SPINE Volume 25, Number 21, pp 2784–2796

Exercise Therapy for Low Back Pain

A Systematic Review Within the Framework of the Cochrane Collaboration Back Review Group

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Study Design. A systematic review of randomized controlled trials was performed.

Summary of Background Data. Exercise therapy is a widely used treatment for low back pain.

Objectives. To evaluate the effectiveness of exercise therapy for low back pain with regard to pain intensity, functional status, overall improvement, and return to work.

Methods. The Cochrane Controlled Trials Register, Medline, Embase, PsycLIT, and reference lists of articles were searched. Randomized trials testing all types of exercise therapy for subjects with nonspecific low back pain with or without radiation into the legs were included. Two reviewers independently extracted data and assessed trial quality. Because trials were considered heterogeneous with regard to study populations, interventions, and outcomes, it was decided not to perform a meta-analysis, but to summarize the results using a rating system of four levels of evidence: strong, moderate, limited, or none.

Results. In this review, 39 trials were identified. There is strong evidence that exercise therapy is not more effective for acute low back pain than inactive or other active treatments with which it has been compared. There is conflicting evidence on the effectiveness of exercise therapy compared with inactive treatments for chronic low back pain. Exercise therapy was more effective than usual care by the general practitioner and just as effective as conventional physiotherapy for chronic low back pain.

Conclusions. The evidence summarized in this systematic review does not indicate that specific exercises are effective for the treatment of acute low back pain. Exercises may be helpful for patients with chronic low back pain to increase return to normal daily activities and work. [Key words: Cochrane Collaboration, effectiveness, exercise, low back pain, systematic review] **Spine 2000; 25:2784–2796**

Low back pain is a major health problem among populations in Western industrialized countries, and a major cause of medical expenses, absenteeism, and disability.[55] Although low back pain usually is a self-limiting and benign disease that tends to improve spontaneously over time,[56] a many varied therapeutic interventions are available for the treatment of low back pain.[46,54] However, the effectiveness associated with most of these interventions has not yet been demonstrated beyond doubt and, consequently, the therapeutic management of low back pain varies widely. One of the major challenges for researchers in the field of low back pain is to provide evidence of which treatment, if any, is of most benefit for subgroups of patients with low back pain. In this systematic review, the results on the effectiveness of exercise therapy are presented.

Exercise therapy is a widely used treatment for low back pain. The authors previously conducted a systematic review on the effectiveness of physiotherapy exercises for back pain.[27] In this review 16 randomized controlled trials (RCTs) were included, most of which were considered to be of poor methodologic quality. No conclusion could be drawn on whether exercise therapy is more effective than other conservative types of treatment, and little evidence was found in favor of a specific type of exercise (*e.g.,* back or abdominal strengthening, McKenzie, Williams, flexion, extension, or stretching exercises). An update of the evidence on exercise therapy was included in a systematic review of conservative treatment for acute and chronic low back pain.[54] Ten trials on acute and 16 trials on chronic low back pain were included, and it was concluded that strong evidence exists showing both that exercise therapy is not effective for acute low back pain and that exercise therapy is effective for chronic low back pain.

Because the authors' previous reviews were based on literature published before 1995, and because several new RCTs have been published since, an update of this review seemed indicated. Furthermore, recent developments in the methodology of systematic reviews have been used. The objective of this systematic Cochrane review was to determine whether exercise therapy is more effective than reference treatments for nonspecific low back pain, and to determine which type of exercise is most effective.

Methods

Criteria Used in Considering Studies for This Review.

Types of Studies. Only RCTs were included in this review.

Types of Participants. Only RCTs that involved subjects ages 18 to 65 years who had been treated for nonspecific low back pain in a primary health care or occupational setting were included in this review. Low back pain was defined as pain

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Potential conflict of interest: A.M. is the first author of one of the trials included in this review. The methodologic quality assessment and data extraction of this trial were performed by two other reviewers (B.K. and M.v.T.).

located below the scapulas and above the cleft of the buttocks, with or without radiation to the lower extremities, including nerve root pain or sciatica. All RCTs that involved subjects with low back pain caused by specific pathologic entities such as infection, neoplasm, metastasis, osteoporosis, rheumatoid arthritis, or fractures were excluded.

Types of Interventions. This review included RCTs that used one or more types of exercise therapy. All types of exercises were included, such as specific back exercises as well as abdominal, flexion, extension, static, dynamic, strengthening, stretching or aerobic exercises, if they were prescribed or performed in the treatment of low back pain. Additional physical treatment methods such as ultrasound or short-wave diathermy were allowed. However, RCTs in which the exercise therapy was given as part of a back school or multidisciplinary treatment program were excluded.

Types of Outcome Measures. An RCT was included if it used at least one of the four primary outcome measures the authors considered to be the most important: 1) pain visual analog scale, 2) a global measure (*e.g.,* overall improvement, proportion of patients recovered, subjective improvement of symptoms), 3) an assessment of back pain–specific functional status (*e.g.,* Roland Disability Questionnaire, Oswestry Scale), and 4) return to work (*e.g.,* return to work status, days off work). Physiologic outcomes of physical examination (*e.g.,* range of motion, spinal flexibility, degrees of straight leg raising or muscle strength) and generic functional status (*e.g.,* SF-36 [Short Form 36], Nottingham Health Profile, Sickness Impact Profile) were considered secondary outcomes. Other outcomes such as medication use and side effects also were considered.

Search Strategy for Identification of Studies. All relevant RCTs meeting the inclusion criteria were identified by the following:

A computer-aided search of the Medline (from 1966 to April 1999), Embase (from 1988 to September 1998), and Psyclit (from 1984 to April 1999) databases using the search strategy recommended by the Editorial Board of the Cochrane Back Review Group.[53] If RCTs were published in English, Dutch, Finnish, and German, they were included because the reviewers who conducted the methodologic quality assessment and data extraction were able to read papers published in these languages. The complete search strategy is available on request.

Screening references given in relevant reviews and identified RCTs.

Screening of the Cochrane library, 1999, Issue 1.

Methods of the Review.

Study Selection. The study selection was performed in two stages. First, two reviewers (R.E. and M.vT.) independently selected the trials published up to December 1996 for inclusion in the systematic review. They both conducted the search strategy and selected the RCTs. The same two reviewers also independently applied the selection criteria to the studies retrieved by the literature search. Consensus was used to resolve disagreements concerning selection and inclusion of RCTs, and a third reviewer (BK) was consulted if disagreements persisted. Second, two reviewers (B.K. and M.vT.) updated the search to April 1999 using the same strategy and methods.

Methodologic Quality Assessment. The methodologic quality of the RCTs up to December 1996 was assessed independently by two reviewers (A.M. and M.vT.), who were blinded with regard to the authors, institution, and journal. The methodologic quality of the additional nine studies identified after 1996 also was assessed independently by two reviewers (B.K. and M.vT.), but they could not be blinded because they had selected the studies themselves just a few weeks before they performed the quality assessment.

A modified version of the criteria list from previous systematic reviews[27,54] was used to assess the methodologic quality of the RCTs (Table 1). As compared with the original criteria list, only items reflecting the internal validity of the RCTs were included, and equal weights were assigned to all items. Each item was scored positive, negative, or unclear. The quality assessment was pilot tested (by A.M. and M.vT.) using three RCTs on back pain but not on exercise therapy. A consensus method was used to resolve disagreements, and a third reviewer was consulted if disagreements persisted. If the article did not contain information on the methodologic criteria, the authors were contacted for additional information. If the authors could not be contacted or if the information was no longer available, the criteria were scored as "unclear."

Data Extraction. Two reviewers (again, A.M. and M.vT. blinded for studies up to December 1996 and B.K. and M.vT. nonblinded for the studies published from 1997 to April 1999) independently extracted the data using a standardized form. A consensus method was used to resolve disagreements, and a third reviewer was consulted if disagreements persisted. Data extraction was pilot tested (by A.M. and M.vT.) using three RCTs on back pain but not on exercise therapy.

Data Analysis. Clinical homogeneity was evaluated by exploring the differences between the RCTs with regard to study population, types of exercises and reference treatments, and outcomes and measurement instruments. Studies were considered heterogeneous with regard to study populations, interventions, and outcomes. Therefore, it was decided not to perform a meta-analysis, but to summarize the results using a rating system for levels of evidence. The rating system comprised the following four levels of scientific evidence that had been used in previous systematic reviews in the field of back pain,[54] which were based on the quality and outcome of the studies:

Level 1. Strong evidence: provided by generally consistent findings in multiple high-quality RCTs

Level 2. Moderate evidence: provided by generally consistent findings in one high-quality RCT and one or more low-quality RCTs, or by generally consistent findings in multiple low-quality RCTs

Level 3. Limited or conflicting evidence: provided by only one RCT (either high or low quality) or inconsistent findings in multiple RCTs

Level 4: No evidence: no RCTs.

High-quality studies were defined as RCTs that fulfilled five or more of the validity criteria, but that also performed sensitivity analyses exploring the results when high quality was redefined using other thresholds, and exploring the results if high quality was defined as having adequate concealment of treatment allocation.

Subgroup analyses were conducted for 1) acute and subacute low back pain (12 weeks or less) and chronic low back

Table 1. Methodologic Quality Criteria

Concealment of treatment allocation	Yes	No	Do not know
Withdrawal/dropout rate	Yes	No	Do not know
Cointerventions avoided or equal	Yes	No	Do not know
Blinding of patients	Yes	No	Do not know
Blinding of observer	Yes	No	Do not know
Intention-to-treat analysis	Yes	No	Do not know
Compliance	Yes	No	Do not know
Similarity of baseline characteristics	Yes	No	Do not know
Blinding of care provider	Yes	No	Do not know

pain (more than 12 weeks), and 2) low back pain with and without radiation.

Results

Study Selection

The Medline search up to April 1999 resulted in 156 references to potential studies. The agreement between the two reviewers who did the selection was 76%. The Embase search resulted in 304 references, and agreement was 87%. Disagreements were discussed and resolved, if necessary by reading the whole paper. If both reviewers were not sure about inclusion of a study from the title, abstract, and key words in Medline and Embase, they applied for a copy of the paper and used it for a final decision.

A total of 46 articles on 40 RCTs were identified. One study was excluded from this systematic review because it had no clear contrast for exercises.[47] Two trials were reported in one article,[60] and several trials were reported in two articles (*i.e.,* studies by Gilbert et al,[14,22] Manniche et al,[35,36] Stankovic and Johnell,[48,49] Faas et al,[17,18] and Frost et al.[20,21] One trial by Lindström[30,31] was reported in two articles and a doctoral thesis.[29] Finally, 39 RCTs were included that all were published in English.

Study Characteristics

Only two studies had included a homogeneous population of patients who had low back pain without radiation.[51,52] Only four studies had included a homogeneous population of patients with radiating symptoms or sciatica.[8,28,39,40] Four studies did not clearly report whether patients who had low back pain with or without radiation were included.[13,43,48,49,61] The remaining 29 studies included a mixed population of patients with and without radiating symptoms.

Of the 39 trials, 12 studies reported on acute low back pain;[7,10,14,17–19,22,34,39,40,44,48,49,52,59] 23 studies reported on chronic patients with low back pain;[3,5,6,11,13,20,21,23–26,28–31,33,35–38,41,42,45,50,51,60] 3 studies reported on a mixed population of patients with acute and chronic low back pain;[8,9,61] and 1 study did not report any information on the duration of symptoms.[43]

In three studies, the study population consisted of women only.[3,39,40] In two studies, only men were included,[60] and in one study it the male-to-female ratio was not reported.[26] All the remaining 33 studies included both genders. The Interventions section of Table 3 shows that the exercise therapies varied in intensity from low-intensity (*e.g.,* walking)[50] to high-intensity exercises (*e.g.,* graded activity program,[29–31,50] dynamic endurance exercises,[25] and an intensive training program).[44] Interventions also varied in duration from three treatment sessions in 5 days[10] to 12 months of home exercise training.[3,33]

Methodologic Quality

The reviewers disagreed on 122 of the 351 scores (35%). Disagreements were resolved in most cases, and a third reviewer had to make the final decision only twice. Requests to comment on the quality score and to provide more information were sent to all but five authors because it was not possible to find a recent address for them. One posted envelope was returned because the address was insufficient. Of the 39 study authors, a total of 18 responded.[5,7,8,11,13,20,21,23 24,33,35–37,39,40,42,45,50–52,59] On the basis of their comments and information, it was decided to change 31 assessments (19%): 18 "unclear" scores became "positive"; 4 "unclear" scores became "negative"; 8 "negative" scores became "positive"; and 1 "positive" score became "negative."

The final assessment (Table 2) showed that 16 (41%) of the 39 RCTs included in this systematic review of exercise therapy for low back pain were considered high-quality studies.[5,7,11,17,18,20,21,23,24,29–31,33–37,39,41,45,50] All but 2 of these 16 high-quality studies were published in 1990 or after, whereas only 7 of the 23 low-quality RCTs were published in 1990 or after.

Effectiveness of Exercise Therapy

Because only two studies had included a homogeneous population of patients with low back pain and no radiation,[51,52] and only four studies had included a homogeneous population of patients with radiating symptoms or sciatica,[8,28,39,40] it was not useful to perform subgroup analyses for radiation *versus* no radiation.

Exercise Therapy *Versus* Other Active Treatment. In 19 studies, exercise therapy was compared with another active conservative treatment. Two of these studies reported on a mixed population with acute and chronic low back pain and thus were not included in the subgroup analyses reported in the following sections.[8,61]

Acute Low Back Pain (12 Weeks or Less). Eight RCTs involving 1149 patients with acute low back pain compared exercise therapy with another active conservative treatment: usual care by a primary care physician in three studies,[17,18,44,52] manual therapy in five studies,[7,19,40,44,59] back school in one study,[48,49] and nonsteroidal anti-inflammatory drugs (NSAIDs) in one study.[59] Two studies were of high quality.[7,17,18]

Only one low-quality study reported better outcomes for the exercise therapy group on primary outcomes (*i.e.,* pain and return to work), as compared with a mini back school.[48,49] Two studies reported better recovery[19] and more improvement in spinal flexion[40] with manipulation than with exercise. The

Table 2. Quality Assessment of Randomized Controlled Trials on the Effectiveness of Exercise Therapy for Low Back Pain

Reference	1	2	3	4	5	6	7	8	9	Total
Bentsen et al[3]	+	+	−	−	−	+	−	+	−	4
Bronfort et al[5]	+	−	+	+	+	+	+	+	−	7
Buswell[6]	?	−	−	−	−	−	−	?	−	0
Cherkin et al[7]	+	+	+	−	−	+	+	+	−	6
Coxhead et al[8]	?	+	−	−	−	+	−	+	−	3
Davies et al[9]	?	+	−	−	+	−	−	?	−	2
Delitto et al[10]	?	?	−	−	−	+	−	−	−	1
Deyo et al[11]	+	+	+	−	+	+	+	+	−	7
Elnaggar et al[13]	+	−	−	−	+	+	−	+	−	4
Faas et al[17,18]	+	+	+	−	−	+	+	+	−	6
Farrell & Twomey[19]	?	+	−	−	+	+	−	+	−	4
Frost et al[20,21]	+	+	−	−	+	+	+	+	−	6
Evans et al,[14] Gilbert et al[22]	?	+	−	−	−	−	−	+	−	2
Hansen et al[23]	+	+	+	−	+	−	−	+	−	5
Hemmilä et al[24]	+	+	+	−	+	+	−	+	−	6
Johanssen et al[25]	?	−	−	−	−	−	−	?	−	0
Kendall & Jenkens[26]	?	+	−	−	−	−	−	−	−	1
Lidström & Zachrisson[28]	?	+	−	−	?	+	−	?	−	2
Lindström et al[29–31]	+	+	+	−	+	+	+	+	−	7
Ljunggren et al[33]	+	+	−	−	−	+	+	+	−	5
Malmivaara et al[34]	+	+	+	−	+	+	+	+	+	8
Manniche et al[35,36]	+	+	+	−	+	+	−	+	−	6
Manniche et al[37]	+	−	+	−	+	+	−	+	−	5
Martin et al[38]	−	−	−	−	−	−	−	−	−	0
Nwuga & Nwuga[39]	−	+	−	−	+	+	+	+	−	5
Nwuga[40]	−	+	−	−	+	+	−	+	−	4
O'Sullivan et al[41]	+	+	+	−	+	−	+	+	−	6
Risch et al[42]	−	+	−	−	−	+	−	+	−	3
Sachs et al[43]	−	+	−	−	−	+	−	?	−	2
Seferlis et al[44]	?	−	?	−	+	+	+	+	−	4
Snook et al[45]	−	+	−	+	+	+	+	+	−	6
Stankovic & Johnell[48,49]	+	+	?	−	?	+	−	+	−	4
Torstensen et al[50]	+	+	+	−	+	+	+	+	−	7
Turner et al[51]	+	−	−	−	−	−	−	+	−	2
Underwood & Morgan[52]	+	+	−	−	−	+	−	−	−	3
Waterworth & Hunter[59]	−	+	+	−	−	+	−	+	−	4
White '66a	?	+	+	−	−	+	−	?	−	3
White '66b	?	+	−	−	−	+	−	?	−	2
Zylbergold & Piper[61]	?	+	−	−	−	+	−	+	−	3

+ = positive, − = negative, ? = unclear.

other five studies did not find significant differences in pain intensity, functional status, or overall improvement between exercise and other active treatments. Therefore, there is strong evidence (Level 1) that exercise therapy is not more effective for acute low back pain than other active treatments with which it has been compared.

Chronic Low Back Pain (More Than 12 Weeks). Nine RCTs involving 1105 patients with chronic low back pain compared exercise therapy with another active conservative treatment: usual care by a primary care physician in three studies,[29–31,41,60] conventional physiotherapy (consisting of hot packs, massage, traction, mobilization, short-wave diathermy, ultrasound, stretching, flexibility and coordination exercises, electrotherapy) in three studies,[23,24,50] manual therapy in one study,[24] back school in one study,[20,21] behavior therapy in one study,[51] and instructions in the control of early morning lumbar flexion in one study.[45] Seven studies were of high quality.[20,21,23,24,29–32,41,45,50]

The three studies (all of high quality) comparing exercises with conventional physiotherapy did not show any significant differences with regard to pain intensity, functional status, overall improvement, or return to work.[23,24,50] Therefore, there is strong evidence (Level 1) that exercise therapy and conventional physiotherapy are equally effective for chronic low back pain.

Two high-quality studies compared exercises with usual care by a general practitioner and reported better outcomes for the exercise group in terms of return to work,[29–31] pain intensity, and functional status.[41] One low-quality study comparing exercises with usual care also reported better return to work in the exercise group.[60] Therefore, there is strong evidence (Level 1) that exercise therapy is more effective than usual care by a general practitioner for chronic low back pain.

The other studies found limited evidence (Level 3) that exercises provided better outcomes in terms of pain and functional status than back school education,[20,21] and that exercises plus operant-conditioning behavior therapy provided better outcomes on pain and generic functional status than exercises alone.[51] However, there is limited evidence (Level 3) that early morning lumbar flexion control provides better outcomes in terms of pain and functional status than exercises, but these exercises were chosen as a control in this study because they had been shown to be ineffective.[45] There is also limited evidence (Level 3) that manual therapy provides better pain relief than exercise for chronic low back pain.[24]

Table 3. Study Characteristics

Study	Participants	Interventions	Outcomes
Bentsen et al[3]	74 women with chronic nonspecific LBP with or without radiation, age 57 yrs.	(I1) Home training plus dynamic strength exercises: 3 back and abdominal strengthening exercises, 10 times a day at home, 1 yr, plus dynamic exercises at fitness center, gradually intensified, 30 min, twice a week, 3 mos (n = 41). (I2) Home training: 3 back and abdominal strengthening exercises, 10 times a day, 1 yr (n = 33).	Functional status (Million scale) significantly different at baseline and after 12 mos, but not after 3 mos. (I1) More improved after 12 months (data in graphs). Data poorly presented.
Bronfort et al[5]	174 patients with nonspecific chronic LBP with or without radiation, 93 men and 81 women, ages 20–60 yrs.	(I1) Strengthening exercises plus spinal manipulative therapy: trunk and leg extension exercises, abdominal muscle strengthening, 20 repetitions each, 1 hour, 20 sessions, 11 weeks (n = 71). (I2) Stretching exercises plus spinal manipulative therapy: 20 1-hour sessions, 11 weeks (n = 71). (R) Strengthening exercises plus NSAIDs (500 mg naproxen, twice a day): trunk and leg extension exercises, abdominal muscle strengthening, 20 repetitions each, 1 hour, 20 sessions, 11 weeks (n = 71).	Mean pain intensity (11-point scale) after 5 and 11 weeks adjusted for baseline values: (I1) 3.4 ± 1.9, 2.7 ± 2.0; (I2) 3.9 ± 2.1, 3.3 ± 2.3. Mean functional status (RDQ) after 5 and 11 weeks: (I1) 19.1 ± 19.3, 15.1 ± 17.4; (I2) 20.8 ± 17.3, 18.4 ± 17.1. Mean generic health (COOP charts) after 5 and 11 weeks: (I1) 71.9 ± 14.3, 75.4 ± 12; (I2) 72.0 ± 16.5, 74.8 ± 16.3. No significant differences.
Buswell[6]	50 patients with chronic recurrent LBP with or without radiation referred to physiotherapy, 31 men and 19 women, ages 16–59 yrs.	(I1) Flexion program, 8–14 treatments (n = 25) (I2) Extension program (McKenzie), 8–14 treatments (n = 25).	Improvement of total pain at baseline and after treatment: (I1) 5.5, 2.5, (I2) 6.0, 2.8; static pain: (I1) 4.3, 2.0, (I2) 3.6, 2.5; pain on movement: (I1) 2.5, 0.4, (I2) 1.5, 1.1; pain lying: (I1) 1.1, 0.4, (I2) 1.1, 0.7; pain sitting: (I1) 2.4, 0.4, (I2) 2.4, 1.1; pain standing: (I1) 2.4, 0.7, (I2) 2.0, 0.8. No significant differences.
Cherkin et al[7]	323 patients with acute low back pain with or without radiation, 168 men and 155 women, ages 20–64 yrs, visiting primary care physician, still pain after 7 days.	(I) McKenzie exercises that centralize symptoms, experienced, trained physical therapists, McKenzie back book, lumbar support cushion, up to 9 treatments at discretion of therapist, 1 mo (n = 133). (R1) Chiropractic manipulation, short-lever, high-velocity thrust, experienced chiropractors, up to 9 treatments at discretion of chiropractor, no other physical treatments permitted (n = 122). (R2) Educational booklet (n = 66).	Mean (95% CI) global improvement (bothersomeness 11-point NRS) at baseline and after 4 and 52 weeks: (I) 6.0 (5.6–6.5), 2.3 (1.9–2.8), 2.7 (2.2–3.2); (R1) 5.5 (5.1–5.8), 1.9 (1.5–2.2), 2.0 (1.6–2.4); (R2) 5.3 (4.9–5.7), 3.1 (2.4–3.9), 3.2 (2.4–4.0); mean (95% CI) functional status (RDQ): (I) 12.2 (11.2–13.1), 4.1 (3.3–4.9), 4.1 (3.2–5.0); (R1) 12.1 (11.2–13.1), 3.7 (2.9–4.5), 3.1 (2.4–3.9); (R2) 11.7 (10.4–13.0), 4.9 (3.8–6.0), 4.3 (3.1–5.5). Mean costs of care over 2 years: (I) $437; (R1) $429; (R2) $153. No significant differences between (I) and (R1) or between I and R2. Significantly more patients rated care good or excellent after 4 weeks in I and R1 than in R2.
Coxhead et al[8]	334 patients with acute and chronic LBP with sciatica, 185 men and 149 women, mean age 41.9 ± 12.2 yrs. Mean duration of symptoms at baseline 14.3 ± 16.1 weeks.	(I) Exercises including all ranges of motion and muscle groups, 4 weeks, daily first week and decreasing frequency in the next 3 weeks, duration and intensity at physiotherapist's discretion (n = 150). (R) Traction, motor-driven Tru-Trac apparatus, intermittent traction at preset forces and time intervals, 4 weeks, or manipulation, 4 weeks, or corset, ready-made fabric lumbar support, 4 weeks, daily first week and decreasing frequency in the next 3 weeks, duration and intensity at physiotherapist's discretion (n = 142).	No. (%) of patients improved after 4 weeks and 4 mos: (I) 120 (80), 85 (69); (R) 107 (75), 96 (76). Mean improvement on pain scale (−100 to +100) after 4 weeks: (I) 49.0 ± 40.0, (R) 46.3 ± 38.2. No. (%) returned to work after 4 weeks of those off work at baseline: (I) 16 (33); (R) 17 (32).
Davies et al[9]	47 patients with LBP 3 weeks to 6 mos duration, with or without radiation, interfering with their usual sporting activities, 32 men and 11 women who completed 4 weeks treatment, ages 15–45 yrs.	(I1) Extension exercises, patients lying prone and raising their trunks, and short-wave diathermy, 4 weeks, supervised by physiotherapist (n = 14). (I2) Isometric flexion, strengthening abdominal and trunk muscles in lying and standing position, and short-wave diathermy, 4 weeks, supervised by physiotherapist (n = 14). (R) Short-wave diathermy, 4 weeks (n = 15).	No. of patients showing improvement after 2 and 4 weeks: (I1) 11, 13; (I2) 7, 12; (R) 8, 10. Not significant.
Delitto et al[10]	24 patients with acute or subacute (<7 weeks) LBP with or without radiation referred to physical therapy, 14 men and 10 women, ages 14–50 yrs.	(I1) McKenzie extension (prone press-ups) and mobilization of the anterior superior iliac spine, 3 times per week, supervised by physical therapist, handout, advice to exercise at home (n = 14). (I2) Williams flexion exercises, 3 times per week, supervised by physical therapist, handout, advice to exercise at home (n = 10).	Mean functional status (Oswestry) at baseline and after 3 and 5 days: (I1) 34 ± 4, 21 ± 4, 10 ± 4; (I2) 41 ± 3.5, 35 ± 3.5, 32 ± 4. I1 significantly more improved than I2.
Deyo et al[11]	145 patients with chronic (>3 mos) nonspecific LBP with or without radiation, self-referred through newspaper advertisements, 61 men and 84 women, ages 18–70 yrs.	(I1) Relaxation and stretching exercises (identical to I2) and TENS (identical to R1) (n = 34). (I2) Relaxation and stretching exercises, uniform set of 12 sequential exercises, leg-stretching, bend-sitting, heel-cord, hamstring and knee-chest stretching, 2–3 repetitions every day, repeated instructions and feedback, and sham TENS (n = 29). (R1) TENS: conventional high-frequency TENS, 80–100 pulses per sec, amplitude 30, 2 weeks, acupuncture-like TENS for 2 weeks, method of preference for 2 weeks (n = 31). (R2) Sham TENS: identical to R1 but nonfunctioning device (n = 31).	Difference (95% CI) between I1 and I2 versus R1 and R2 after 4 and 12 weeks in improvement of pain (VAS 0–100): 14.3 (2.7, 26.2), 7.0 (−6.4, 20.1); exercise significantly better after 4 weeks. Difference in pain intensity (100-mm VAS) after 4 and 12 weeks: −6.1 (−13.3, 1.3), 0.9 (−8.0, 9.7); no significant differences. Difference in functional status (SIP) after 4 and 12 weeks: −0.07 (−2.2, 0.9), −0.07 (−1.9, 1.7); no significant differences.

Table 3. (Continued)

Study	Participants	Interventions	Outcomes
Elnaggar et al[13]	56 patients with chronic (3 mos or more) nonspecific (mechanical) LBP, 28 men and 28 women, ages 20–50 yrs.	(I1) McKenzie extension exercises: 30 min per day, 2 weeks, 7 sessions each week, 3 sessions supervised by physiotherapist, 4 sessions at home, 6 types of exercises, 10 repetitions each (n = 28). (I2) Williams flexion exercises: 30 min per day, 2 weeks, 7 sessions each week, 3 sessions supervised by physiotherapist, 4 sessions at home, 6 types of exercises, 10 repetitions each (n = 28).	Mean scores on McGill Pain Questionnaire (range, 0–78) pretreatment and posttreatment: (I1) 15.9 ± 7.8 and 10.6 ± 8.6 *vs* (I2) 14.1 ± 9.8 and 8.9 ± 9.4. No significant difference.
Faas et al[17,18]	473 patients with acute (<3 weeks) nonspecific LBP with or without radiation above the knee consulting a GP, 270 men and 203 women, ages 16–65 yrs.	(I) Stretching, flexion, side movements, isometric abdominal exercises and information, individual treatment by physiotherapist, advice to exercise daily, 20 min, twice a week, 5 weeks (n = 156). (R1) Usual care by GP: analgesics on demand, information, discussion (n = 155). (R2) Placebo ultrasound therapy: 0.1 W/cm^2, no heat effect, 20 min, twice a week, 5 weeks (n = 162).	Mean decrease in pain intensity (85-mm VAS) after 1, 3, and 12 mos: (I) 19 ± 21, 24 ± 24, 26 ± 23; (R1) 22 ± 22, 24 ± 30, 27 ± 26; (R2) 19 ± 23, 22 ± 28, 26 ± 26. Percentage with recurrences during 12 mos follow-up: (I) 70%; (R1) 70%; (R2) 66%. No significant differences in no. of recurrences, duration of pain, or functional status (NHP) during 1-yr follow-up. Only NHP energy more improved in I than in R1 during first 3 mos.
Farrell & Twomey[19]	56 patients with acute (<3 weeks) nonspecific LBP with or without radiation, 30 men and 18 women completed the study and were included in the analysis, ages 20–65 yrs.	(I) Isometric flexion exercises for abdominal muscles and short-wave diathermy, physiotherapist, 3 times a week, 3 weeks, plus ergonomic instructions and advice to exercise 3–4 times a day at home (n = 24). (R) Passive manipulation and mobilization by physiotherapist, 3 times a week, 3 weeks (n = 24).	Mean no. of treatments to reach symptom-free status: (I) 5.8 ± 2.3; (R) 3.5 ± 1.6. No. of patients symptom-free within 2 weeks: (I) 7; (R) 16; R significantly better than I. Mean pain score (0–10 scale) at baseline and after 3 weeks: (I) 5.2, 0.3, (R) 4.9, 0.3; not different.
Frost et al[20,21]	81 patients with chronic (>6 mos) nonspecific LBP with or without radiation, referred to a hospital orthopedic outpatient department, 34 men and 37 women who completed the study and were included in the analysis, ages 18–55 yrs.	(I) Fitness program, warmup, stretching, progressive exercises, light aerobic exercises 8 1-hour sessions, 4 weeks, and back school education (n = 36). (R) Back school education, discussion, advice regarding functional activities and exercise, relaxation techniques, ergonomic advice, video on prevention (n = 35).	Mean scores on functional status (Oswestry) and pain (0–100 scale) pretreatment: (I) 23.6 ± 9.7, 20.9 ± 12.3 vs (R) 23.6 ± 12.3, 25.6 ± 17.9 and posttreatment: (I) 17.6 ± 10.9, 12.1 ± 9.9 vs (R) 21.7 ± 13.6, 22.1 ± 20.1. I significantly more improved than R. After 6 months I significantly more improved functional status than R. After 2 yrs, mean reduction in functional status significantly better in I (7.7%) than R (2.4%).
Evans & Gilbert[14,22]	252 patients with acute nonspecific LBP with or without radiation, 128 men and 124 women, ages 16 yrs and older.	(I1) Isometric flexion program, 5 repetitions of 5 types of sit-up and pelvic tilt exercises, 20 min, 2 mos or longer if back pain persisted or recurred, education, bed rest (n = 65). (I2) Isometric flexion program, and bed rest (identical to I1 and R1) (n = 62). (R1) Bed rest, advice to remain in bed for at least 4 days (n = 60). (R2) No intervention (n = 65).	No. of patients reporting no pain after 6 and 12 weeks: (I1) 34, 47; (I2) 33, 46; (R1) 36, 44; (R2) 33, 43. No significant differences in pain, mobility, or daily activities.
Hansen et al[23]	180 patients with (sub)chronic LBP with or without radiation, self-referred through internal company newspaper, 123 men and 57 women, ages 21–64 yrs.	(I) Intensive dynamic back-muscle training: trunk lifting, leg-lifting, pull to the neck, 5 series of 10 repetitions each, total of 300 contractions, 1-hour sessions twice weekly for 4 weeks (n = 60). (R1) Physical therapy: manual traction, hot packs, massage and flexibility, coordination and slowly progressive back and abdominal muscle exercises, 1-hour sessions twice weekly for 4 weeks (n = 59). (R2) Placebo control: semihot packs and light traction (10% of body weight), 1-hour sessions twice weekly for 4 weeks (n = 61).	No significant differences in pain level (10-point scale) between groups posttreatment and after 1, 6, and 12 mos. Overall treatment effect (10-point scale) of I and R1 significantly higher at all evaluations than R2. No significant changes over time.
Hemmilä et al[97]	114 patients with nonspecific chronic LBP with or without radiation, referred to a health center, 65 men and 49 women, ages 17–64 yrs.	(I) Exercise program: bending and rotation exercises, 10 times every 15 min, sit-up, arch-up and trunk rotation exercises, 10 times each, twice a day, auto-stretching, maximum 10 1-hour sessions to ensure performance, 6 weeks (n = 35). (R1) Bone setting: gentle mobilization in sitting position, maximum 10 one-hour sessions, 6 weeks (n = 45). (R2) Physiotherapy: manual, thermal and electrotherapy (massage, manual traction, mobilization, hot/cold packs, short-wave diathermy, ultrasound, TENS), maximum 10 one-hour sessions, 6 weeks (n = 34).	Mean pain score (100-mm VAS) at baseline and after 6 weeks, 3 and 6 months: (I) 40, 30, 31, 29; (R1) 46, 30, 29, 25; (R2) 43, 25, 26, 25. After 6 mos R1 more improved than I, no other significant differences. No differences between groups in pain provocation score and pressure pain threshold.

Table 3. (Continued)

Study	Participants	Interventions	Outcomes
Johanssen et al[25]	40 consecutive patients with chronic (>3 mos) nonspecific LBP with or without radiation, still employed, 14 men and 13 women completed 3 mos training, ages 18–65 yrs.	(I1) Dynamic back, neck, and abdominal endurance exercises, stretching, warm-up, supervised by physiotherapist, greatest possible extension, up to 100 repetitions, 1-hour sessions, group training, twice a week, 3 months (n = 13). (I2) Coordination and balance exercises, warmup, jogging up to 40 repetitions, within limited ROM, group training, twice a week, 3 months (n = 14).	Median pain score (scale 0–8) pretreatment and after 3 and 6 mos (I1) 6, 3, 4 *vs* (I2) 6, 5, 4; not significant. Median disability score (scale 0–12) (I1) 6, 2, 1 *vs* (I2) 5, 3, 2; not significant.
Kendall & Jenkins[26]	47 patients with chronic nonspecific LBP with or without radiation, gender and age of population not reported.	(I1) Isometric flexion: strengthening abdominal and trunk muscles in lying and standing position, 12 repetitions each, 3 times a day, postural advice (n = 14). (I2) Mobilization and strengthening exercises: 6 types of exercises each in lying and kneeling position, 6–12 repetitions, twice a day, postural advice and lifting techniques (n = 14). (I3) Extension exercises, 5 types of strengthening back extensor muscles in lying and kneeling position, 6–12 repetitions each, twice a day, postural advice and lifting techniques (n = 14).	No. of patients symptom-free or improved after 1 and 3 mos (I1) 13, 11, (I2) 11, 8; (I3) 7, 6. I1 significantly better than I2 and I3.
Lidström & Zachrisson[28]	62 patients with LBP with sciatica for more than month, from orthopedic outpatient clinic, 29 men and 33 women, ages 21–61 yrs.	(I1) Mobilizing exercises (prone kneeling and supine lying positions) and strengthening exercises (back and abdominal muscles, isotonically), hot packs 15 min and massage, advice to exercise at home, 10 treatments by physiotherapist in 1 month (n = 21). (I2) Isometric strengthening of abdominal and hip extensor muscles, isometrically against maximum resistance, 6 times each, and intermittent pelvic traction for 20 min, instruction on Fowler position, 10 treatments by physiotherapist in 1 mo (n = 20). (R) Hot packs and rest (n = 21).	No. of patients with noticeable improvement after 4 weeks according to clinician and patient: (I1) 9, 10 (I2) 17, 18 and (R) 12, 14. Patients in I2 significantly better than I1 and R. Need for analgesics after treatment: (I1) 7; (I2) 0; (R) 4.
Lindström et al[29–31]	103 blue-collar workers sick-listed for 6 weeks because of nonspecific LBP with or without radiation, 71 men and 32 women, mean age 40.9 ± 10.8 yrs.	(I) Graded activity program: measurements of functional capacity, workplace visit, back school education, and individual, submaximal, gradually increased exercise program with an operant-conditioning behavioral approach (Fordyce), 3 days a week until return to work, no home exercises (n = 51). (R) Usual care by company health care physician (n = 52).	Proportion of patients returned to work within 6 or 12 weeks after randomization: (I) 59%, 80% *vs* (R) 40%, 58%. Significant. Mean duration of sick leave due to LBP during the second follow-up yr: (I) 12.1 ± 18.4 weeks *vs* (R) 19.6 ± 20.7 weeks. No differences in functional status after 1 yr.
Ljunggren et al[33]	153 patients with chronic nonspecific LBP with or without radiation, 70 men and 56 women completed the treatment and were included in the analysis, ages 18–65 yrs, occupationally active, previous physiotherapy.	(I) Conventional physiotherapy exercises, sit-ups, push-ups, back muscle strengthening, stretching, 3 series of 10 repetitions, 3 times a week, 12 mos (n = 64). (R) Specific exercises with TerapiMaster, mobilization, traction, strengthening of low back, thigh, buttocks, abdominal and chest muscles, 12 mos (n = 62).	Mean (SD) days of absenteeism and satisfaction post-treatment (12 mos): (I) 17.2 (6.0), 7.7 (1,8), (R) 15,4 (5.3), 7.7 (1.8), and at follow-up (24 mos):(I) 9.9 (3.2), 5.7 (1.3), (R) 9.3 (3.1), 5.6 (1.3). No significant differences between groups.
Martin et al[38]	50 patients with nonspecific LBP with or without radiation for at least 6 weeks, 18 men and 18 women completed the trial and were included in the analysis, ages 20–58 yrs.	(I1) Mobilizing and strengthening abdominal and back muscles, supervised by physiotherapist, 20 min, 3 times a week, 3 weeks, advice to exercise 20 min a day at home (n = 12). (I2) Isometric exercises to strengthen abdominal and pelvic floor muscles, supervised by physiotherapist, 20 min, 3 times a week, 3 weeks, advice to exercise 20 min a day at home (n = 12). (R) Detuned ultrasound (10 min) and detuned short-wave diathermy (10 min), 20 min, 3 times a week, 3 weeks (n = 12).	Pain intensity (5-point scale) at baseline and after 5 weeks: (I1) 2.0, 1.7; (I2) 1.8, 2.0; (R) 2.3, 1.35. Function scores (5-point scale) at baseline and after 5 weeks: (I1) 425, 250; (I2) 450, 400; (R) 380, 400. I1 and R significantly more improved on pain than I2.
Nwuga & Nwuga[39]	62 female patients with acute LBP due to prolapsed intervertebral disc, referred to physiotherapy, ages 20–40 yrs.	(I1) McKenzie extension plus postural instruction, no. and frequency of exercises to discretion of physiotherapist (n = 31). (I2) Williams flexion plus postural instruction, no. and frequency of exercises to discretion of physiotherapist (n = 31).	Change in 10-point pain rating after 6 weeks (I1) −5.3 *vs* (I2) −2.7. I1 significantly better than I2. No. (%) of patients returning for treatment after 2 mos: (I1) 5 (16), (I2) 9 (29).
Nwuga[40]	51 female patients with acute LBP due to prolapsed intervertebral disc, referred to physical therapy, ages 20–40 yrs.	(I) Isometric flexion (pelvic tilt) of back and abdominal muscles, 10 contractions for 5 sec and 10 sec relaxation, lifting and postural education, and short-wave diathermy, 20 min 3 times per week until pain was no longer present (n = 25). (R) Spinal manipulation, lumbar oscillatory rotation, lifting and postural education, 3 times per week until pain was no longer present (n = 26).	Improvement in degrees of spinal flexion and straight leg raising after 6 weeks: (I) 13, 4; (R) 34, 39. Manipulation significantly better than exercise. No. of patients (%) returning for treatment after 3 mos: (I) 7 (28); (R) 3 (11.5). No data on pain intensity, global improvement, or functional status.

Table 3. (Continued)

Study	Participants	Interventions	Outcomes
O'Sullivan et al[41]	44 patients with chronic (>3 mos) LBP with or without radiation, with radiologically confirmed spondylolysis or spondylolisthesis; 27 men and 15 women, ages 16–49 yrs.	(I) Specific training of the deep abdominal muscles, with coactivation of the lumbar multifidus proximal; gradual increase to 10 contractions with 10-sec holds; 10–15 min daily at home; weekly visit to physiotherapist experienced in this approach; 10 weeks (n = 22). (R) Usual care by medical practitioner; treatments (*e.g.*, regular weekly general exercise: swimming, walking, gym work), supervised exercise programs, trunk curl exercises, heat, massage, ultrasound; 10–weeks (n = 22).	Mean pain intensity (100-mm VAS) pretreatment, posttreatment, and after 3, 6, and 30 mos: (I) 59 ± 24, 19 ± 21, 27 ± 25, 25 ± 24, 23 ± 23, (R) 53 ± 26, 48 ± 23, 53 ± 24, 55 ± 25, 52 ± 22; mean functional status (Oswestry scale): (I) 29 ± 15, 15 ± 17, 16 ± 16, 15 ± 14, 15 ± 15; (R) 26 ± 16, 25 ± 18, 23 ± 16, 27 ± 18, 30 ± 20. I significantly more improved than R regarding pain intensity and functional status posttreatment and up to 30 mos follow-up.
Risch et al[42]	54 patients with chronic LBP with or without radiation, referred for rehabilitation, 34 men and 20 women, ages 22–70 years.	(I) Dynamic extension exercise program: 2 times a week for 4 weeks followed by once a week for 6 weeks (n = 31). (R) Waiting-list control group (n = 23).	Mean pain score pre- and posttreatment (I) 3.4 ± 1.6, 2.9 ± 1.7 *vs* (R) 3.7 ± 1.6, 4.1 ± 1.5; (I) significantly better. Mean physical disability score (SIP): (I) 9.1 ± 9.3, 7.7 ± 9.4 *vs* (R) 15.2 ± 10.4, 19.3 ± 15.6; (I) significantly better.
Sachs et al[43]	30 patients with back pain referred to work tolerance program, duration and type of symptoms not reported, 15 men and 15 women, mean age 35 ± 8 yrs.	(I1) Work tolerance rehabilitation program: stretching, strengthening, cardiovascular conditioning exercises, functional weight training, job simulation endurance, 4–6 hours, plus exercises on B-200 isostation, sagittal, lateral and rotation, 2 sets of 10 repetitions at 50% of maximum strength, 15 min (n = 14). (R) Work tolerance rehabilitation program: identical to I but without exercises on B-200 isostation (n = 16).	No significant difference in ROM after 3-week treatment period.
Seferlis et al[44]	180 patients sick-listed less than 2 weeks for LBP with or without sciatica, 95 men and 85 women, ages 19–64 yrs.	(I) Intensive training program, small groups, muscle training and general condition training, strength and coordination, abdominal, gluteal, paraspinal, shoulder and lower extremity muscles, 3 times per week, 8 weeks (n = 60). (R1) Manual therapy program, number of sessions decided by physiotherapist, autotraction, manipulation of lumbar facet joint and sacroiliac joint, mobilization, muscle energy technique, stretching, coordination training (n = 60). (R2) GP program, standard treatment, rest, sick leave, drug prescription, postural advice, back school or physiotherapy for patients failing to recover (n = 60).	No significant differences in pain intensity, functional status after 1, 3, and 12 mos between 3 groups. Median (range) no. of days off work due to back pain after 1 year: (I) 23 (5–365); (R1) 28 (4–365); (R2) 30 (4–365); no significant differences. Mean satisfaction with treatment (5-point scale) after 1, 3, and 12 mos: (I) 4.3 ± 0.8; 4.4 ± 0.6, 4.1 ± 1.1; (R1) 4.4 ± 0.8, 4.5 ± 0.6, 4.3 ± 0.9; (R2) 3.4 ± 1.2, 3.5 ± 1.1, 3.6 ± 1.2; I and R1 significantly better than R2. Mean no. of treatment sessions: (I) 18; (R1) 10; (R2) 4.
Snook et al[45]	85 patients with chronic or recurrent LBP, recruitment through local newspapers, ages 30–60 yrs.	(I) Exercises: pelvic tilt, modified sit-up, double knee to chest, hamstring stretch, side leg raise, and cat and camel, written instructions and videotape, 45 min, home exercises thereafter (n = 43). (R) Control of early morning lumbar flexion: getting out of bed without bending the back, subjects were told not to bend, squat, or sit for the first 2 hours every day, for 6 mos (n = 42).	Mean pain intensity (0–10 scale), disability days, medication days after 6 mos: (I) 2.79, 10.7, 49.9; (R) 1.52, 3.0, 16.7. No direct statistical comparison between groups was presented. Control group more improved, but baseline differences existed.
Stankovic & Johnell[48,49]	100 patients with acute (<4 weeks) LBP, still employed, 23 women and 77 men, mean age 34.4 ± 9.7 yrs.	(I) McKenzie extension exercise program: 20 min exercises and postural instructions to restore or maintain lumbar lordosis (n = 50). (R) Mini back school: one lesson of 45 min on back care and education including ergonomic instruction (n = 50).	Significantly less pain and better spinal mobility in I at 3 weeks and after 1 year (no data). No. of recurrences after 1 and 5 years significantly less in (I) 22/49, 30/47 than (R) 37/46, 37/42. Mean no. of days of sick leave: (I) 11.9 ± 6.5; (R) 21.6 ± 15.3, statistically significant. No. of subjects on sick leave during period from 1 to 5 years: (I) 24/47; (R) 32/42, statistically significant. Mean duration of sick leave during recurrences: (I) 84.1 ± 144.3 days; (R) 103.9 ± 181.5 days, not statistically significant.
Torstensen et al[50]	208 patients with chronic nonspecific LBP with or without radiation, from social security offices, sick-listed for 8–52 weeks, 103 men and 105 women, ages 20–65 yrs.	(I1) Progressively graded exercise therapy, groups with a maximum of 5, mobilizing hypomobile areas of the spine and stabilizing exercises for other parts, use of specially designed exercise equipment (pulleys, benches, bars, dumbbells), 7 to 9 different exercises, total of about 1000 reps per session, 15 min warmup period, sessions of 1 hour, 3 times per week, 12 weeks (n = 71). (I2) Self-exercise by walking, walking was unorganized and could be performed whenever the participant had time, 1 hour walking, 3 times per week, 12 weeks (n = 70).	Mean pain intensity (VAS) in low back at baseline, posttreatment and after 1 year: (I1) 53.1 ± 21.3, 37.2 ± 25.3, 40.5 ± 24.4; (I2) 55.0 ± 21.0, 50.4 ± 27.2, 50.0 ± 28.0; (R) 50.9 ± 19.2, 39.0 ± 28.0, 42.9 ± 29.5. I1 and R significantly better than I2 posttreatment and after 1 yr. Mean pain intensity (VAS) in leg at baseline, posttreatment and after 1 yr: (I1) 24.9 ± 21.3, 18.8 ± 24.9, 21.2 ± 21.7; (I2) 28.7 ± 28.8, 35.2 ± 33.9, 35.7 ± 33.8; (R) 24.2 ± 22.9, 24.5 ± 27.4, 25.7 ± 24.5.

Table 3. (Continued)

Study	Participants	Interventions	Outcomes
Torstensen et al[50] (continued)		(R) Conventional physiotherapy, combination of heat or cold, massage, stretching, electrotherapy, traction, few exercises on treatment table, treatment applied to what physiotherapist anticipated to be effective, sessions of 1 hour, 3 times per week, 12 weeks (n = 67).	I1 and R significantly better than I2 posttreatment. Mean functional status (ADL) at baseline, posttreatment and after 1 year: (I1) 51.7 ± 10.7, 46.2 ± 13.1, 44.1 ± 13.79; (I2) 50.0 ± 11.9, 52.7 ± 16.6, 50.6 ± 16.6; (R) 49.4 ± 10.5, 46.9 ± 13.1, 43.0 ± 12.9. I1 and R significantly better than I2 posttreatment and after 1 year No. (%) of patients completely satisfied with their treatment: (I1) 26 (34); (R) 19 (32); 6 (10). No. (%) of patients returned to work after 1 yr: (I1) 41 (58); (I2) 40 (57); (R) 42 (63); not significant. Indirect costs (I1) 7.05; (I2) 8.15; (R) 5.98 million Norwegian kroner.
Turner et al[51]	96 patients with chronic (>6 mos) nonspecific LBP without radiation referred by physician or self-referred, ages 20–65 yrs, 50 men and 46 women.	(I1) Aerobic exercises: walking/jogging program based on a quota system, progressing from 10 to 20 min and from 60% to 70% of maximum heart rate, warmup and cool-down stretching, 5 times a week, 8 weeks (n = 24). (I2) Aerobic exercises (identical to I1) and operant-conditioning behavioral therapy, spouses participated, 8 weekly 2-hour sessions, groups of 5–10 patients (n = 24). (R1) Operant-conditioning behavioral therapy with spouses participating (identical to I2), 8 weekly 2-hour sessions, groups of 5–10 patients (n = 25). (R2) Waiting-list control group (n = 23).	Mean scores on McGill Pain Questionnaire and SIP pretreatment (I1) 19.42, 8.42; (I2) 25.54, 8.50; (R1) 20.96, 7.90 and (R2) 21.17, 6.24 and posttreatment (I1) 17.52, 5.49; (I2) 12.41, 4.59; (R1) 17.71, 4.72 and (R2) 20.95, 5.37. I2 significantly more improved than I1 and R2. No significant differences between I1, I2, and R1 after 6 and 12 mos.
Underwood & Morgan[52]	75 patients with acute (<4 weeks) nonspecific LBP without radiation, from 1 general practice, 45 men and 30 women, ages 16–70 yrs.	(I) General advice plus teaching of McKenzie principles by experienced physiotherapist, groups up to 5 patients, 1 hour, educational leaflet, home exercises (n = 35). (R) General advice, usual care (n = 40).	Mean decrease in functional status (Oswestry scale) at baseline and after 4, 12, and 52 weeks: (I) 18.6, 21.5, 21.5; (R) 24.1, 28.6, 27.6. Mean decrease in pain intensity (100-mm VAS) at baseline and after 4, 12, and 52 weeks: (I) 26.4, 33.3, 35.8; (R) 27.0, 38.4, 36.7. No significant differences. Outcomes after 1 yr: back pain no problem in previous 6 mos, (I) 50%; (R) 14%.
Waterworth & Hunter[59]	112 patients with acute nonspecific LBP with or without radiation consulting a GP, 70 men and 38 women completed the trial and were included in the analysis, ages 18–50 yrs.	(I) Program of flexion and extension exercises, short-wave diathermy for 15–20 min, and ultrasound for 5–10 min by physiotherapist, 5 sessions of 45 min per week, 10–12 days (n = 34). (R1) NSAIDs: diflunisal 1000 mg immediately, 500 mg twice daily for 10 days (n = 36). (R2) Spinal manipulation and mechanical therapy according to McKenzie, 5 sessions of 45 min per week, 10–12 days (n = 38).	Mean change in pain intensity on 4-point scale after 4 and 12 days: (I) −0.9, −1.6; (R1) −0.9, −1.7; (R2) −1.1, −1.7. No significant differences in pain or mobility. Percentage of patients with good or excellent overall improvement: (I) 70%; (R1) 78%; (R2) 73%.
White '66a	148 male patients with chronic LBP with or without radiation.	(I1) Mild static trunk exercises, short-wave diathermy and posture training by physiotherapist, back exercise classes, calisthenics in pool, occupational therapy, treatment until improvement or deterioration (n = 76). (I2) Vigorous flexion and extension exercises, heavy occupational therapy, treatment until improvement or deterioration (n = 72).	Proportion of patients showing improvement after treatment (maximum 7 weeks) 38% (I1) *vs* 35% (I2). Not significant.
White '66b	194 male patients with accepted claims for compensation for discogenic chronic LBP with or without sciatica, ages 19–60 yrs.	(I) Hospital bed rest, light progressive, moderate progressive, and heavy progressive activities, 6 weeks unless fit for work earlier (n = 99). (R) Usual care (n = 95).	Percentage of patients with satisfactory result at work during 3 mos after discharge from study: (I) 42%; (R) 16%.
Zylbergold & Piper[61]	28 patients selected from a waiting list of a physical therapy department, ages 25–65 yrs.	(I1) Flexion exercises emphasizing pelvic rhythm training, 15 min, instruction to continue exercises at home, and heat, 15 min, twice a week, 1 month (n = 10). (I2) Home care instructions in back care, body mechanics, and pelvic tilt exercises (n = 10). (R) Manual therapy consisting of posteroanterior pressures, rotational mobilizations, manual traction, 15 min, and heat, 15 min, twice a week, 1 mo (n = 8).	Mean change in pain intensity (5-point scale) and functional status (32-point scale) after 1 month: (I1) −1.0 ± 0.85, 2.05 ± 1.4; (I2) −1.5 ± 0.10, 5.03 ± 7.48; (R) −0.6 ± 0.82, 2.95 ± 4.3. No significant difference in pain, functional status, or mobility.

LBP = low back pain; I = intervention (exercise therapy); R = reference; NSAID = nonsteroidal anti-inflammatory drug; RDQ = Roland Disability Questionnaire; NRS = Numerical Rating Scale; TENS = transcutaneous electrical nerve stimulation; VAS = visual analog scale; SIP = Sickness Impact Profile; GP = general practitioner; NHP = Nottingham Health Profile; ROM = range of motion; ADL = Activities of Daily Living.

Exercise Therapy *Versus* Inactive or Placebo Treatment. In 11 studies, some type of "inactive" control group was used. One study comparing exercise with short-wave diathermy in a mixed population of patients with acute and chronic low back pain was not included in the subgroup analyses presented in the following sections.[9]

Acute Low Back Pain (12 Weeks or Less). Four studies in 888 patients with acute low back pain compared exercise therapy with some type of inactive treatment: bed rest,[14,22,34] placebo ultrasound/short-wave diathermy,[17,18] and an educational booklet.[7] Three studies were of high quality,[7,17,18,34] and one was of low quality.[14,22] Two high-quality RCTs reported no differences on pain[17,18] or functional status,[7] and one high-quality RCT reported even a better outcome for the control group.[34] The low-quality RCT reported no differences in pain, functional status, or mobility.[14,22] There is strong evidence (Level 1) that exercise therapy is not effective for acute low back pain.

Chronic Low Back Pain (More Than 12 Weeks). Six studies in patients with chronic low back pain compared exercise therapy with some type of inactive treatment: hot packs and rest,[28] semihot packs and sham traction,[23] waiting list controls,[42,51] transcutaneous electrical nerve stimulation (TENS) or sham TENS,[11] and detuned ultrasound and detuned short-wave diathermy.[38] International guidelines on the management of low back pain in primary care consider TENS and hot packs inactive or ineffective treatments as single methods.[4,16,58] Two studies were of high quality.[11,23]

The two high-quality studies reported conflicting results. Deyo et al[11] reported a larger decrease of pain for stretching and relaxation exercises than for no exercises (TENS or sham TENS), whereas Hansen et al[23] reported no differences between strengthening exercises and semihot packs and sham traction. The results of the four low-quality studies also were inconsistent in pain, functional status, or overall improvement. Therefore, there is conflicting evidence (Level 3) on the effectiveness of exercise therapy for chronic low back pain.

Effectiveness of Flexion and Extension Exercises (Including McKenzie). Ten studies, three of which were of high quality,[7,34,39] reported on the effectiveness of extension exercises. The authors of seven of these RCTs stated that these extension exercises were according to the McKenzie principles[6,7,10,13,39,48,49,52], and three authors made no such statement.[9,26,34]

Ten studies reported on the effectiveness of flexion exercises[6,9,10,13,14,19,22,26,39,40,61], only one of which was of high quality.[39]

Two studies reported on a mixed population of patients with acute and chronic low back pain and thus were not included in the subgroup analyses presented in the following sections.[9,61]

Acute Low Back Pain (12 Weeks or Less). *Flexion Exercises.* Three low-quality studies involving 359 patients with acute low back pain compared flexion exercises with an active or inactive treatment. One study did not find any differences regarding pain or functional status, as compared with bed rest or no intervention.[14,22] The other two studies reported even worse outcomes for the flexion exercise group regarding spinal flexion and straight leg raising as compared with spinal manipulation,[40] and regarding the number of symptom-free patients as compared with passive manipulation and mobilization.[19] There is moderate evidence (Level 2) that flexion exercises are not effective in the treatment of acute low back pain.

Extension Exercises. Four studies involving 684 patients with acute low back pain compared extension exercises with an active or inactive treatment: two high quality[7,34] and two low-quality studies.[48,49,52] The two high-quality studies showed that extension exercises were not significantly different from chiropractic treatment and an educational booklet with regard to bothersomeness of symptoms or functional status,[7] and that extension exercises were significantly less effective than ordinary activity in terms of ain, functional status,and return to work.[34] Therefore, there is strong evidence (Level 1) that extension exercises are not effective in the treatment of acute low back pain.

Flexion Versus Extension Exercises. Two small studies involving 86 patients with acute low back pain compared flexion with extension exercises.[10,39] One of these studies, considered to be of high quality, reported a significantly greater decrease of pain with extension exercises than with flexion exercises for patients with prolapsed intervertebral discs.[39] The other study, considered to be of low quality, reported better improvement regarding functional status with extension exercises of patients with and without sciatica.[10] Therefore, there is moderate evidence (Level 2) that extension exercises are more effective than flexion exercises.

Chronic Low Back Pain (More Than 12 Weeks).

Flexion Exercises. Because no RCTs were identified that compared flexion exercises with active or inactive treatments, there is no evidence (Level 4) concerning the effectiveness of flexion exercises for chronic low back pain.

Extension Exercises. Because no RCTs were identified that compared flexion exercises with active or inactive treatments, there is no evidence (Level 4) concerning the effectiveness of extension exercises for chronic low back pain.

Flexion versus *Extension Exercises.* Three small low-quality studies involving 153 patients with chronic low back pain compared extension with flexion exercises.[6,13,26] Two studies reported no differences in pain intensity,[6,13] whereas one study reported a better global improvement with flexion exercises.[26] Therefore, there is conflicting evidence (Level 3) about which exercises, extension or flexion, are more effective for chronic low back pain.

Effectiveness of Strengthening Exercises.

Acute Low Back Pain (12 Weeks or Less). Because no RCTs were identified, there is no evidence (Level 4) concerning the effectiveness of strengthening exercises for acute low back pain.

Chronic Low Back Pain (More than 12 Weeks). Nine studies included some type of strengthening exercises for chronic low back pain[3,5,23,26,28,33,35,36,38,42], four of which were of high quality.[5,23,33,35,36]

Of the four high-quality studies, one reported better outcomes regarding pain and functional status with an intensive, dynamic strengthening program than with mild exercises.[35,36] The other three high-quality studies reported no differences regarding pain or functional status between strengthening exercises and conventional physical therapy exercises[23,33] or stretching exercises, although in the last study, both groups also received spinal manipulative therapy.[5] Therefore, there is strong evidence (Level 1) that strengthening exercises are not more effective than other types of exercise.

Four studies compared strengthening exercises with some type of inactive treatment and showed conflicting results. The high-quality study showed a significantly better overall treatment effect than semihot packs and light traction, but did not show any differences in pain intensity.[23] In two low-quality studies, there were no differences regarding pain or functional status compared with hot packs and rest[28] as well as detuned ultrasound and detuned short-wave diathermy.[38] The other low-quality study reported better outcomes regarding pain and functional status than for a waiting list control group.[42] Therefore, there is conflicting evidence (Level 3) that strengthening exercises are more effective than inactive treatment for chronic low back pain.

Discussion

Study Selection

Selection of all relevant studies is crucial to the validity of a systematic review. However, publication bias (*i.e.*, selective publication of studies with statistically significant findings) may be introduced in systematic reviews if only studies published in English are included.[12] Although the current authors also searched for studies published in German, Dutch and Finnish, only English studies were identified and included in this systematic review. Because many scientific journals in non-English languages are not indexed in Medline and Embase, other attempts to identify non-English studies might be more appropriate. Because of time and money restrictions, it was decided not to undertake any other efforts. However, if new studies are identified, they will be included in a future update of this review. Readers are invited to submit any RCT that may have been missed.

Methodologic Quality

Only two studies met the criterion that required blinding of patients,[5,45] and only one met the criterion that required blinding of care providers.[34] Obviously, it is very difficult, and perhaps impossible, to blind patients and care providers in studies of exercise therapy. Therefore, this criterion was defined as positive if the credibility of the treatments was evaluated and treatments were equally credible and acceptable to patients. In a pragmatic trial, the patients should have been fully naive or not treated with exercise therapy for at least the preceding 6 months. Future studies on exercise therapy may include control groups equally credible to the patient, in an effort to evaluate the success of this attempt to avoid bias.

The fact that blinding of patients is difficult indicates that it also is very difficult to have blinded assessments of patient's self-reported outcomes such as pain, functional status, global improvement, and return to work. These are considered primary outcomes in back pain research. The studies that met the criterion that required blinding of outcome assessments usually had included what the current authors considered secondary outcomes of physical examination: range of motion, spinal flexibility, and degrees of straight leg raising or muscle strength.

There was a clear trend showing a higher methodologic quality in studies published after 1990. The finding that approximately 41% of the studies were of high quality shows a tremendous improvement in methodologic quality as compared with the authors' previous systematic review conducted in 1991, in which only 17% of the included studies were considered to be of high quality. Although the authors' method of assessment has changed, this is not the explanation for this finding. Using up-to-date Cochrane methodology also results in the older studies scoring low. This positive development coincides with a concurrent increase in the publication of systematic reviews, including Cochrane reviews, over the past decade.

Recently, recommendations for the reporting of RCTs have been developed, which have been adopted by several leading medical journals and included in their instructions to authors.[2] Journals in the field of back pain should also adopt these guidelines, so that the high quality of future reports on RCTs in this field will be guaranteed and readers can evaluate the internal and external validity of the trial. In the current review, 31 quality assessment scores were changed after additional information was provided by 18 authors, which indicates that the quality of the report is not similar to the quality of the trial. Four of the 18 studies changed from low to high quality after the comments of the authors were included in the quality assessment. Although it may be difficult to contact authors of trials published several years previously, giving authors the opportunity to supply additional information seems to minimize bias in systematic reviews.

Effectiveness of Exercise Therapy

In the authors' previous systematic review of 16 RCTs published up to 1990, they concluded that it was still unclear whether exercise therapy is better than other conservative treatments or whether a specific type of exercise is more effective.[27] In the 8 years between the previous review and the current one, 23 additional studies were published or identified, and these have been included in the current systematic review.

The current results point to strong evidence that exercise therapy is not more effective than inactive treatments or other active treatments for acute low back pain. The current review also included literature on specific types of exercises that have been evaluated frequently in RCTs. The evidence showed that flexion and extension exercises are not effective in the treatment of acute low back pain.

In a previous review of exercise therapy, McKenzie exercises were found to provide some short-term symptomatic improvement in acute low back pain.[15] However, this review included only a subset of two studies on McKenzie exercises, which possibly resulted in biased results. Physiotherapists usually claim that exercises for acute low back pain may prevent future recurrences or chronicity. Sound RCTs that confirm this assumption are lacking.

The current findings on acute low back pain are in line with clinical practice guidelines for the management of low back pain published in the United States,[4] the United Kingdom,[58] the Netherlands,[16] and New Zealand.[1] These guidelines state that according to scientific evidence, specific back exercises do not provide improvement in clinical outcomes. The U.S. guidelines state that low-stress aerobic exercises such as walking, biking, or swimming can be started during the first 2 weeks after the start of the low back pain complaints or after the start of an episode of LBP. This recommendation is similar to those in the other guidelines stating that the continuation of ordinary activities improves recovery and leads to less disability in patients with acute low back pain.

The evidence for chronic low back pain is less clear and less consistent. There is strong evidence that exercise therapy is more effective than the usual care by general practitioners, and that exercise therapy and conventional physiotherapy (consisting of hot packs, massage, traction, mobilization, short-wave diathermy, ultrasound, stretching, flexibility and coordination exercises, and electrotherapy) are equally effective. However, it still is unclear whether exercise therapy is more effective than inactive treatment for chronic low back pain, and it also remains unclear whether any specific type of exercise (flexion, extension, or strengthening exercises) is more effective than another. Although sound scientific evidence is lacking, there seems to be consensus currently that management of patients with chronic low back pain should be aimed at restoring normal function and behavior. Waddell[57] stated that exercise should play a role in active rehabilitation of patients with chronic low back pain, but that active rehabilitation and exercise therapy are not identical. Exercises may be useful within an active rehabilitation program if they facilitate and precipitate an increase in ordinary activity and return to work. Specific back exercises have no clinical effect.

■ Conclusions

Implications for Practice

Specific back exercises are not recommended for patients with acute and chronic low back pain. Exercises may be useful in the treatment of chronic low back pain if they aim at improving return to normal daily activities and work.

Implications for Research

Future RCTs should focus on the effectiveness of exercises as part of an active rehabilitation program for chronic low back pain, and return to normal daily activities and work should be the main outcomes.

■ Key Points

- A systematic review of 39 randomized controlled trials was performed.
- The effectiveness of exercise therapy for low back pain was evaluated.
- Primary outcome measures were pain intensity, functional status, overall improvement, and return to work.
- Exercise therapy was not more effective for acute low back pain than inactive or active treatments.
- Excerise therapy was more effective than ususal care by the general practitioner and just as effective as conventional physiotherapy for chronic low back pain.

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