain in occupational settings, although the evidence for other types of exercise therapy in other populations is inconsistent. In acute low back pain, exercise therapy and other programs were equally effective (pain, 0.03 point [CI, -1.3 to 1.4 points]).

**Limitations:** Limitations of the literature, including low-quality studies with heterogeneous outcome measures inconsistent and poor reporting, and possibility of publication bias.

**Conclusions:** Exercise therapy seems to be slightly effective at decreasing pain and improving function in adults with chronic low back pain, particularly in health care populations. In subacute low back pain populations, some evidence suggests that a graded-activity program improves absenteeism outcomes, although evidence for other types of exercise is unclear. In acute low back pain populations, exercise therapy is as effective as either no treatment or other conservative treatments.

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Low back pain is one of the leading causes of disability. Exercise therapy is a management strategy that is widely used in low back pain. It encompasses a heterogeneous group of interventions ranging from general physical fitness or aerobic exercise to muscle-strengthening and various types of flexibility and stretching exercises.

In 2000, van Tulder and colleagues (1) published a Cochrane review of the literature assessing the effectiveness of exercise therapy for low back pain for pain intensity, functional status, overall improvement, and return to work. They included 39 randomized, controlled trials of all types of exercise therapy for individuals with acute and chronic nonspecific low back pain. They synthesized the evidence by using a levels-of-evidence approach because of the heterogeneity and insufficiency of the literature and concluded that the evidence did not support effectiveness of exercises for acute low back pain but that exercises may be helpful for chronic low back pain. Since the completion of van Tulder and colleagues' systematic review, several new trials have been published. Recent reviews on related topics have been restricted by population (2–4) or type of exercise therapy (5) and have used only qualitative methods of synthesis (2, 3, 5, 6). Recent clinical guidelines that included exercise therapy for low back pain used quantitative methods to synthesize results of randomized, controlled trials; controlled trials; and observational studies (7); however, only 12 studies overlap with the 61 trials

included in our review. An updated review on this topic is needed. Cautious use of quantitative meta-analysis for direct and indirect comparisons in appropriate subgroups will be informative to synthesize this literature.

We aimed to assess the effectiveness of exercise therapy for reducing pain and disability in adults with nonspecific acute, subacute, and chronic low back pain compared with no treatment (including placebo and sham treatment) and other conservative treatments.

## METHODS

We searched the electronic databases MEDLINE and EMBASE (up to October 2004), PsychInfo and CINAHL (1999 to October 2004), and the Cochrane Central Reg-

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**Context**

Many experts recommend exercise therapy for nonspecific low back pain.

**Contribution**

This meta-analysis summarizes data from 61 randomized, controlled trials that compared exercise therapy with placebo, no treatment, conservative management, or another exercise group. Exercise therapy decreased pain and improved physical function by modest amounts in adults with chronic low back pain. In adults with acute low back pain, exercise therapy, conservative management, and no treatment had similar effects on pain.

**Cautions**

Trials used various measures to assess pain and function, and many were small and of low quality.

—The Editors

ister of Controlled Trials (Issue 3, 2004). We conducted citation searches, screened cited references of exercise reviews, and contacted content experts for additional trials. We did not restrict the searches or inclusion criteria to any specific language. The complete search strategy is available on request.

We included published reports of completed randomized, controlled trials that included adults with acute (<6 weeks), subacute (6 to 12 weeks), or chronic (>12 weeks) nonspecific low back pain. We excluded studies that involved individuals with low back pain caused by specific pathologies or conditions. Exercise therapy was defined as “a series of specific movements with the aim of training or developing the body by a routine practice or as physical training to promote good physical health” (6). We included studies that compared exercise therapy with no treatment or placebo treatment, other conservative therapy, or another exercise group.

Outcomes of interest were self-reported pain intensity, condition-specific physical functioning and global improvement, and return to work or absenteeism. We abstracted outcome assessment data for 3 time periods: short-term (post-treatment assessment closest to 6 weeks after randomization but not longer than 12 weeks), intermediate (6 months), and long-term ( $\geq 12$  months) follow-up.

We followed a standard protocol for study selection and data abstraction (8). Two reviewers independently assessed study eligibility, data extraction, trial quality, and clinical relevance. We used consensus and a third reviewer, if necessary, to resolve disagreements. We extracted population characteristics (patient population source or setting, study inclusion criteria, duration of low back pain episode, and age of patients), intervention characteristics (description and types of exercise therapy, duration and number of treatment sessions, intervention delivery type, and co-inter-

ventions), outcome data, and overall conclusions about the effectiveness of the exercises onto pretested standardized forms. Assessment of quality included appropriate randomization, adequate concealment of treatment allocation, adequacy of follow-up, and outcome assessment blinding (9). We defined high-quality studies as those that met all key quality criteria. We assessed clinical relevance of each trial with 4 items: participants described in detail to assess clinical comparability, interventions and treatment settings adequately described to allow repetition, clinically relevant outcomes measured and reported, and probability that treatment benefits are worth potential harms. Reviewers were not blinded to authors, institution, or journal of publication because of feasibility and because they were familiar with most of the literature. We contacted authors of published trials to clarify or provide additional information if the study provided insufficient information.

**Statistical Analysis**

We discussed the analyses of study results with clinical content experts. We synthesized the earliest outcomes provided for acute, subacute, and chronic low back pain, comparing exercise with no treatment and with other conservative treatment and overall for short-, intermediate-, and long-term follow-up periods. Because of important gaps in the reporting of return-to-work or absenteeism data and global assessment, quantitative analyses were only possible for pain and functioning outcomes. In the low back pain literature, studies used several outcome measures to assess the constructs of pain intensity (for example, a 10-mm or 100-mm visual analogue scale [VAS] or 0- to 10-point numerical rating scale) (see recent review by von Korf and colleagues [10]) and condition-specific functioning (for example, the 24-point Roland Morris Disability Questionnaire or the 100-point Oswestry Disability Index) (see recent review by Kopec [11]). There are moderate to high correlations between the different measures of the 2 constructs. In our review, we rescaled individual trial outcomes for pain and functioning to 0 to 100 points. For example, we rescaled a VAS pain score ( $\pm$ SD) of 5.1 points  $\pm$  2.3 points out of 10 points to 51 points  $\pm$  23 points out of 100 points, where positive mean effect sizes indicated improvement (that is, decreased pain and decreased functional limitations). Rescaling is common (11), and it facilitates comparison and interpretability of the syntheses. On the basis of current literature on minimal clinically important differences, we considered a 20-point (of 100 points) improvement in pain (12) and 10-point (of 100 points) improvement in functioning outcomes (13) to be clinically important. We considered differences to be statistically significant at the 5% level. We assessed the adequacy of sample size to detect these differences in each trial by assuming a power of 90%.

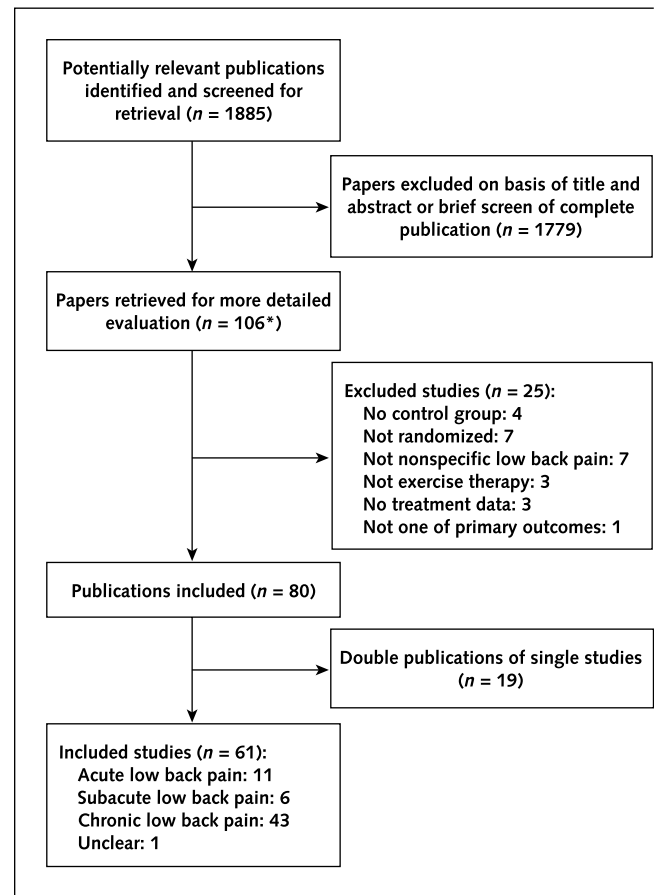
To be consistent with the previous review and to allow for more thorough use of available data, we used both a qualitative rating system and quantitative meta-analyses.

We conducted the latter by pooling weighted mean differences with random-effects models and data from at least 3 studies (14). We included exercise treatment groups from included trials in the syntheses if they had an independent no-treatment or other-conservative-treatment comparison group. This requirement appropriately meant that we excluded studies with no comparison group (that is, trials that contrasted several exercise therapy groups only) and we did not double-count comparison groups in the meta-analyses. This latter criterion is necessary to avoid correlation in effect sizes resulting from the use of repeated comparison data. We extracted data on means or median follow-up outcomes for study groups. To maximize the available data, we imputed missing variance scores by using the mean variance from studies with similar duration. We conducted sensitivity analyses to assess the effect of excluding studies that reported median values and did not adequately present variance scores. We assessed statistical heterogeneity by using  $I^2$  statistics and 95% CIs (15). We evaluated publication bias with the Egger test and funnel plots (16).

We based qualitative assessment of results on primary outcome measures and considered the methodologic quality and the reviewers' overall conclusions for each exercise therapy group. We included exercise therapy groups in the qualitative synthesis if the trial included a no-treatment or other-conservative-treatment comparison group. Two reviewers independently rated the findings for each exercise therapy group. We considered studies to provide evidence of effectiveness if statistically significant improvement was observed in at least 1 key outcome in favor of the exercise group and clinically important improvement was observed within or between groups. We considered studies to provide evidence that the exercise therapy was ineffective if the comparison group statistically significantly improved and the exercise group did not statistically significantly improve. We rated studies as neutral if results were not statistically and clinically significant and as unclear if data were insufficient. We used a consensus process to examine patterns in trial results. Levels of evidence were strong (consistent findings in several high-quality trials), moderate (consistent findings in several low-quality trials or 1 high-quality trial), limited (1 low-quality trial), conflicting (inconsistent findings in several trials), or none (no randomized trials available). We defined consistent findings as 75% or more trials (66% in sensitivity analysis) showing similar results.

Further analyses explored heterogeneity due to study-level variables, such as population source and study quality. We characterized the population sources as health care (primary, secondary, or tertiary care centers), occupational (patients presenting to occupational health care facilities or personnel in compensatory situations), or from a general or mixed population (for example, including individuals recruited by newspaper advertisements) to differentiate the studies with patients in typical treatment settings (health

Figure 1. Flow diagram of systematic review inclusion or exclusion.



care and occupational) from those including individuals with low back pain who may not normally present for treatment. We compared outcomes for subgroups of studies conducted in these populations (17). We assessed the effect of study quality on effect sizes by using subgroup analysis.

We used SAS for Windows, version 8.0 (SAS Institute, Inc., Cary, North Carolina) (for descriptive); Stata, version 8.0 (Stata Corp., College Station, Texas) (for publication bias); and Review Manager 4.2 (Cochrane Collaboration, Oxford, United Kingdom) for analyses.

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## RESULTS

### Study Characteristics

Figure 1 shows details of included and excluded studies. In van Tulder and colleagues' review (1), which as-

Table. Description of the Included Studies\*

Characteristic	All Studies (n = 61)	Acute (n = 11)	Subacute (n = 6)†	Chronic (n = 43)‡
Population source, n (%)				
Health care	33 (54)	7 (78)	3 (50)	22 (51)
Occupational	12 (20)	2 (22)	3 (50)	7 (16)
General population	7 (11)	0	0	7 (16)
Mixed	7 (11)	0	0	7 (16)
Mean age (95% CI), y	41 (39–42)	38 (35–40)	38 (32–44)	42 (40–44)
Men (95% CI), %	0.49 (0.45–0.55)	0.56 (0.46–0.66)	0.63 (0.42–0.84)	0.46 (0.39–0.52)
Mean observed duration of low back pain (95% CI)	4.5 y (2.6–6.3 y)	8 d (5–11 d)	12 wk	5.6 y (3.4–7.8 y)
Mean observed severity of pain at baseline (95% CI)‡	47 (43–51)	45 (36–53)	56 (33–78)	46 (41–50)
Outcome measures assessed, n (%)				
Pain	52 (85)	10 (91)	6 (100)	36 (84)
Functional abilities	46 (75)	9 (82)	4 (67)	33 (77)
Work status	21 (34)	5 (45)	6 (100)	9 (21)
Global assessment	13 (21)	3 (27)	1 (17)	7 (16)
Cost evaluation information presented, n (%)	8 (13)	2 (18)	2 (33)	4 (9)
Adverse effects assessed, n (%)				
Any reported	14 (23)	2 (18)	2 (33)	10 (23)
Negative reported	10 (16)	2 (18)	1 (17)	7 (16)
Study quality (criteria met), n (%)				
All 4	8 (13)	1 (9)	1 (17)	6 (14)
Any 3	18 (30)	4 (36)	3 (50)	10 (23)
Any 2	15 (25)	2 (18)	2 (33)	11 (26)
Any 1	15 (25)	3 (27)	0	12 (28)
None	5 (8)	1 (9)	0	4 (9)

\* Discrepancies between sum and denominator reflect missing information.

† Study samples were classified according to most appropriate category on the basis of inclusion criteria and reported duration. Thirteen studies included patients with mixed duration of low back pain.

‡ Based on 100-point scale.

sessed 10 quality items, including the 4 key items investigated in our review, the reviewers disagreed on 122 of the 351 quality assessment scores (35%). Disagreements were resolved by consensus in most cases, and a third reviewer only had to make a final decision twice. In the new trials included in our current review, the reviewers disagreed on 19 of the 124 key item scores (15%), resulting in a  $\kappa$  score of 0.76 (95% CI, 0.67 to 0.86), indicating high agreement. For our review, we resolved disagreements by consensus in all but 2 cases, when we needed a third reviewer to reach a decision.

The Table contains the descriptive summary and characteristics of the 61 studies included (18–95), and Appendix Table 1 (available at [www.annals.org](http://www.annals.org)) presents a complete description of these studies. Only 8 studies scored “positive” on all key validity criteria (18–31). On the basis of information in the published report, we initially rated 37 (15%) of the key quality items assessed as unclear (the most common item with insufficient description was “adequate concealment of treatment allocation”). Contacting the authors of the trials supplemented this information, modifying 14% of the criteria for which responses were received. Assessment of clinical relevance found that many

of the trial publications supplied inadequate information. Ninety percent of studies adequately described the study population, but only 54% adequately described the exercise intervention. Seventy percent of the trials adequately reported relevant outcomes. Few studies reported on adverse events (16 studies [26%]). Twelve studies reported mild negative reactions to the exercise program, such as increased low back pain and muscle soreness, in some patients. We could not assess the treatment benefit-to-harm ratio because of limitations of reporting. Appendix Table 2 (available at [www.annals.org](http://www.annals.org)) presents the pain and function outcomes for each trial. The VAS score (out of 100 points) was the most common outcome measure used to assess pain across studies (22 studies), and 83% of studies reporting pain used a VAS score of 100 points, a VAS score of 10 points, a numerical rating scale score of 100 points, or a numerical rating scale score of 10 points. Other pain outcome measures included the McGill pain questionnaire (4 studies), a 5- or 9-point Likert pain scale (1 study), the Aberdeen pain scale (1 study), and the West Haven Yale questionnaire (1 study). The most common functional limitation outcome measures, used in 59% of trials, were the Oswestry Disability Index (15 studies) and the Roland

Morris disability questionnaire (12 studies). Other functional measures included VAS function scale (4 studies), activities of daily living scale (3 studies), sickness impact profile (2 studies), Quebec disability index (2 studies), Manniche low back rating scale (2 studies), and 5 additional scales that were each used in single trials. The mean follow-up times for the short-, intermediate-, and long-term follow-up periods were 6.3 weeks (CI, 5.3 to 7.3 weeks), 21.0 weeks (CI, 18.4 to 23.6 weeks), and 53.6 weeks (CI, 48.7 to 58.6 weeks), respectively.

## Effectiveness

### Acute Low Back Pain Populations

Ten of 11 trials involving 1192 adults with acute low back pain had nonexercise comparisons. These trials provided conflicting evidence: 1 high-quality trial conducted in an occupational setting found mobilizing home exercises to be less effective than usual care (25), and 1 low-quality trial conducted in a health care setting found that a therapist-delivered endurance program improved short-term functioning more than no treatment (62). Of the remaining 8 low-quality trials, 6 trials found no statistically significant or clinically important differences between exercise therapy and usual care or no treatment and the results of 2 trials were unclear. We most commonly rated these trials as low-quality because of inadequate assessor blinding. One trial (80) had inadequate power to detect clinically important differences in pain, and 5 trials (68, 76, 80, 81, 95) had inadequate power to detect clinically important differences in functioning.

The pooled analysis of trials with adequate numerical data did not show a difference in short-term pain relief between exercise therapy and no treatment (3 trials), with an effect of  $-0.59$  point (CI,  $-12.69$  to  $11.51$  points) out of 100 points. There was no difference at earliest follow-up in pain relief with exercise therapy when compared with other conservative treatments (7 trials) ( $0.31$  point [CI,  $-0.10$  to  $0.72$  point]) (compared with all comparisons [10 trials],  $0.03$  point [CI,  $-1.34$  to  $1.40$  points]). Similarly, exercise therapy did not have a statistically significant positive effect on functional outcomes. Outcomes show similar trends at the 3 follow-up periods in this population (Figure 2).

### Subacute Low Back Pain Populations

In 6 studies involving 881 individuals with subacute low back pain, 7 exercise groups had nonexercise comparisons. One high-quality and 1 low-quality trial found reduced absenteeism outcomes with a graded-activity intervention in the workplace compared with usual care (22, 90). This provides moderate evidence of effectiveness of a graded-activity exercise program in subacute low back pain in occupational settings. One low-quality trial found improved functioning over usual care with an exercise program combined with behavioral therapy (47). We rated 2 trials with inadequate assessor blinding as neutral, although

they were adequately powered to detect clinically important differences in at least 1 primary outcome (35, 91). The results of 1 trial were unclear (64). The evidence is conflicting about the effectiveness of other types of exercise therapy in subacute low back pain compared with other treatments.

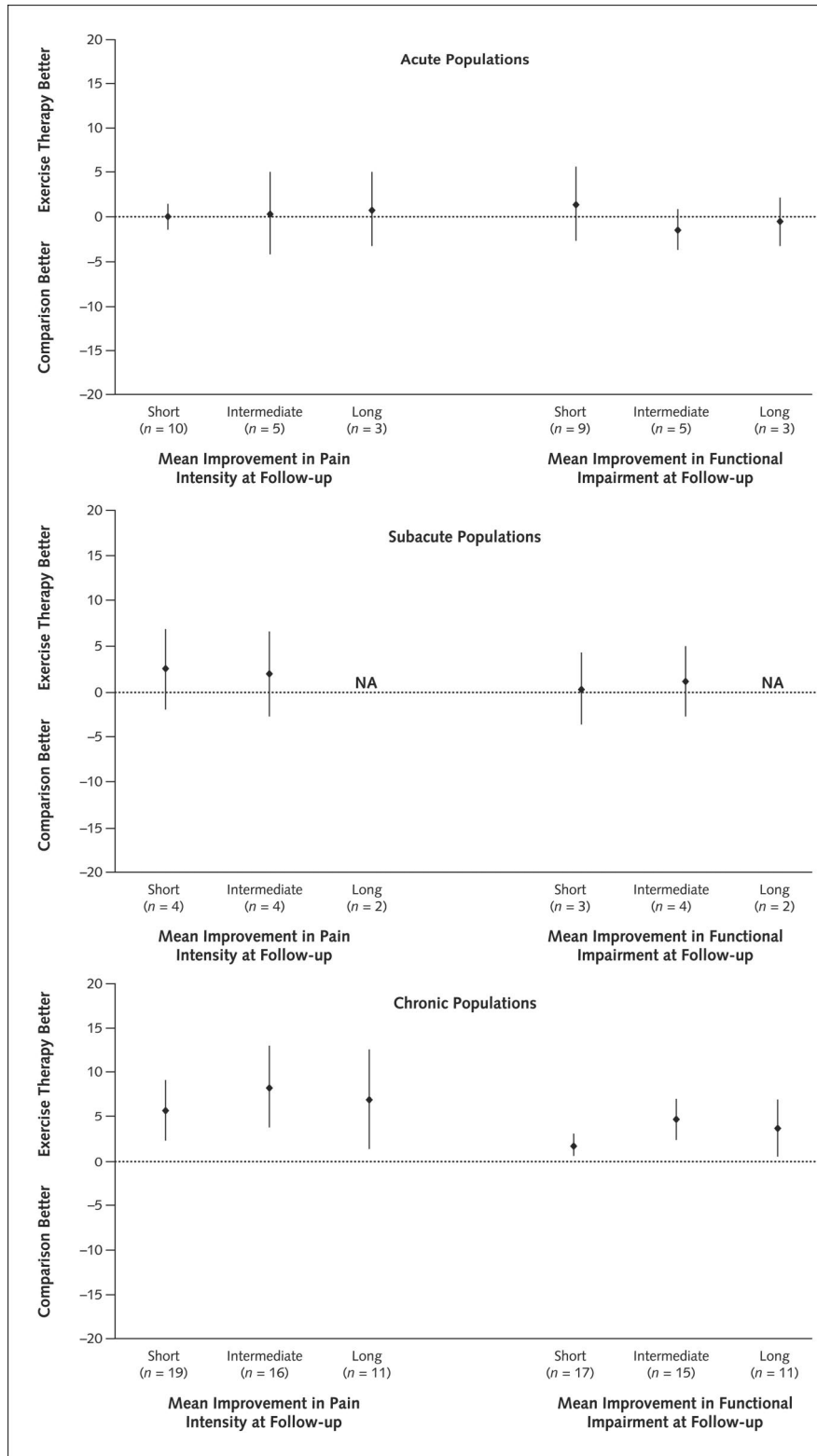
Meta-analysis of pain outcomes at the earliest follow-up, including 5 studies with available data, resulted in a pooled weighted mean difference in pain score of 1.89 points (CI,  $-1.13$  to  $4.91$  points) relative to any comparison. The pooled analysis of 4 trials presenting data on functional outcomes found a mean difference of 1.07 points (CI,  $-3.18$  to  $5.32$  points) relative to other comparisons. Evidence is insufficient to support or refute the effectiveness of exercise therapy in subacute low back pain for reducing pain intensity and improving function. Figure 2 shows the results for short- and intermediate-term follow-up periods in the subacute low back pain population.

### Chronic Low Back Pain Populations

In 43 trials including 3907 individuals with chronic low back pain, 33 exercise groups had nonexercise comparisons. These trials provide strong evidence that exercise therapy is at least as effective as other conservative interventions and conflicting evidence that exercise therapy is more effective than other treatments for chronic low back pain. Two exercise groups in high-quality studies and 9 groups in low-quality studies found that exercise was more effective than comparison treatments. These studies, mostly conducted in health care settings, commonly used exercise programs that were individually designed and delivered (as opposed to independent home exercises) (19, 43, 48, 57, 75, 88). The exercise programs commonly included strengthening or trunk-stabilizing exercises (19, 44, 48, 50, 75, 88). Conservative care was often added to exercise therapy, including behavioral and manual therapy, advice to stay active, and education. One low-quality trial found that a group-delivered aerobics and strengthening exercise program resulted in less improvement in pain and function outcomes than behavioral therapy (57). Of the remaining trials, 14 (2 high-quality and 12 low-quality) found no statistically significant or clinically important differences between exercise therapy and other conservative treatments. Four of these trials were inadequately powered to detect clinically important differences on at least 1 outcome (56, 82, 89, 92). We commonly rated trials as low-quality because of inadequate assessor blinding.

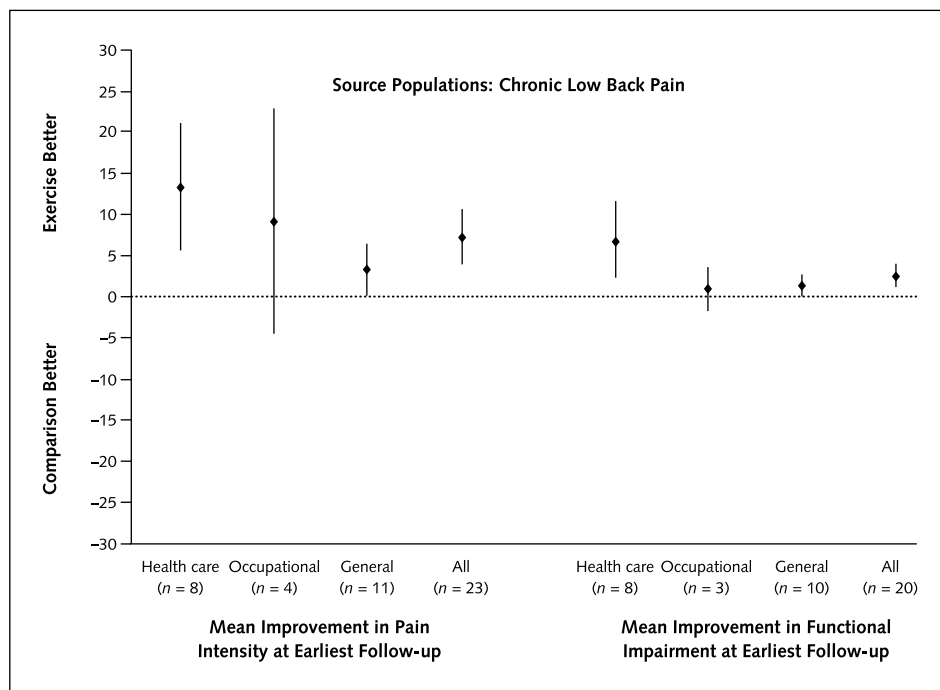
Meta-analysis of pain outcomes at the earliest follow-up included 23 exercise groups with an independent comparison and adequate data. Synthesis resulted in a pooled weighted mean improvement of 10.2 points (CI, 1.31 to 19.09 points) for exercise therapy compared with no treatment and 5.93 points (CI, 2.21 to 9.65 points) for exercise therapy compared with other conservative treatment (compared with all comparisons, 7.29 points [CI,

Figure 2. Results of meta-analyses of exercise versus any comparison for acute (top), subacute (middle), and chronic low back pain populations (bottom) and pain and function outcomes at short-, intermediate-, and long-term follow-ups.



Results shown are mean change on a 100-point scale (lines are 95% CIs). Clinically important improvement is considered to be 20 of 100 points for pain intensity and 10 of 100 points for functional impairment.

Figure 3. Meta-analyses for population source subgroups in chronic low back pain populations: health care, occupational, and general or mixed populations at earliest follow-up.



Results shown are mean change on a 100-point scale (lines are 95% CIs). Clinically important improvement is considered to be 20 of 100 points for pain intensity and 10 of 100 points for functional impairment.

3.67 to 10.91 points]). At the earliest follow-up, smaller improvements occurred in functional outcomes with an observed mean positive effect of 3.00 points (CI, -0.53 to 6.48 points) compared with no treatment and 2.37 points (CI, 0.74 to 4.0 points) compared with other conservative treatment (compared with all comparisons, 2.50 points [CI, 1.04 to 3.94 points]). Results considering different follow-up periods were similar for pain and functional outcomes (Figure 2). Egger test results suggested publication bias among studies in chronic low back pain populations ( $P = 0.015$ ); funnel plot analysis showed that this was likely because 3 studies demonstrated highly variable, large positive effects (56, 60, 63).

Sensitivity analyses for qualitative syntheses did not affect the conclusions. We conducted meta-analyses, excluding the results of studies that presented data as median scores (21, 57, 58, 62, 89) or did not provide variance scores (40, 41, 63, 68). This did not affect the pooled results for acute and subacute low back pain populations. In chronic low back pain populations, our sensitivity analysis resulted in lower, although still statistically significantly improved, pooled effect sizes. Complete results of all analyses are available on request.

#### Further Analyses

We conducted analyses on studies from acute, subacute, and chronic low back pain populations to assess the effect of study level variables. Tests of statistical heterogeneity

of pain outcomes found that 57% (CI, 12% to 79%), 37% (CI, 0% to 76%), and 81% (CI, 72% to 87%) of the heterogeneity for acute, subacute, and chronic low back pain populations, respectively, was not due to chance. Function outcomes showed values of 80% (CI, 63% to 89%), 47% (CI, 0% to 82%), and 52% (CI, 19% to 71%), respectively. To account for heterogeneity, we used random-effects models and investigated clinically relevant subgroups of studies. A complete exploration of intervention heterogeneity is included in our accompanying paper (96).

Indirect subgroup comparisons using qualitative synthesis and meta-analysis found that trials examining health care study populations observed higher mean improvements in functioning and pain over their comparison groups than trials examining occupational or general populations (Figure 3). In chronic populations, mean improvements in health care settings were 13.3 points (CI, 5.5 to 21.1 points) for pain and 6.9 points (CI, 2.2 to 11.7 points) for function outcomes. The adjusted differences between studies with different source populations found statistically significantly greater improvement in outcomes in health care populations compared with studies from general population or mixed populations, with a mean improvement of 9.96 points (CI, 1.6 to 18.4 points) in pain outcomes and 5.52 points (CI, 0.6 to 10.4 points) in functioning.

We conducted meta-analyses on the subgroup of high-

quality trials. The observed effectiveness of exercise therapy decreased and only remained statistically significant for pain outcomes in the chronic low back pain population.

## DISCUSSION

We believe that our review is the most up-to-date assessment of the effectiveness of exercise therapy in key population subgroups. For the most part, results were similar by using either a qualitative rating system or meta-analysis. We draw the following conclusions, which provide useful information for primary care clinicians to help guide their patient management and referral practices.

1. In acute low back pain, evidence suggests that exercises are not more effective than other conservative treatments. Meta-analysis showed no advantage over no treatment for pain and functional outcomes over the short- or long-term follow-up.

2. Some evidence suggests effectiveness of a graded-activity exercise program in subacute low back pain in occupational settings. The effectiveness for other types of exercise therapy in other populations is unclear.

3. In chronic low back pain, evidence strongly suggests that exercise is at least as effective as other conservative treatments. Individually designed strengthening or stabilizing programs seem to be effective in health care settings. Meta-analysis found functional outcomes statistically significantly improved; however, the effects were very small, with less than a 3-point (out of 100) difference between the exercise and comparison groups at earliest follow-up. Pain outcomes also statistically significantly improved in groups receiving exercises relative to other comparisons, with a mean of approximately 7 points. Effects were similar over longer follow-up, although CIs increased. Mean improvements in pain and functioning may be clinically meaningful in studies from health care populations in which improvements were statistically significantly greater than those observed in studies from general or mixed populations.

Our study has several strengths and also some limitations. Many randomized, controlled trials informed our study, and we collected the data in a systematic way within the framework of the Cochrane Collaboration, suggesting that our synthesis represents the current state of the literature. However, limitations in the quality and reporting of the trials are notable. We rated only a few studies as high-quality, and this may have led to an overestimation of effect. Also, many studies lacked information to assess quality and clinical relevance. Contacting the authors of the trials provided data that were missing, emphasizing the importance and usefulness of this practice. The only outcome measure used in most studies was pain intensity (in 85%), which limits the ability to report on other important outcomes. In 1998, a group of back pain researchers recommended standardized use of outcome measures in back pain research, suggesting a minimum of pain, functional

status, and general health measures (97). The lack of consistency observed is disappointing, as is the fact that only three quarters of the studies in our review included a measure of functional status and only 15% included a measure of general health. Journals in the field of back pain should adopt reporting guidelines (98) and, even more important, use them in their review process to improve the quality of future reports of trials in this field. We found potential publication bias in studies in chronic low back pain, which may have resulted in an overestimation of the effectiveness of exercise therapy in this population. Initiatives in other fields to register randomized, controlled trials will also be important in low back pain research. We used both qualitative and quantitative synthesis strategies in our review, which were informative. Qualitative synthesis methods facilitate the inclusion of results from trials that inadequately report outcomes. This is particularly useful when only some studies are available, for example, in subacute populations in our review. However, the qualitative synthesis was more challenging in assessing the evidence in chronic populations, where many studies were available.

Our meta-analysis found no evidence that exercise therapy is more effective than no treatment in improving outcomes in acute low back pain. This finding is consistent with the original Cochrane review on this topic (1) and other systematic reviews (2, 6, 7). However, we emphasize that exercise therapy is not the same as advice to stay active, which is a recommended treatment strategy in acute populations (6, 99). In the subacute population, which was not considered separately in the original Cochrane review, 6 trials were available. In a recent systematic review of various conservative interventions, Pengel and colleagues (100) concluded that there was an important gap in evidence for these interventions in treating subacute low back pain. In our review, 2 trials (22, 90) found reduced absenteeism outcomes with a graded-activity intervention compared with usual care, although there continues to be uncertainty about other types of exercises and in health care populations. We also recommend more clear definitions and further high-quality research of exercise therapy in this population. Finally, our positive findings in chronic low back pain populations reflect the conclusions of earlier reviews (2, 6, 7). Our quantitative analysis estimates the average treatment effect and its uncertainty, highlighting an overall small treatment benefit. Our finding of greater improvement in trials investigating health care populations is important. Future intervention studies should be conducted in populations that are seeking care and therefore best represent low back pain patients. We do not recommend further research on the effectiveness of general exercise therapy interventions in chronic low back pain. Trials should investigate specific exercise intervention strategies in well-defined populations of patients with low back pain (96).

Evidence from randomized, controlled trials demonstrates that exercise therapy effectively reduces pain and functional limitations in the treatment of chronic low back

pain, although cautious interpretation is required due to limitations in this literature. Overall, mean improvements in outcomes across all research settings are small, although statistically significant, compared with other conservative treatment options. Clinically important improvements are more likely in health care settings. Some evidence suggests effectiveness of a graded-activity exercise program in subacute low back pain in occupational settings, although the evidence for other types of exercise therapy in other populations is unclear and further research is required. This literature suggests exercise therapy is as effective as either no treatment or other conservative treatments for acute low back pain.

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Appendix Table 1. Characteristics of Included Randomized, Controlled Trials\*

Study, Year (Reference)	Patients, <i>n</i>	Study Methodst	Population Characteristics	
			Source	Duration of Low Back Pain
<b>Acute populations</b>				
Chok et al., 1999 (62)	54	+, ?, +, -	Secondary or tertiary care (referred)	Acute
Delitto et al., 1993 (65)	24	- , ? , ? , -	Secondary or tertiary care (referred)	Acute
Faas et al., 1993 (37)	473	+, +, +, -	Primary care	Acute
Farrell and Twomey, 1982 (68)	48	-, ?, +, +	Unclear	Acute
Gilbert et al., 1985 (69)	187	-, ?, +, -	Primary care	Acute
Hides et al., 1996 (95)	41	+, +, +, -	Secondary or tertiary care (referred)	Acute
Malmivaara et al., 1995 (25)	186	+, +, +, +	Occupational	Acute
Seferlis et al., 1998 (76)	180	-, ?, -, +	Occupational	Acute
Stankovic and Johnell, 1990 (54)	100	+, +, +, ?	Unclear	Acute
Underwood and Morgan, 1998 (80)	75	+, +, +, -	Primary care	Acute
Waterworth and Hunter, 1985 (81)	108	-, -, +, -	Primary care	Acute
<b>Subacute populations</b>				
Cherkin et al., 1998 (35)	321	+, +, +, -	Secondary or tertiary care (referred)	Subacute
Davies et al., 1979 (64)	43	-, ?, +, +	Primary care	Subacute
Lindström et al., 1992 (22)	103	+, +, +, +	Occupational	Subacute§
Moffett et al., 1999 (47)	187	+, +, +, -	Primary care	Subacute§
Staal et al., 2004 (90)	134	+, +, +, -	Occupational	Subacute
Storheim et al., 2003 (91)	93	+, +, -, -	Occupational	Subacute
<b>Chronic populations</b>				
Alexandre et al., 2001 (56)	33	?, ?, +, ?	Occupational	Chronic
Aure et al., 2003 (32)	49	+, +, +, -	Occupational	Chronic

Appendix Table 1—Continued

Exercise Description	Exercise Intervention Characteristics			Comparison Group
	Intervention Time, h <sup>±</sup>	Delivery Format	Other Interventions	
1) Extensor endurance program: aerobics, stretching, strengthening	13.5	Individual	Advice to stay active or education; passive modality	No treatment
1) Williams flexion exercise regimen with home exercises	7.3	Individual	Manual therapy	
2) McKenzie regimen, plus long-lever manipulation	7.3	Individual	Manual therapy	
1) 8 exercises: "resting position," side bending, stretching, isometric abdominal strengthening	3.3	Individual	Advice to stay active or education; analgesics or NSAIDs	1) Sham treatment
1) Isometric abdominal exercises, ergonomic advice, home abdominal exercises	2.7	Individual; independent home exercises	Advice to stay active or education; passive modality	2) Usual general practitioner care Other conservative treatment
1) Adapted Kendall flexion routine (home program), education, plus analgesics	4.8	Independent home exercises	Advice to stay active or education; analgesics or NSAIDs	1) Usual general practitioner care
2) Exercise, education, plus bed rest for 4 d	4.8	Independent home exercises	Education; bed rest	2) Other conservative treatment
1) Multifidus isometric retraining	NA	NA	Advice to stay active or education; analgesics or NSAIDs	Usual general practitioner care
1) Flexibility or mobilizing exercises: back extension, lateral bending movements	10	Independent home exercises	Advice to stay active or education; analgesics or NSAIDs	1) No treatment 2) Other conservative treatment
1) Intensive training program: information, muscle training, and general conditioning	130.5	Group	Advice to stay active or education	1) Other conservative 2) Usual general practitioner care treatment
1) McKenzie analysis and exercises	2	Individual; independent home exercises	Advice to stay active or education	No treatment
1) Education on McKenzie principles, teaching extension exercises, plus general advice	1.8	Group	Advice to stay active or education; analgesics or NSAIDs	Usual general practitioner care
1) Conservative physiotherapy including active flexion and extension exercises	6.3	Individual	Advice to stay active or education	1) Other conservative treatment 2) Other conservative treatment
1) McKenzie exercise program (trained physiotherapists, centralize symptoms)	7.3	Individual	Advice to stay active or education	1) No treatment
1) Extension exercises ("prone, raising trunk" described as back-muscle strengthening)	9.6	Individual	Passive modality	Other conservative treatment
2) Flexion exercises (described as "mobilizing")	9.6	Individual	Passive modality	
1) Individual graded-activity program (quota-based): endurance, strengthening, aerobics	133	Individual; independent home exercises	Advice to stay active or education; back school	Usual general practitioner care
1) Aerobics, strengthening, stretching	8	Group	Behavioral therapy; advice to stay active or education	Usual general practitioner care
1) Graded-activity program	13	Individual	Advice to stay active or education	Usual general practitioner care
1) Intensive training program: aerobic, strength, flexibility	31	Group	None	1) Other conservative treatment 2) Usual general practitioner care
1) Several components: exercise, plus home exercises	24	Group	Advice to stay active or education	No treatment
1) Stretching exercises (2 of 3); passive manipulation (1 of 3)	10	Individual; independent home exercises	Manual therapy; analgesics or NSAIDs	
2) Individually designed: strengthening, stretching, mobilizing, coordination, and stabilizing exercises for abdomen, back, pelvis, and lower limb; equipment	10	Individual; independent home exercises	Analgesics or NSAIDs	

Continued on following page

Appendix Table 1—Continued

Study, Year (Reference)	Patients, <i>n</i>	Study Method <sup>†</sup>	Population Characteristics	
			Source	Duration of Low Back Pain
Bendix et al., 2000 (60)	138	?, ?, -, -	Occupational	Chronic
Bendix et al., 1995 (57)	106	+, ?, -, -	Secondary or tertiary care (referred)	Chronic
Bentsen et al., 1997 (33)	74	+, +, +, -	General population	Chronic <sup>§</sup>
Bronfort et al., 1996 (34)	103	+, +, -, +	General population	Chronic
Buswell, 1982 (61)	50	-, ?, -, -	Primary care	Chronic <sup>§</sup>
Calmels et al., 2004 (83)	17	?, ?, +, -	Secondary or tertiary care (referred)	Chronic
Dalichau and Scheele, 2000 (63)	63	?, ?, +, -	Secondary or tertiary care (referred)	Chronic
Descarreux et al., 2002 (66)	20	+, -, +, -	General population	Chronic <sup>§</sup>
Deyo et al., 1990 (18)	125	+, +, +, +	General population	Chronic
Elnaggar et al., 1991 (36)	56	+, +, -, +	Secondary or tertiary care (referred)	Chronic
Frost et al., 1995 (19)	71	+, +, +, +	Primary care	Chronic
Frost et al., 2004 (84)	286	+, +, -, -	Secondary or tertiary care (referred)	Chronic <sup>§</sup>
Galantino et al., 2004 (85) <sup>  </sup>	22	+, ?, -, -	Mixed	Chronic
Gur et al., 2003 (86)	75	?, ?, +, -	Secondary or tertiary care (referred)	Chronic
Hansen et al., 1993 (21)	180	+, +, +, +	Mixed	Chronic <sup>§</sup>
Hemmilä et al., 1997 (40)	114	-, +, +, +	Mixed	Chronic
Hildebrandt et al., 2000 (43)	222	+, +, -, -	Primary care	Chronic

Appendix Table 1—Continued

Exercise Description	Exercise Intervention Characteristics			Comparison Group
	Intervention Time, h <sup>±</sup>	Delivery Format	Other Interventions	
1) Aerobics and strengthening (machines)	36	Group	None	
2) Functional restoration; comprehensive multidisciplinary approach including aerobics, strengthening, stretching	36	Group	Behavioral therapy; back school	
1) Functional restoration; comprehensive multidisciplinary approach including aerobics, strengthening, stretching	24	Group	Behavioral therapy; back school	Other conservative treatment
2) Aerobics and strengthening	24	Group	Back school	
1) Dynamic strength back exercises: at gym and home	21.8	Individual; independent home exercises	None	
2) Home exercises	21.8	Independent home exercises only	None	
1) Dynamic trunk (Manniche) and abdominal strengthening	20	Individual	Manual therapy	Other conservative treatment
2) Same exercise plus NSAIDs	20	Individual	Analgesics or NSAIDs	
1) Extension exercise program (cites McKenzie)	11	Individual	Manual therapy; advice to stay active or education	
2) Flexion program (mobilizing exercises plus posture)	11	Individual	Manual therapy; advice to stay active or education	
1) Isokinetic strengthening exercises (Cybex [Medway, Massachusetts] machines)	4.5	Individual	Manual therapy	
2) Physiotherapy exercises: series of 3 groups of exercises (whole body)	4.5	Individual	None	
1) Strengthening: warm-up aerobic exercises, 60-min equipment training (total body)	12	Individual	Lumbar support	No treatment
2) Same as above with no lumbar support during exercises	12	Individual	None	
1) Standard stretching or strengthening program	18.3	Independent home exercises	None	
2) Force, extensibility exercises of trunk and hip muscles based on initial evaluation; targeted increased	18.3	Supervised home exercises	None	
1) 12 sequential relaxation and stretching exercises (improve flexibility); exercises plus TENS	10.6	Supervised home exercises	Advice to stay active or education; passive modality	Other conservative treatment
1) Extension exercises ("prone, raising trunk" described as back-muscle strengthening)	7	Supervised home exercises	None	
2) Flexion exercises (described as "mobilizing")	7	Supervised home exercises	None	
1) Warm-up, stretching, progressive exercises, light aerobic and advice, plus back school	8	Group	Advice to stay active or education; back school	Other conservative treatment
1) Standard physiotherapy: 94% received exercises (stretching, strengthening, mobility exercises)	3.5	Individual	Manual therapy; advice to stay active or education	Other conservative treatment
1) Hatha yoga: sequence of postures that leads to a state of relaxation (strength, flexibility, balance)	19.5	Group; independent home exercises	None	No treatment
1) Stretching and strengthening exercises of lumbar and extremity muscle groups	5	Independent home exercises	None	Other conservative treatment
2) Same exercises as above with additional intervention	5	Independent home exercises	Low-power laser therapy	
1) Intensive dynamic back-muscle training: extension strengthening	8	Individual	None	1) Other conservative treatment 2) Other conservative treatment
1) Bending, rotation exercises; "auto-stretching when appropriate"	13.8	Independent home exercises	None	1) Other conservative treatment 2) Other conservative treatment
1) Postural exercises (Cesar therapy)	10.5	Individual	None	Usual general practitioner care

Continued on following page

Appendix Table 1—Continued

Study, Year (Reference)	Patients, <i>n</i>	Study Method <sup>†</sup>	Population Characteristics	
			Source	Duration of Low Back Pain
Johannsen et al., 1995 (70)	27	–, ?, –, –	Secondary or tertiary care (referred)	Chronic
Jousset et al., 2004 (87)	85	+, ?, +, –	Occupational	Chronic
Kankaanpää et al., 1999 (44)	54	+, +, +, –	Occupational	Chronic
Kendall and Jenkins, 1968 (71)	42	–, ?, +, –	Primary care	Chronic
Kuukkanen and Mälikä, 2000 (72)	57	?, ?, +, –	Occupational	Chronic <sup>§</sup>
Lidström and Zachrisson, 1970 (73)	62	–, ?, +, ?	Secondary or tertiary care (referred)	Chronic <sup>§</sup>
Lie and Frey, 1999 (74)	27	+, ?, –, +	Primary care	Chronic
Manniche et al., 1988 (26)	105	+, +, +, +	Secondary or tertiary care (referred)	Chronic
Mannion et al., 1999 (29)	148	+, +, +, +	General population	Chronic
Moseley, 2002 (48)	57	+, +, –, –	Primary care	Chronic
Niemistö et al., 2003 (88)	204	+, +, +, –	General population	Chronic
Petersen et al., 2002 (49)	260	+, +, –, +	Secondary or tertiary care (referred)	Chronic
Preyde, 2000 (50)	98	+, –, +, +	Mixed	Chronic <sup>§</sup>
Rasmussen-Barr et al., 2003 (89)	47	?, ?, –, –	Primary care	Chronic <sup>§</sup>
Risch et al., 1993 (75)	54	–, –, +, –	Secondary or tertiary care (referred)	Chronic

Appendix Table 1—Continued

Exercise Description	Exercise Intervention Characteristics			Comparison Group
	Intervention Time, h <sup>±</sup>	Delivery Format	Other Interventions	
1) Aerobics, exercises emphasizing coordination, balance, stability, stretching	24	Group	None	
2) Aerobics, dynamic exercises emphasizing muscle endurance: abdominal, shoulder, hip muscle stretching	24	Group	None	
1) Functional restoration	150	Group	None	
2) Active individual therapy (strengthening, stretching, aerobics recommended)	19	Individual; independent home exercises	Advice to stay active or education	
1) Strengthening (machines) with stretching, coordination (David Beck Clinic program)	36	Group	Behavioral therapy; advice to stay active or education	Other conservative treatment
1) Mobilizing, strengthening, posture	7.9	Independent home exercises	Advice to stay active or education	
2) Isometric flexion exercises: strengthening abdominal and trunk muscles (2 exercises)	7.9	Independent home exercises	Advice to stay active or education	
3) Strengthening extension muscles, posture, lifting	7.9	Independent home exercises	Advice to stay active or education	
1) Strengthening, endurance, balance and coordination	21	Independent home exercises only	None	No treatment
1) Mobilizing (kneeling and supine) and strengthening (isotonic abdominal and back) exercises and home exercises	4.8	Individual; independent home exercises	Passive modality	1) Other conservative treatment 2) Other conservative treatment
1) Mobilizing and stretching, walking in "flexible way"	15	Group; independent home exercises	None	
2) Stabilizing exercises and walking without instructions	15	Group; independent home exercises	None	
1) Intensive strengthening: trunk, back strengthening routine	45	Individual	None	
2) Back strengthening routine; similar to group 1, lower dose	45	Individual	None	
3) Isometric exercises for lower back	45	Individual	Manual therapy; passive modality	
1) Aerobics, stretching	24	Group	None	
2) Controlled progressive exercises with machines (David Beck Clinic program)	24	Group	None	
3) Physiotherapy including exercises using resistance bands and general strength training	17.6	Individual	Ergonomic advice; passive modality	
1) Specific trunk muscle training: individualized with home exercise program (Richardson and Jull)	12	Individual; independent home exercises	Manual therapy; advice to stay active or education	Usual general practitioner care
1) Stabilizing exercises aiming to correct lumbopelvic rhythm	4	Individual; independent home exercises	Manual therapy; advice to stay active or education	Usual general practitioner care
1) Strengthening training: stationary bike, intensive dynamic back strengthening in flexion and extension	6.9	Group	None	
2) McKenzie therapy	6.9	Individual	None	
1) Stretching, flexion or extension, "general strengthening or mobility"	2	Individual	Manual therapy	1) Sham treatment
2) Comprehensive massage (massage and exercises)	2	Individual	Advice to stay active or education	2) Other conservative treatment
1) Stabilizing exercises: activation and control deep abdominal, multifidus muscles	7	Individual; supervised home exercises	Advice to stay active or education	Other conservative treatment
1) Dynamic extension strengthening program (machine)	11.4	Individual	None	No treatment

Continued on following page

Appendix Table 1—Continued

Study, Year (Reference)	Patients, <i>n</i>	Study Method <sup>†</sup>	Population Characteristics	
			Source	Duration of Low Back Pain
Rittweger et al., 2002 (51)	60	+, +, +, -	General population	Chronic
Lønn et al., 1999 (46); Soukup et al., 1999 (52)	120	+, +, +, -	Mixed	Chronic <sup>§</sup>
Torstensen et al., 1998 (31)	208	+, +, +, +	Occupational	Chronic
Tritilanunt and Wajanavisit, 2001 (78)	72	+, ?, +, -	Secondary or tertiary care (referred)	Chronic
Turner et al., 1990 (79)	96	+, +, -, -	Mixed	Chronic
Yelland et al., 2004 (92)	110	+, +, +, -	Mixed	Chronic
Yeung et al., 2003 (93)	52	?, +, +, -	Primary care	Chronic
Yozbatiran et al., 2004 (94)	30	?, ?, +, -	Secondary or tertiary care (referred)	Chronic
Zylbergold and Piper, 1981 (82)	28	-, ?, +, -	Primary care	Chronic <sup>§</sup>
<b>Unclear population</b>				
Ljunggren et al., 1997 (45)	126	+, +, +, -	Primary care	Unclear

\* 61 studies were included: 11, 6, and 43 in acute, subacute, and chronic low back pain populations, respectively (1 unclear). + = yes; - = no; ? = unknown; NA = not applicable; NSAIDs = nonsteroidal anti-inflammatory drugs; TENS = transcutaneous electrical nerve stimulation.

<sup>†</sup> Study method factors: adequate randomization, allocation concealment, adequate follow-up, outcome assessor blinding.

<sup>‡</sup> Intervention time calculated as “best estimate” when a home exercise program was used and study adherence information was not available (see text).

<sup>§</sup> Sensitivity analysis as “mixed” population.

|| Galantino et al. (85) was excluded from quantitative syntheses because of flaw: small study with >50% loss to follow-up.

Appendix Table 1—Continued

Exercise Description	Exercise Intervention Characteristics			Comparison Group
	Intervention Time, h <sup>±</sup>	Delivery Format	Other Interventions	
1) Lumbar extension, repetitive contraction cycles, constant speed, load gradually increased; resistance exercise of the abdominal and thigh muscles	3	Individual	None	
2) Specific exercise: "platform that oscillates around a resting axis between the subject's feet ... during exercise units, the subject performed slow movements of the hip and waist, with bending in the sagittal and frontal planes and rotation in the horizontal plane"	3	Individual	None	
1) Mensendiek exercise: aerobic, stretching, strength, coordination, and ergonomic education	20	Group	None	No treatment
2) Active back school, 30-min exercise session	20	Group	Back school	
1) Ordinary activity level: walking exercise program	36	Independent home exercises	None	Other conservative treatment
2) Medical exercise therapy: mobilizing and strengthening with special equipment; aerobic exercise warm-up	36	Group	None	
1) Aerobic exercises	NA	NA	Advice to stay active or education	
2) Flexion exercises, posture, and behavioral therapy	NA	NA	Advice to stay active or education	
1) Increasing aerobic fitness (fast walking, slow jogging); warm-up, cooldown stretching	16	Group	None	1) No treatment
2) Behavioral and exercise therapy: same as exercise plus behavioral therapy (with spousal participation)	16	Group	Behavioral therapy	2) Other conservative treatment
1) Sagittal loading flexibility or mobilizing exercises	12	Independent home exercises	Passive modality	Other conservative treatment
1) Stretching, mobilizing, strengthening exercises	7.5	Group; independent home exercises	Advice to stay active or education	
2) Stretching, mobilizing, strengthening exercises plus electroacupuncture	7.5	Group; independent home exercises	Passive modality; advice to stay active or education	
1) Warm-up, stretching, progressive exercises, light aerobics on land	8	Group	None	
2) Warm-up, stretching, progressive exercises, light aerobics in water	8	Group	None	
1) Flexion exercises	3.5	Individual	Passive modality	1) No treatment 2) Other conservative treatment
1) Terapi Master (Nordisk Terapi, Arendal, Norway) device for general exercise: strengthening, stretching	39	Supervised home exercises	None	
2) Conventional physical therapy exercises: low-tech strengthening, stretching	39	Supervised home exercises	None	

Appendix Table 2. Results Available for Trials Included in Systematic Review\*

Study, Year (Reference)	Rating of Results†	Outcome Measures Reported (Scale)	Initial Pain Intensity		Pain Intensity at Follow-up					
					Short-Term		Intermediate		Long-Term	
			Ex	C	Ex	C	Ex	C	Ex	C
<b>Acute populations</b>										
Chok et al., 1999 (62)‡	Positive	Pain (VAS), function (RMDQ)	23.0 ± 24.0	26.7 ± 19.7	10.2 ± 29.9	22.8 ± 18.5	8.1 ± 34.7	20.1 ± 24.4		
Delitto et al., 1993 (65)	Unclear	Function (ODQ)								
Faas et al., 1993 (37)	Neutral	Pain (VAS/85 points), function (LOM), RTW	36.1	36.6	17.1 ± 21.0	14.6 ± 22.0	12.1 ± 24.0	12.6 ± 30.0	10.1 ± 23.0	9.6 ± 26.0
Farrell and Twomey, 1982 (68)	Neutral	Pain (VAS/10 points), function (BU), global	5.2	4.9	0.3	0.3				
Gilbert et al., 1985 (69)§	Neutral	Pain (MPQ), function (ADS)	22.7 ± 6.7	25.2 ± 8.6	7.5 ± 1.2	7.7 ± 2.0				
Hides et al., 1996 (95)	Neutral	Pain (VAS), function (RMDQ)	42	47	0	11				
Malmivaara et al., 1995 (25)	Negative	Pain (VAS/10 points), function (ODQ), RTW	6.1	5.9	3.1	2.4	1.8 ± 1.8	2.1 ± 1.8		
Seferlis et al., 1998 (76)	Neutral	Pain (VAS/10 points), function (ODQ), RTW	5.1 ± 1.4	5.1 ± 1.4	4.6 ± 1.7	4.6 ± 1.7	3.5 ± 2.6	3.5 ± 2.6	2.5 ± 1.7	2.5 ± 1.7
Stankovic and Johnell, 1990 (54)	Unclear	Pain (VAS), RTW		5.1 ± 1.4		4.6 ± 1.7		3.5 ± 2.6		2.5 ± 1.7
Underwood and Morgan, 1998 (80)	Neutral	Pain (VAS), function (ODQ), RTW, global	44.4	50.4	18.0 ± 28.4	23.4 ± 28.4	11.1 ± 27.6	12.0 ± 27.6	8.6 ± 31.8	13.7 ± 31.8
Waterworth and Hunter, 1985 (81)	Unclear	Pain (Likert/4 points), global	2.1	2.0	0.4	0.4				
<b>Subacute populations</b>										
Cherkin et al., 1998 (35)	Neutral	Pain (VAS/10 points), function (RMDQ/23 points), RTW	6.0 ± 2.5	5.5 ± 2.1	2.3 ± 2.9	1.9 ± 3.3	2.7 ± 2.8	2.0 ± 2.2	2.0	1.6
Davies et al., 1979 (64)	Unclear	Pain (VAS), RTW, global	11.2 ± 4.4	8.7 ± 3.3	5.0 ± 6.0	6.0 ± 5.1	1.8 ± 3.6	3.7 ± 5.4		
Lindström et al., 1992 (22)	Unclear	Pain (VAS), RTW	41.3 ± 28.2	44.5 ± 28.8		3.1 ± 3.2		3.2 ± 3.2		2.8
Moffett et al., 1999 (47)	Positive	Pain (APS), function (RMDQ), RTW	27.9 ± 11.1	25.5 ± 10.9	16.4 ± 9.9	16.5 ± 9.9	17.7 ± 12.0	17.4 ± 12.0	15.0 ± 11.2	17.0 ± 11.2
Staal et al., 2004 (90)	Positive	Pain (NRS/10 points), function (RMDQ), RTW	6.7 ± 1.8	6.4 ± 1.7	2.8 ± 2.4	2.5 ± 2.8	2.9 ± 3.1	2.7 ± 2.8		
Storheim et al., 2003 (91)	Neutral	Pain (VAS), function (RMDQ), RTW	53.2 ± 23.2	55.7 ± 19.6			38.3 ± 22.4	34.8 ± 25.1		
<b>Chronic populations</b>										
Alexandre et al., 2001 (56)	Neutral	Pain (VAS/10 points)	5.7 ± 8.3	5.8 ± 14.7	0.6 ± 8.6	3.7 ± 11.3				
Aure et al., 2003 (32)	Positive	Pain (VAS), function (ODQ), RTW	55.0 ± 18.6		22.0 ± 18.6		22.0 ± 21.2		21.0 ± 18.6	
Bendix et al., 2000 (60)‡	Neutral	Pain (NRS), function (MRS), RTW, global	54.0 ± 23.9		37.0 ± 26.3		42.0 ± 23.9		35.0 ± 23.9	
Bendix et al., 1995 (57)‡	Neutral	Pain (VAS/10 points), function (ADL/30 points), RTW	6.0 ± 1.5						5.7 ± 3.9	
	Neutral		5.1 ± 2.7						5.1 ± 4.5	
	Positive		5.3				2.7 ± 2.3		3.3 ± 3.4	
	Negative		5.4	5.9			4.4 ± 2.9	5.6 ± 2.9	5.3 ± 3.3	6.5 ± 2.5

Appendix Table 2—Continued

Initial Functional Impairment		Functional Impairment at Follow-up					
		Short-Term		Intermediate		Long-Term	
Ex	C	Ex	C	Ex	C	Ex	C
11.5 ± 4.0	11.0 ± 4.7	4.0 ± 6.4	9.5 ± 4.0	3.0 ± 5.8	4.0 ± 5.4		
41.0 ± 3.5		32.0 ± 4.0					
34.0 ± 4.0		10.0 ± 4.0					
24.3	24.1	15.3 ± 19.0	13.1 ± 17.0	12.3 ± 20.0	12.1 ± 18.0	10.3 ± 19.0	10.1 ± 18.0
	23.3		13.3 ± 18.0		10.3 ± 19.0		8.3 ± 19.0
1.8	1.9	1.2	1.1				
35.9 ± 13.7	36.3 ± 13.1	21.3 ± 9.2	24.3 ± 10.0				
40.4 ± 16.4	36.6 ± 12.4	24.4 ± 8.8	20.9 ± 8.5				
10.3	13.6	0	3				
33.8	34.6	18.6 ± 16.4	16.0 ± 16.4	10.8 ± 10.2	11.8 ± 10.2		
	32.0 ± 0.0		10.0 ± 0.0		7.4 ± 0.0		
30.0 ± 18.0	30.0 ± 18.0	20.0 ± 18.0	20.0 ± 18.0	11.7 ± 12.0	11.7 ± 12.0	9.8 ± 11.0	9.8 ± 11.0
30.0 ± 18.0		20.0 ± 18.0		11.7 ± 12.0		9.8 ± 11.0	
26.2	35.6	7.6 ± 19.6	11.5 ± 19.6	4.7 ± 20.4	7.0 ± 20.4	4.7 ± 20.4	8.0 ± 20.4
12.2 ± 5.6	12.1 ± 5.5	4.1 ± 4.6	3.7 ± 4.4	4.1 ± 5.0	3.1 ± 4.4	2.6	2.6
	11.7 ± 5.4		4.9 ± 4.3		4.3 ± 4.9		4.5
6.7 ± 4.0	5.6 ± 3.9	3.8 ± 3.2	3.6 ± 3.2	3.7 ± 3.9	3.9 ± 3.9	3.5 ± 3.7	3.8 ± 3.7
13.3 ± 4.6	13.0 ± 4.9	6.3 ± 6.7	4.9 ± 6.2	7.8 ± 6.6	6.4 ± 6.6		
8.2 ± 3.5	8.9 ± 3.4			6.1 ± 3.8	5.5 ± 4.1		
39.0 ± 13.2		18.0 ± 13.2		16.0 ± 13.2		17.0 ± 13.2	
39.0 ± 14.3		30.0 ± 12.0		30.0 ± 14.3		26.0 ± 14.3	
16.0 ± 7.4						13.0 ± 8.8	
16.0 ± 5.9						12.0 ± 13.2	
15.5				8.5 ± 9.5		8.9 ± 6.0	
14.4	15.3			13.5 ± 5.1	16.1 ± 7.5	13.7 ± 6.9	16.4 ± 3.8

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Appendix Table 2—Continued

Study, Year (Reference)	Rating of Results†	Outcome Measures Reported (Scale)	Initial Pain Intensity		Pain Intensity at Follow-up						
					Short-Term		Intermediate		Long-Term		
			Ex	C	Ex	C	Ex	C	Ex	C	
Bentsen et al., 1997 (33)	Unclear	Function (Million), RTW									
	Neutral										
Bronfort et al., 1996 (34)	Neutral	Pain (VAS/10 points), function (RMDQ)	5.3 ± 1.5	5.4 ± 1.4	3.4 ± 1.9	3.9 ± 2.1	2.7 ± 2.0	3.3 ± 2.3	2.9	2.9	
	Neutral		5.5 ± 1.7		3.6 ± 2.2		3.5 ± 2.2		3.2		
Buswell, 1982 (61)	Unclear	Pain (unknown measure)	6.0 ± 0.0		2.8 ± 0.0						
	Unclear		5.5 ± 0.0		2.5 ± 0.0						
Calmels et al., 2004 (83)	Neutral	Pain (VAS), function (QDI)									
	Neutral										
Dalichau and Scheele, 2000 (63)	Unclear	Pain (VAS/10 points), function (ODQ)	6.3	5.5	2.1	5.5	3.3	5.6			
	Unclear		5.8		3.1		5.2				
Descarreux et al., 2002 (66)	Negative	Pain (VAS), function (ODQ)	31.3		27.8 ± 9.0						
	Positive		30.9		16.6 ± 9.7						
Deyo et al., 1990 (18)	Positive	Pain (VAS), function (SIP), global	43.6	38.9	19.8 ± 20.4	25.9 ± 20.4	26.5 ± 24.6	25.6 ± 24.6			
Elnaggar et al., 1991 (36)	Positive	Pain (MPQ)	15.9 ± 7.8		10.6 ± 8.6						
	Positive		14.1 ± 9.8		8.9 ± 9.4						
Frost et al., 1995 (19)	Positive	Pain (VAS), function (ODQ)	20.9 ± 12.3	25.6 ± 17.9	12.1 ± 9.9	22.1 ± 20.1					
Frost et al., 2004 (84)	Neutral	Function (ODQ), global									
Galantino et al., 2004 (85)‡	Unclear	Function (ODQ)									
Gur et al., 2003 (86)	Neutral	Pain (VAS/10 points), function (RMDQ)	6.2 ± 2.1	6.1 ± 1.9	1.8 ± 1.2	1.9 ± 1.4					
	Neutral		6.5 ± 1.6		2.9 ± 1.3						
Hansen et al., 1993 (21)‡	Neutral	Pain (VAS/9 points), global	3.5 ± 0.9	4.0 ± 0.8	3.0 ± 0.7	3.0 ± 0.4	4.0 ± 1.2	4.0 ± 0.8	2.5 ± 0.8	3.0 ± 0.8	
				5.0 ± 0.8		3.0 ± 0.8		4.0 ± 0.8		4.0 ± 1.0	
Hemmilä et al., 1997 (40)	Positive	Pain (VAS)	40.0	46.0	30.0	30.0	29.0	25.0			
				43.0		25.0		25.0			
Hildebrandt et al., 2000 (43)	Positive	Global									
Johanssen et al., 1995 (70)‡	Unclear	Pain (Likert/9 points), function (ADL/12 points), RTW	6.0 ± 1.7		5.0 ± 2.6		4.0 ± 2.6				
	Unclear		6.0 ± 1.7		3.0 ± 3.5		4.0 ± 2.6				
Jouset et al., 2004 (87)	Neutral	Pain (VAS/10 points), function (QDI), RTW	5.0 ± 2.2				3.1 ± 2.5				
	Neutral		4.6 ± 2.2				4.0 ± 2.8				
Kankaanpää et al., 1999 (44)	Positive	Pain (VAS), function (PDI)	54.1 ± 19.6	42.8 ± 28.4	36.8 ± 28.8	44.9 ± 26.7	35.9 ± 27.4	46.0 ± 20.5	28.0 ± 18.6	44.4 ± 22.5	
Kendall and Jenkins, 1968 (71)	Unclear	Global									
	Unclear										
	Unclear										
Kuukkanen and Mälkiä, 2000 (72)	Neutral	Pain (VAS/11 points), function (ODQ)	1.9 ± 1.5	1.8 ± 1.7	1.3 ± 1.2	1.1 ± 1.3	1.0 ± 1.3	1.3 ± 1.6	1.0 ± 1.3	1.3 ± 1.8	
Lidström and Zachrisson, 1970 (73)	Unclear	Global									
Lie and Frey, 1999 (74)	Negative	Global (COS), includes pain and function									
	Positive										

Appendix Table 2—Continued

Initial Functional Impairment		Functional Impairment at Follow-up					
		Short-Term		Intermediate		Long-Term	
Ex	C	Ex	C	Ex	C	Ex	C
33.3 ± 17.8	34.7 ± 17.9	19.1 ± 19.3	20.8 ± 17.3	15.1 ± 17.4	18.4 ± 17.1		
35.0 ± 16.9		20.8 ± 17.8		20.9 ± 17.0			
48.0 ± 10		42.0 ± 18					
47.0 ± 14		43.0 ± 15					
60.0	50.0	40.0	49.0	45.0	52.0		
55.0		42.0		52.0			
6.5	6.9	3.2 ± 3.1	3.2 ± 3.1	3.5 ± 4.0	2.5 ± 4.0		
23.6 ± 9.7	23.6 ± 12.3	16.3 ± 10.3	21.2 ± 14.2	15.1 ± 8.3	23.4 ± 15.2	15.4 ± 11.3	22.5 ± 15.4
21.12 ± 11.08	21.6 ± 11.0	18.47 ± 9.34	20.27 ± 9.29	18.23 ± 11.59	19.8 ± 10.61	17.85 ± 10.99	19.4 ± 11.47
24.98 ± 10.28	36.73 ± 18.49	21.15 ± 10.18	38.91 ± 17.56				
17.8 ± 4.6	16.3 ± 3.9	6.3 ± 3.5	6.6 ± 2.9				
15.1 ± 4.2		5.5 ± 3.2					
5.0 ± 2.6		3.0 ± 3.5		2.0 ± 2.6			
6.0 ± 5.2		2.0 ± 4.3		1.0 ± 4.3			
34.6 ± 15.4				22.0 ± 16			
31.6 ± 15.9				22.9 ± 17.7			
12.3 ± 10.1	10.1 ± 7.6	10.4 ± 11.9	11.6 ± 10.9	6.1 ± 5.8	13.3 ± 10.8	5.3 ± 8.1	9.8 ± 9.0
17.0 ± 9.5	14.0 ± 8.7	10.0 ± 7.6	11.0 ± 7.8	8.0 ± 6.6	12.0 ± 9.0	0.0 ± 0.0	10.0 ± 9.5
						6.0 ± 5.2	

Continued on following page

Appendix Table 2—Continued

Study, Year (Reference)	Rating of Results†	Outcome Measures Reported (Scale)	Initial Pain Intensity		Pain Intensity at Follow-up					
					Short-Term		Intermediate		Long-Term	
			Ex	C	Ex	C	Ex	C	Ex	C
Manniche et al., 1988 (26)‡	Unclear	Pain (VAS/30 points), function (ADL/15 points)	13.3 ± 4.9		5.7 ± 9.4		5.0 ± 10.7			
	Unclear Unclear		14.0 ± 6.9 11.7 ± 6.1		10.3 ± 9.7 9.2 ± 15.7		11.1 ± 10.8 11.5 ± 8.9			
Mannion et al., 1999 (29)	Positive	Pain (VAS/10 points), function (RMDQ)	4.2 ± 1.8		3.1 ± 2.1		2.8 ± 2.1		2.9 ± 2.2	
	Positive Neutral		4.1 ± 1.8 4.4 ± 1.8		3.6 ± 2.5 3.2 ± 2.2		3.1 ± 2.3 3.2 ± 2.0		3.2 ± 2.2 3.2 ± 2.0	
Moseley et al., 2002 (48)	Positive	Pain (NRS), function (RMDQ/18 points)	4.8 ± 0.0	4.5 ± 0.0	1.9 ± 1.5	3.1 ± 1.5				
Niemistö et al., 2003 (88)	Positive	Pain (VAS), function (ODQ), RTW	60.0 ± 21.0	53.3 ± 21.2			25.0 ± 23.0	36.1 ± 23.3	26.0 ± 23.0	32.2 ± 23.3
Petersen et al., 2002 (49)‡	Neutral	Pain (VAS/60 points), function (MRS), RTW, global	19.0 ± 13.4		14.0 ± 18.1		17.0 ± 18.1		18.0 ± 14.2	
	Positive		18.5 ± 13.8		10.0 ± 37.8		13.0 ± 30.7		14.0 ± 31.5	
Preyde, 2000 (50)	Neutral	Pain (PPI), function (RMDQ)	2.2 ± 0.7	2.2 ± 0.8	1.6 ± 0.8	1.0 ± 0.7	1.3 ± 0.8	1.2 ± 1.5		
	Positive		2.4 ± 0.8	2.0 ± 0.7	0.4 ± 0.6	1.6 ± 0.8	0.4 ± 0.6	1.8 ± 0.6		
Rasmussen-Barr et al., 2003 (89)‡	Neutral	Pain (VAS), function (ODQ)	33.0 ± 23.53	32.0 ± 25.0	20.0 ± 17.65	24.0 ± 33.82	14.0 ± 16.18	22.0 ± 33.82	13.0 ± 14.71	18.0 ± 29.4
Risch et al., 1993 (75)	Positive	Pain (WHY), function (SIP)	3.4 ± 1.6	3.7 ± 1.6	2.9 ± 1.7	4.1 ± 1.5				
Rittweger et al., 2002 (51)	Neutral	Pain (VAS), function (VAS/70 points)	4.5 ± 2.2		1.2 ± 1.8					
	Neutral		4.2 ± 1.9		1.4 ± 1.8					
Lønn et al., 1999 (46); Soukup et al., 1999 (52)	Neutral	Pain (VAS), function (VAS)	41.0 ± 15.0	42.0 ± 21.0			23.0 ± 16.0	24.0 ± 17.0	26.0 ± 19.0	32.0 ± 23.0
	Unclear	Pain (OEP-VAS), function (VAS/10 points)	3.5 ± 18.9				1.8 ± 15.7		2.2 ± 22.0	
Torstensen et al., 1998 (31)	Neutral	Pain (VAS), function (ODQ), RTW	55.0 ± 21.0		50.4 ± 27.2				50.0 ± 28.0	
	Neutral		53.1 ± 21.3	50.9 ± 19.2	37.2 ± 25.3	39.0 ± 28.0			40.5 ± 24.4	42.9 ± 29.5
Tritilanunt and Wajanavisit, 2001 (78)	Positive	Pain (VAS)	5.6 ± 1.8		2.3 ± 1.8					
	Neutral		5.4 ± 1.8		4.0 ± 1.9					
Turner et al., 1990 (79)	Neutral	Pain (MPQ), function (SIP)	19.4 ± 10.6	21.0 ± 9.9	17.5 ± 10.2	17.7 ± 12.1	15.6 ± 9.1	19.5 ± 15.7	14.9 ± 7.9	16.4 ± 13.6
	Positive		25.5 ± 12.4	21.2 ± 8.8	14.8 ± 11.4	21.0 ± 10.6	13.3 ± 9.1		18.2 ± 13.3	
Yelland et al., 2004 (92)	Neutral	Pain (VAS), function (RMDQ/23 points)	54.6 ± 19.8	52.3 ± 20.3	42.0 ± 26.5	37.0 ± 45.4	33.0 ± 26.5	32.0 ± 30.3	34.1 ± 28.2	35.8 ± 30
Yeung et al., 2003 (93)	Neutral	Pain (NRS/10 points), function (VAS)	5.88 ± 1.84		5.19 ± 2.47		5.27 ± 2.31			
	Positive		6.38 ± 1.77		3.77 ± 2.12		3.46 ± 2.18			
Yozbatiran et al., 2004 (94)	Neutral	Pain (VAS/10 points), function (ODQ)	5.06 ± 2.28		2.53 ± 2.28					
	Neutral		5.46 ± 2.19		1.93 ± 1.7					
Zylbergold and Piper, 1981 (82)	Neutral	Pain (Likert/5 points), function (Likert/5 points)	2.3 ± 1.3	2.9 ± 0.9	1.3 ± 0.9	1.4 ± 0.1				
				2.1 ± 1.6		1.5 ± 0.8				

Appendix Table 2—Continued

Initial Functional Impairment		Functional Impairment at Follow-up					
		Short-Term		Intermediate		Long-Term	
Ex	C	Ex	C	Ex	C	Ex	C
10.3 ± 5.4		9.0 ± 5.7		5.9 ± 9.7			
11.4 ± 6.6		8.8 ± 8.7		8.3 ± 8.9		0.0 ± 0.0	
10.2 ± 8.3		8.5 ± 11.5		7.8 ± 9.1			
8.0 ± 5.1		6.7 ± 5.0		5.7 ± 4.8		5.8 ± 4.8	
7.7 ± 4.7		6.3 ± 5.1		5.4 ± 4.4		6.2 ± 4.6	
7.9 ± 4.0		6.8 ± 4.9		7.7 ± 5.3		7.4 ± 4.9	
29.5 ± 9.7	28.8 ± 9.7			14.7 ± 11.6	18.6 ± 11.0	13.7 ± 11.6	16.5 ± 11.6
39.3 ± 16.3		29.2 ± 27.3		34.8 ± 42.9		33.3 ± 28.9	
36.7 ± 18.4		28.6 ± 35.2		26.7 ± 31.5		30.8 ± 36.3	
7.2 ± 5.2	8.6 ± 4.4	6.8 ± 5.6	3.4 ± 2.8	5.7 ± 4.8	2.9 ± 3.1		
8.3 ± 4.2	7.2 ± 4.2	2.4 ± 2.8	6.8 ± 3.5	1.5 ± 2.0	6.5 ± 4.2		
18.0 ± 14.71	14.0 ± 10.29	9.0 ± 10.29	12.0 ± 5.88	6.0 ± 5.88	13.0 ± 14.71	8.0 ± 8.82	8.0 ± 16.18
9.1 ± 9.3	15.2 ± 10.4	7.7 ± 9.4	19.3 ± 15.6				
20.3 ± 9.9		10.5 ± 12.8		12.0 ± 12.4			
20.7 ± 14.3		11.6 ± 11.1		14.8 ± 13.6			
40.0 ± 20.8	41.0 ± 51.3			60.0 ± 17.8	61.0 ± 21.1	58.0 ± 23.8	52.0 ± 24.1
4.7 ± 18.9				7.0 ± 18.9		6.7 ± 22.0	
50.0 ± 11.9		52.7 ± 16.6				50.6 ± 16.6	
51.7 ± 10.7	49.4 ± 10.5	46.2 ± 13.1	46.9 ± 13.1			44.1 ± 13.8	43.0 ± 12.9
8.4 ± 8.2	7.9 ± 6.4	5.5 ± 6.8	4.7 ± 4.1	6.3 ± 10.1	7.6 ± 9.9	4.7 ± 7.8	5.3 ± 6.7
8.5 ± 4.6	6.2 ± 5.0	3.6 ± 3.0	5.4 ± 5.9	4.5 ± 4.7		4.8 ± 3.4	
13.0 ± 5.1	15.0 ± 4.3	8.5 ± 9.5	11.0 ± 11.4	7.5 ± 7.6	9.5 ± 9.5	8.2 ± 6.7	9.9 ± 5.9
32.49 ± 13.79		32.48 ± 15.31		25.82 ± 13.11			
35.32 ± 11.72		20.36 ± 13.06		19.86 ± 10.12			
38.4 ± 14.32		21.06 ± 12.73					
40.0 ± 20.14		20.66 ± 13.49					
7.3 ± 3.8	9.8 ± 6.9	5.2 ± 1.4	4.7 ± 7.5				
	8.7 ± 5.4		5.8 ± 4.3				

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Appendix Table 2—Continued

Study, Year (Reference)	Rating of Results†	Outcome Measures Reported (Scale)	Initial Pain Intensity		Pain Intensity at Follow-up					
					Short-Term		Intermediate		Long-Term	
			Ex	C	Ex	C	Ex	C	Ex	C
<b>Unclear population</b>										
Ljunggren et al., 1997 (45)	Positive Positive	RTW								

\* Values are means ( $\pm$ SD) for pain and functional impairment as presented in the study publications, unless otherwise noted. Additional rows for studies report results for additional treatment groups. ADL = activities of daily living scale; ADS = Activity Discomfort Scale; APS = Aberdeen Pain Scale (out of 100 points); BU = Berquist-Ullman functional limitations; C = comparison group; COS = clinical overall score (out of 1000 points); Ex = exercise therapy group; LOM = loss of mobility dimension (out of 100 points); MPQ = McGill Pain Questionnaire (out of 78 points); MRS = Manniche low back pain rating scale (out of 100 points); NRS = numerical rating scale (11-point scale); ODQ = Oswestry Disability Questionnaire (out of 100 points); OEP-VAS = mean visual analogue scale of 13 pain-related questions; PDI = Pain and Disability Index; PPI = present pain intensity of McGill Pain Questionnaire (out of 5 points); QDI = Quebec Disability Index; RMDQ = Roland Morris Disability Questionnaire (out of 24 points, unless otherwise noted); RTW = return to work; SIP = Sickness Impact Factor—Physical (out of 100 points); VAS = visual analogue scale (out of 100 points, unless otherwise noted); WHY = West Haven Yale questionnaire.

† Qualitative, consensus-derived reviewer rating of overall conclusions about the effectiveness of the exercise intervention, with exercise groups listed in same order as described in Table 2.

‡ Values are median ( $\pm$ SD) calculated from the most conservative interquartile range presented.

§ Values presented calculated from rate of change ( $\pm$ SD).

|| Galantino et al. (85) was excluded from quantitative syntheses because of flaw: small study with >50% loss to follow-up.

Appendix Table 2—Continued

Initial Functional Impairment		Functional Impairment at Follow-up					
		Short-Term		Intermediate		Long-Term	
Ex	C	Ex	C	Ex	C	Ex	C