Original Investigation

Prevention of Low Back Pain
A Systematic Review and Meta-analysis

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IMPORTANCE Existing guidelines and systematic reviews lack clear recommendations for prevention of low back pain (LBP).

OBJECTIVE To investigate the effectiveness of interventions for prevention of LBP.

DATA SOURCES MEDLINE, EMBASE, Physiotherapy Evidence Database Scale, and Cochrane Central Register of Controlled Trials from inception to November 22, 2014.

STUDY SELECTION Randomized clinical trials of prevention strategies for nonspecific LBP.

DATA EXTRACTION AND SYNTHESIS Two independent reviewers extracted data and assessed the risk of bias. The Physiotherapy Evidence Database Scale was used to evaluate the risk-of-bias. The Grading of Recommendations Assessment, Development, and Evaluation system was used to describe the quality of evidence.

MAIN OUTCOMES AND MEASURES The primary outcome measure was an episode of LBP, and the secondary outcome measure was an episode of sick leave associated with LBP. We calculated relative risks (RRs) and 95% CIs using random-effects models.

RESULTS The literature search identified 6133 potentially eligible studies; of these, 23 published reports (on 21 different randomized clinical trials including 30 850 unique participants) met the inclusion criteria. With results presented as RRs (95% CIs), there was moderate-quality evidence that exercise combined with education reduces the risk of an episode of LBP (0.55 [0.41-0.74]) and low-quality evidence of no effect on sick leave (0.74 [0.44-1.26]). Low- to very low–quality evidence suggested that exercise alone may reduce the risk of both an LBP episode (0.65 [0.50-0.86]) and use of sick leave (0.22 [0.06-0.76]). For education alone, there was moderate- to very low–quality evidence of no effect on LBP (1.03 [0.83-1.27]) or sick leave (0.87 [0.47-1.60]). There was low- to very low–quality evidence that back belts do not reduce the risk of LBP episodes (1.01 [0.71-1.44]) or sick leave (0.87 [0.47-1.60]). There was low-quality evidence of no protective effect of shoe insoles on LBP (1.01 [0.74-1.40]).

CONCLUSION AND RELEVANCE The current evidence suggests that exercise alone or in combination with education is effective for preventing LBP. Other interventions, including education alone, back belts, and shoe insoles, do not appear to prevent LBP. Whether education, training, or ergonomic adjustments prevent sick leave is uncertain because the quality of evidence is low.

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Low back pain (LBP) is one of the most burdensome health problems worldwide,[1] generating enormous costs in treatments and time lost from work.[2] The global point prevalence of LBP is 12%; with the aging population, the number of people affected is likely to increase over the coming years.[3] A key contributor to the burden is the high recurrence rate: approximately one-half of patients experience a recurrence of LBP within 1 year after recovering from a previous episode.[4-6] It is therefore important to know whether it is possible to prevent LBP and, if so, which interventions are most effective.

Although there have been several systematic reviews of strategies to prevent LBP, most have major limitations. Many of the existing reviews are out-of-date,[7,8] report data from randomized clinical trials (RCTs) of symptomatic participants,[9] do not consider the strength of evidence (eg, using the Grading of Recommendations Assessment, Development, and Evaluation [GRADE] system),[8,10] are restricted to a particular type of intervention[11] or setting, or do not follow a prespecified, publicly accessible protocol.[7,8]

Therefore, a comprehensive, high-quality review that includes the most recent publications is needed to provide a current overview of the effectiveness of prevention strategies. The aim of this systematic review was to evaluate the evidence on the effectiveness of interventions for prevention of episodes of LBP and use of sick leave due to LBP.

Methods

Literature Search

The PRISMA Statement was used to guide the conduct and reporting of the study.[12] This study searched the following electronic databases from the earliest record to November 22, 2014: MEDLINE, EMBASE, Physiotherapy Evidence Database (PEDro), and the Cochrane Central Register of Controlled Trials. A sensitive search strategy was used based on the recommendations of the Cochrane Back Review Group[13] for *randomized controlled trials* and *back pain* as well as search terms for *prevention*.[14] The full search strategy is outlined in eTable 1 in the Supplement. The reference lists of relevant reviews and trials were screened for additional studies, and we also used citation tracking of all included trials.

During the first screening, 2 reviewers (D.S. or M.J.H. with V.C.O. or M.C.) evaluated the titles and abstracts of each citation and excluded clearly irrelevant studies. For each potentially eligible study, 2 reviewers (D.S. or M.J.H. with V.C.O. or M.C.) examined the full-text article and assessed whether the study fulfilled the inclusion criteria. In cases of disagreement, a decision was made by consensus or, if necessary, a third reviewer (C.G.M.) was consulted.

Study Selection

We included RCTs assessing the effectiveness of prevention strategies for nonspecific LBP. To be eligible, trials needed to meet the following criteria: (1) included participants without LBP at study entry or at least 1 outcome was not present at baseline (eg, some participants had mild LBP, but all were working and the study outcome was an episode of work absence due to LBP); (2) aimed to prevent future episodes of LBP; (3) compared intervention group with groups that received no intervention, placebo, or minimal intervention; and (4) reported a measure of a new episode of LBP (eg, episode of LBP or episode of sick leave due to LBP). Studies that used a quasi-randomized design or reported the comparison of 2 prevention strategies (eg, exercise vs lumbar support) were excluded. No restrictions were placed on the setting or context of the included studies, languages, or date of the RCT report.

Data Extraction and Synthesis

We assessed the quality of the trials' methods using the PEDro scale[15,16] by either downloading the available scores from the PEDro database (http://www.pedro.org.au) or rating the trial ourselves. Scores on the PEDro scale range from 0 (very low methodologic quality) to 10 (high methodological quality); methodologic quality was not an inclusion criterion of this review.

Two independent reviewers (D.S. or M.J.H. with V.C.O. or M.C.) extracted the characteristics and intervention outcomes of each trial using a standardized data extraction form. When possible, we extracted the raw outcomes (number of persons having an episode of LBP) for each group (intervention and control) and calculated the estimates of treatment effect using methods recommended in the *Cochrane Handbook for Systematic Reviews of Interventions, Version 5.1.0*.[17]

To evaluate the overall quality of the evidence, we used the GRADE system.[18] The GRADE classification was downgraded from high quality by 1 level for each factor that we encountered: (1) design limitation (>25% of participants from studies with low methodologic quality: PEDro score <7), (2) inconsistency of results (wide variance of point estimates across studies or large heterogeneity between trials: I^2 >50%), and (3) imprecision (<400 participants for each outcome). We did not consider the indirectness criterion in this review because we included a specific population with relevant outcomes and direct comparisons. A GRADE profile was completed for each pooled estimate and for single trials comparing an LBP prevention strategy with controls. When only single RCTs were available, evidence from studies with fewer than 400 participants was downgraded for inconsistency and imprecision (ie, sparse data) and rated as low-quality evidence. These trials could be further downgraded to very low-quality evidence if limitations of study design were found (PEDro score <7). Two reviewers (D.S. or M.J.H. with V.C.O. or M.C.) judged whether these factors were present for each outcome. The quality of evidence was defined as (1) high (further research is unlikely to change our confidence in the estimate of effect and there are no known or suspected reporting biases: all domains are fulfilled); (2) moderate (further research is likely to have an important effect on our confidence in the estimate of effect and might change the estimate: 1 of the domains is not fulfilled); (3) low (further research is likely to have an important effect on our confidence in the estimate of effect and is likely to change the estimate: 2 of the domains are not fulfilled); and (4) very low (we are uncertain about the estimate: 3 of the domains are not fulfilled).[19]

Statistical Analysis

Outcome data were extracted for short-term (follow-up evaluations ≤12 months) and long-term (follow-up evaluations >12 months) follow-up. When multiple time points fell into the same category, we used the longest follow-up period.

Trials considered homogeneous were grouped according to the prevention strategy, comparison group, outcome (LBP episode and sick leave), and outcome assessment time points (short-term and long-term). We calculated relative risks (RRs) and 95% CIs and used the random-effects model to pool estimates for each analysis obtained with Comprehensive Meta-analysis, version 2.2.064 (Biostat). For trials that did not report the sample size at the end of the follow-up period, we calculated the RR using the baseline sample size.

Results

The initial electronic database search identified 6133 potentially eligible studies. After screening citations by title and abstract, we considered 159 potentially eligible studies for inclusion and retrieved full-text articles. Twenty-three published reports (21 different RCTs including 30 850 unique participants) met the inclusion criteria and were included in this review.[20-42] Two RCTs were reported in 4 articles[22,30,39,40] (2 with 12-month data[22,39] and 2 with 36-month data[30,40]). **Figure 1** outlines the flow of RCTs through the review.

The included trials investigated 6 different LBP prevention strategies: exercise, education, exercise and education, back belts, shoe insoles, and other prevention strategies. Most of the trials focused largely or completely on working-age populations. The sample size of the trials ranged from 30 to 4325 participants. A comprehensive description of each trial is provided in **Table 1**.

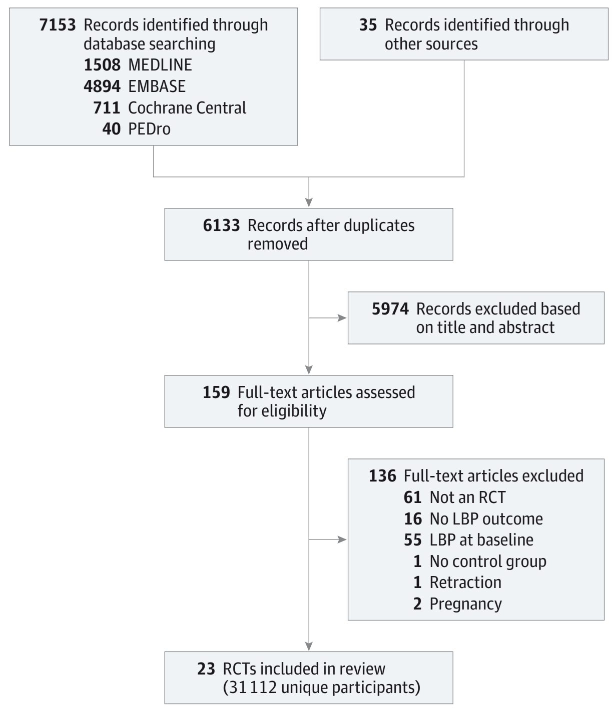
Methodologic quality assessment was conducted using the PEDro scale. The mean (SD) score was 5.1 (1.5), with the key problem items being blinding, concealed allocation, and loss to follow-up (eTable 2 in the Supplement).

Estimates of the effects of LBP prevention strategies on LBP episode or sick leave due to LBP were calculated for 21 trials. The number of events, sample size, and RRs (95% CIs) for the trials are presented in eTable 3 in the Supplement. Trials were grouped according to the prevention strategy, outcome (episode of LBP or sick leave), and follow-up time point (short- or long-term). **Table 2** provides a summary of the findings and GRADE quality ratings.

Exercise vs Control, Minimal Intervention, or Supplement

Four trials reporting data on 898 participants were included in the meta-analysis to estimate the short-term (ie, ≤12 months) efficacy of exercise on incident cases of LBP (presented as RR [95% CI]).[21,25,26,42] The pooled results provide low-quality evidence of a protective effect of exercise (0.65 [0.50-0.86]). In the long-term (ie, >12 months), the pooled results of 2 trials (334 participants) provide very low-quality evidence of no effect of exercise (1.04 [0.73-1.49]) (**Figure 2**).[21,33] Two trials presented data from 128 participants and provide very low-

Figure 1. Flow Diagram of Review Process



LBP indicates lower back pain; PEDro, Physiotherapy Evidence Database; and RCT, randomized clinical trial.

quality evidence that exercise reduces the risk of sick leave due to LBP in the long-term (0.22 [0.06-0.76]) (**Figure 3**).[30,42]

Exercise and Education vs Control, Minimal Intervention, or Supplement

The effect of exercise and education was investigated in 4 trials (442 participants) at short-term follow-up,[22,35,39,42] and in 2 trials (138 participants) at long-term follow-up (LBP episode).[30,40] The pooled results (presented as RR [95% CI]) of 4 trials provide moderate-quality evidence that exercise and education reduce the risk of an episode of LBP at short-term follow-up (0.55 [0.41-0.74]). The long-term results are based on 2 trials[30,40] and provide low-quality evidence of a protective effect (0.73 [0.55-0.96]) (Figure 2).

For prevention of sick leave due to LBP, 3 trials (228 participants)[22,39,42] presented short-term data and 2 trials (138 participants)[30,40] presented long-term data. The pooled results (presented as RR [95% CI]) provide low-quality evidence of no protective effect at short-term follow-up (0.74 [0.44-1.26]) or long-term follow-up (0.72 [0.48-1.08]) (Figure 3).

Education vs Control, Minimal Intervention, or Supplement

The efficacy of education compared with control was investigated in 3 trials (2343 participants) at short-term follow-up and in 2 trials (13242 participants) at long-term follow-up (LBP episode). The pooled results (presented as RR [95% CI]) provide moderate-quality evidence of no protective effect of education at either

Table 1. Characteristics of the Randomized Clinical Trials Included in Review of Low Back Pain Prevention Strategies

Source	Participants	Outcome	Intervention and Control	Time of Sessions	Duration of Intervention
George et al,[20] 2011	4325 Army soldiers; mean (SD) age, 22.0 (4.2) y; male (71%)	LBP episode that resulted in the patient seeking of health care	Traditional exercise: traditional lumbar exercises for the rectus abdominus and oblique abdominal muscles	5 Times/wk for 5 min	12 wk
			Education: evidence-based information on LBP and educational book	1 Time/wk for 45 min	Single session
			Core exercise: core stabilization exercises for transverse abdominus, multifidus, and the erector spinae	5 Times/wk for 5 min	12 wk
Helewa et al,[21] 1999	402 University employees and students, hospital staff, and London residents; mean (SD) age, 38.4 (9.2) y; male (47%)	LBP episode: continuous or intermittent pain resulting in moderate to severe limitation of function lasting >2 d	Exercise: abdominal muscle strength exercises	7 Times/wk for 5 min	24 mo
			Education: classes on spinal anatomy, pathophysiology, posture, lifting techniques, and general fitness	3 Times/wk for 90 min	3 Sessions (baseline, 1- and 2-y follow-up)
Lønn et al,[22] 1999	81 Participants recruited through local media advertisement and referral from other health professionals; mean (range) age, 39.4 (19.2-49.8) y; 46% males	LBP episode: recurrences Sick leave: due to episodes of LBP	Exercise and education: active back school-didactic session included anatomy, biomechanics, pathology, and basic ergonomic principles related to the spinal column and pelvis; practical session included bending the knee and hip joints, while keeping the lumbar segments near midposition and using short-lever arms during functional exercises and obstacle course simulations; strength training of leg muscles and muscles between the upper body and pelvis; stretching exercises for the calf muscles, hamstrings, rectus femoris, and hip flexors Control group: no intervention	2 Sessions/wk for 7 wk and 1/wk for 6 wk; each session 60 min	20 Sessions (13 wk)
Mattila et al,[23] 2011	220 Finnish defense forces; mean age 19.0 y; 100% male	LBP episode: requiring a visit to the physician and suspension from duty for at least 1 d	Shoe insoles: customized insoles made from firm-density polyethylene, and the hard plastic shell was three-quarters the length of the foot Control: no intervention	Daily service time	6 mo
Milgrom et al,[24] 2005	404 New recruits beginning elite infantry training; mean (SD), 18.8 (0.7) y; 100% male	LBP episode: presence of LBP	Semirigid shoe insoles: semirigid biomechanical orthoses Soft shoe insoles: soft biomechanical orthoses Control: simple shoe inserts, without supportive or shock-absorbing qualities	Unclear	14 wk
Moore et al,[25] 2012	30 Outpatients of the Brown Cancer Center, University of Louisville; mean (range) age, 49.0 (43-63) y; 23% male	LBP episode: incidence of self-reported LBP	Exercise: 6 calisthenic exercises to strengthen and stretch the pelvis-spine-attached muscles that move lumbar and lumbosacral joints and control upright, 2-legged balance Control: no intervention	15 min/d	12 mo
Sihawong et al,[26] 2014	563 Office workers; mean (SD) age, 37.1 (10.4) y; 31% male	LBP episode: LBP lasting >24 h during the past month	Exercise: muscle stretching and endurance training (repeatedly contracted each muscle [ie, erector spinae, multifidus, quadratus lumborum, and transversus abdominis] 10 times and rested for 60 s between muscle contractions) Control: no intervention	Twice daily (5 d/wk for 30 s each time)	12 mo
Allen and Wilder,[27] 1996	47 Employees of the Veterans Administration Hospital; age and sex not specified	LBP episode: back injury	Education: training in biomechanics and proper lifting techniques Back belts: training on proper use of back belts	Volunteers were asked to wear the back support belts while on duty whenever they were lifting patients	6 mo
Daltroy et al,[28] 1997	3597 US postal workers; mean (SD) age, 42.5 (12.3) y; 66% male	LBP episode: occurrence of LBP injury	Education: safe lifting and handling; posture while sitting, standing, and lying down; pain management; stretching and strengthening exercises; group discussion of barriers to implementation; on-site work-station ergonomic analysis Control: no intervention	90 min	2 Sessions
Driessen et al,[29] 2011	3047 Employees of 4 Dutch companies; mean (SD) age, 42.0 (21.8) y; 59% male	LBP episode: DMQ asked about the presence of LBP in the previous 3 mo (l, no, never; 2, yes, sometimes; 3, yes, regularly; 4, yes, always); prevalence was determined by combining the categories 1 and 2 as "no LBP" and categories 3 and 4 as" "LBP"	Ergonomic program: implementation of ergonomic measurers aimed to prevent LBP Control: no intervention	6 h	1 Session

(continued)

short-term follow-up (1.03 [0.83-1.27])[37,41,42] or long-term follow-up (0.86 [0.72-1.04])[20,34] (Figure 2). In addition, a single trial (3597 participants) not included in the meta-analysis because it did not report raw data provides moderate-quality evidence of no protective effect of education at long-term follow-up (rate ratio, 1.11 [95% CI, 0.90-1.37]) (eTable 3 in the Supplement).[28]

Two trials (366 participants)[41,42] presented short-term data on sick leave prevention. The pooled results provide

Table 1. Characteristics of the Randomized Clinical Trials Included in Review of Low Back Pain Prevention Strategies (continued)

Source	Participants	Outcome	Intervention and Control	Time of Sessions	Duration of Intervention
Glomsrød et al,[30] 2001	81 Participants recruited from referrals and advertisement; mean (SD) age, 39.8 (6.4) y; 46% male	LBP episode: recurrence of episodes Sick leave: due to episodes of LBP	Exercise and education: active back school-didactic session included anatomy, biomechanics, pathology, and basic ergonomic principles related to the spinal column and pelvis; practical session included bending the knee and hip joints, while keeping the lumbar segments near midposition and using short lever arms during functional exercises and obstacle course simulations; strength training of leg muscles and muscles between the upper body and pelvis; stretching exercises for the calf muscles, hamstrings, rectus femoris, and hip flexors Control: no intervention	2 Sessions/wk for 7 wk; 1 session/wk for 6 wk; each session 60 min	(20 Sessions) 13 wk
Gundewall et al,[31] 1993	69 Nurses and nurse's aides; mean (SD) age, 37.5 (10.5) y; 1% male	Sick leave: work absence due to LBP	Exercise: back muscle exercises to increase endurance, isometric strength and functional coordination Control: no intervention	6 Times/mo for 20 min	13 mo
IJzelenberg et al,[32] 2007	489 Workers from physically demanding jobs; mean (SD) age, 41.3 (9.7) y; 97% male	Sick leave: absent from work during the past 6 mo and 12 mo due to back pain	Education, training, and ergonomic adjustments: individually tailored education and training, immediate treatment of acute LBP, and advice on ergonomic adjustment of the workplace Usual care: Dutch guidelines for the health care of patients with LBP	Unclear	Unclear
Kellett et al,[33] 1991	111 Employees of kitchen unit production; mean (SD) age, 41.7 (10.1) y; 70% male	Sick leave: attributable to LBP	Exercise and education: warm-up, stretching, strengthening, cardiovascular, coordination exercises and cool down; one-third of the classes started with 10-min lecture on theories of back pain prevention, eg, reducing bed rest and increasing activities, eg, swimming Control: no intervention	2 Times/wk for 20-35 min	18 mo
Kraus et al,[34] 2002	12772 Home care attendants; mean (range) age, NS (18-65 y); 5% male	LBP episode: acute-onset, physician-diagnosed injury to the lower back that occurred during a work-related activity	Back belt: stretch nylon back belts Education: information on LBP health Control: no intervention	Unclear	28 mo
Larsen et al,[35] 2002	314 Military conscripts; mean (SD) age, 21.0 (1.5) y; 100% male	LBP episode: No. of persons who reported having consulted the military medical physician with back problems	Education: back school lesson consisted of the theory based on a booklet[43] Exercise: 15 passive prone extensions of the back Control: no intervention	Single 40-min session Twice daily	Single session 10 mo
Larsen et al,[36] 2002	146 Military conscripts; mean (range) age, NS (18-24 y); 99% male	LBP episode: self-reported back problems	Shoe insoles: custom-made biomechanical shoe orthoses Control: no intervention	Whenever wearing their military boots	3 mo
Lavender et al,[37] 2007	2144 Workers from distribution centers that require lifting; mean (range) age, 33.5 (18-65) y; 96% male	LBP episode: self-reported back injury	Education: lifting training; participants were instrumented with motion-capture sensors to quantify the dynamic moments (torque) vector acting on lumbar spine (L5/S1) Video training: demonstrating various lifting techniques	5 Sessions for 30 min Unclear	10 mo Single session
Schwellnus et al,[38] 1990	1388 New military recruits; mean (SD) age, 18.5 (1.2) y; sex NS	LBP episode: overuse back injury	Shoe insoles: neoprene-impregnated with nitrogen bubbles covered with stretch nylon Control: standard military footwear	Daily	9 wk
Soukup et al,[39] 1999	77 Outpatients from medical and physiotherapist practices; mean (SD) age, 37.7 (8.0) y; 47% male	LBP episode: resulting in professional management Sick leave: LBP resulting in use of sick leave	Exercise and education: Mensendieck exercises and biomechanical/ ergonomic, back anatomy, pain mechanisms, and working posture education Control: no intervention	20 Sessions for 60 min	13 wk
Soukup et al,[40] 2001	77 Outpatients from medical and physiotherapist practices; mean (SD) age, 37.7 (8.0) y; 47% male	LBP episode: resulting in professional management Sick leave: LBP resulting in use of sick leave	Exercise and education: Mensendieck exercises and biomechanical/ ergonomic, back anatomy, pain mechanisms and working posture education Control: no intervention	20 Sessions for 60 min	13 wk
van Poppel et al,[41] 1998	624 Airline employees; mean (SD) age, 35.1 (7.8) y; sex NS	LBP episode: in the past month Sick leave: time lost from work in the past month	Back belts: lumbar support with adjustable elastic side pulls with Velcro fasteners and flexible stays Education: lifting instructions	Wear at all times during work hours 1 Session for 2 h and 2 sessions for 1.5 h	6 mo 3 Sessions for 12 wk
Warming et al,[42] 2008	181 Hospital nurses Copenhagen; mean (SD) age, 34.8 (9.3) y; sex NS	LBP episode: perceived LBP Sick leave: due to LBP	Education: patient transfer technique based on the law of physics and the natural movement pattern of moving 1 body part at a time Exercise: physical fitness training: aerobic fitness and strength training Control: no intervention	Working hours 2 Times/wk for 60 min	Two 6-wk sessions 16 Sessions for 8 wk

Abbreviations: DMQ, Dutch musculoskeletal questionnaire; LBP, low back pain; NS, not specified.

Table 2. Summary of Findings and Quality of Evidence Assessment

Summary of Findings				Quality of Evidence Assessment (GRADE)			
Outcome	Time[a]	No. of Participants	RR (95% CI)	Limitation	Inconsistency	Imprecision	Quality
Exercise vs Control/Minimal Intervention/or as Supplement							
LBP episode	Short-term	898[21,25,26,42]	0.65 (0.50-0.86)	Limitation	Inconsistency	No imprecision	Low
LBP episode	Long-term	334[21,33]	1.04 (0.73-1.49)	Limitation	Inconsistency	Imprecision	Very low
Sick leave	Long-term	128[31,42]	0.22 (0.06-0.76)	Limitation	Inconsistency	Imprecision	Very low
Exercise and Education vs No/Minimal Intervention/or as Supplement							
LBP episode	Short-term	442[22,35,39,42]	0.55 (0.41-0.74)	Limitation	No inconsistency	No imprecision	Moderate
LBP episode	Long-term	138[30,40]	0.73 (0.55-0.96)	Limitation	No inconsistency	Imprecision	Low
Sick leave	Short-term	228[22,39,42]	0.74 (0.44-1.26)	Limitation	No inconsistency	Imprecision	Low
Sick leave	Long-term	138[30,40]	0.72 (0.48-1.08)	Limitation	No inconsistency	Imprecision	Low
Education vs Nothing/Minimal Intervention/or as Supplement							
LBP episode	Short-term	2343[37,41,42]	1.03 (0.83-1.27)	Limitation	No inconsistency	No imprecision	Moderate
LBP episode	Long-term	13 242[20,34]	0.86 (0.72-1.04)	Limitation	No inconsistency	No imprecision	Moderate
LBP episode	Long-term	3597[28]	Rate ratio (95% CI), 1.11 (0.90-1.37)	Limitation	No inconsistency	No imprecision	Moderate[b]
Sick leave	Short-term	366[41,42]	0.87 (0.47-1.60)	Limitation	Inconsistency	Imprecision	Very low
Back Belt vs Nothing/Minimal Intervention/or as Supplement							
LBP episode	Short-term	329[27,41]	1.01 (0.71-1.44)	Limitation	Inconsistency	Imprecision	Very low
LBP episode	Long-term	8472[34]	0.85 (0.64-1.14)	Limitation	Inconsistency	Imprecision	Very low[a]
Sick leave	Short-term	282[41]	1.44 (0.73-2.86)	No limitation	Inconsistency	Imprecision	Low[a]
Shoe Insole vs Nothing/Minimal Intervention/or as Supplement							
LBP episode	Short-term	1833[23,24,36,38]	1.01 (0.74-1.40)	Limitation	Inconsistency	No imprecision	Low
Others Prevention Strategies vs Control							
LBP episode	Short-term	3047[29]	OR (95% CI), 1.23 (0.97-1.57)	Limitation	No inconsistency	No imprecision	Moderate[a]
Sick leave	Short-term	360[32]	0.95 (0.51-1.76)	Limitation	Inconsistency	Imprecision	Very low[a]

Abbreviations: GRADE, Grading of Recommendations Assessment, Development and Evaluation; LBP, low back pain; OR, odds ratio; RR, relative risk.

[a] Short-term, follow-up evaluations of 12 months or less; long-term, follow-up evaluations longer than 12 months.

[b] Quality of evidence was evaluated using a single trial.

very low-quality evidence of no protective effect of education on sick leave due to LBP at short-term follow-up (RR, 0.87 [95% CI, 0.47-1.60]) (Figure 3).

Back Belts vs Control, Minimal Intervention, or Supplement

The efficacy of back belts over control to prevent LBP episodes (short- and long-term) or sick leave owing to LBP (short-term) was reported in 3 trials.[27,34,41] For episodes of LBP, pooling of 2 trials (329 participants) (presented as RR [95% CI]) provides very low-quality evidence of no short-term effect of back belts over controls (1.01 [0.71-1.44]) (Figure 2).[27,41] At long-term follow-up, a single trial (8472 participants) provides moderate-quality evidence that back belts do not reduce the risk of LBP episodes when compared with controls (0.85 [0.64-1.14]) (Figure 2).[34] For sick leave owing to LBP, a single trial (282 participants) provides low-quality evidence of no effect of back belts compared with controls at short-term follow-up (RR, 1.44 [95% CI, 0.73-2.86]) (Figure 3).[41]

Shoe Insole vs Control, Minimal Intervention, or Supplement

Four trials reported data from 1833 participants on the short-term efficacy of shoe insoles compared with controls.[23,24,36,38] For prevention of episodes of LBP, there is low-quality evidence that shoe insoles are not superior to control at short-term follow-up (RR, 1.01 [95% CI, 0.74-1.40]) (Figure 2). One trial reported the efficacy of semirigid shoe insole vs control and soft shoe insole vs control.[24] Only the group from the semirigid shoe insole was included in the meta-analysis.

Other LBP Prevention Strategies

Two trials reported the short-term effect of other prevention strategies vs control for LBP episode (3047 participants),[29] and sick leave due to LBP (360 participants).[32] An ergonomic program (moderate-quality evidence) was not more effective than control in reducing episodes of LBP at short-term follow-up (odds ratio, 1.23 [95% CI, 0.97-1.57]) (Table 2). It is unclear whether sick leave due to LBP can be prevented by education, training, and ergonomic adjustments since there was very low-quality evidence (RR, 0.95 [95% CI, 0.51-1.76]) (Figure 3).

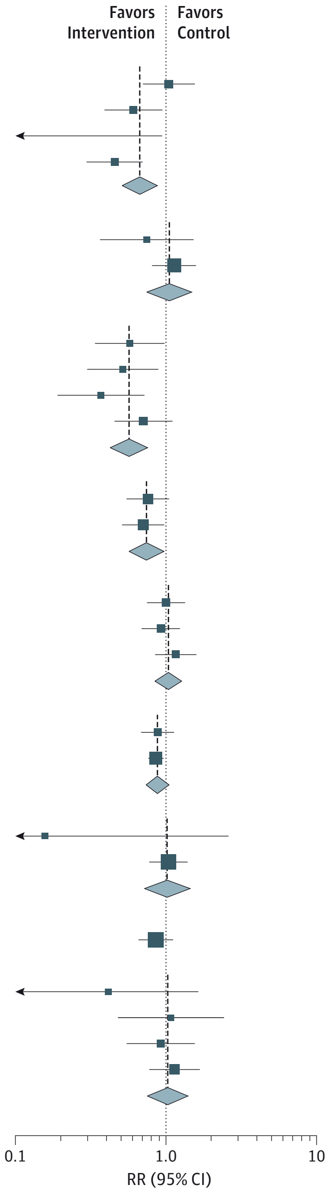
Discussion

Statement of Principal Findings

The results of this systematic review and meta-analysis indicate that exercise in combination with education is likely to reduce the risk of LBP. Exercise alone may reduce the risk of an episode of LBP and sick leave; however, it is uncertain

Figure 2. Relative Risk for Low Back Pain Episode in Controlled Trials on Efficacy of Low Back Pain Prevention Strategies

Source	Intervention		Control		RR (95% CI)	Weight, %
	No. of Events	No. of Patients	No. of Events	No. of Patients		
Exercise vs control (short-term)						
Helewa et al,[21] 1999	28	113	37	157	1.05 (0.69-1.61)	36
Warming et al,[42] 2008	14	35	22	33	0.60 (0.37-0.96)	31
Moore et al,[25] 2012	0	13	10	17	0.06 (0.00-0.96)	1
Sihawong et al,[26] 2014	23	261	53	269	0.45 (0.28-0.71)	32
Pooled effect: I^2 = 67.9%					0.65 (0.50-0.86)	
Exercise vs control (long-term)						
Kellett et al,[33] 1991	8	37	14	48	0.74 (0.35-1.58)	21
Helewa et al,[21] 1999	35	101	45	148	1.14 (0.79-1.64)	79
Pooled effect: I^2 = 0%					1.04 (0.73-1.49)	
Exercise and education vs control (short-term)						
Soukup et al,[39] 1999	11	34	20	35	0.57 (0.32-1.00)	25
Lønn et al,[22] 1999	11	38	20	35	0.51 (0.29-0.90)	24
Larsen et al,[35] 2002	9	101	28	113	0.36 (0.18-0.73)	17
Warming et al,[42] 2008	14	35	29	51	0.70 (0.44-1.13)	34
Pooled effect: I^2 = 0%					0.55 (0.41-0.74)	
Exercise and education vs control (long-term)						
Soukup et al,[40] 2001	18	31	27	35	0.75 (0.53-1.07)	50
Glomsrød et al,[30] 2001	20	37	27	35	0.70 (0.50-0.99)	50
Pooled effect: I^2 = 0%					0.73 (0.55-0.96)	
Education vs control (short-term)						
van Poppel et al,[41] 1998	50	142	49	140	1.01 (0.73-1.38)	35
Lavender et al,[37] 2007	66	957[a]	76	1020[a]	0.93 (0.67-1.27)	34
Warming et al,[42] 2008	22	33	29	51	1.17 (0.83-1.65)	31
Pooled effect: I^2 = 0%					1.03 (0.83-1.27)	
Education vs control (long-term)						
Kraus et al,[34] 2002	89	4300[a]	109	4635[a]	0.88 (0.67-1.16)	31
George et al,[20] 2011	300	1995	406	2312	0.86 (0.75-0.98)	69
Pooled effect: I^2 = 0%					0.86 (0.72-1.04)	
Back belt vs control (short-term)						
Allen and Wilder,[27] 1996	0	23	3	24	0.15 (0.01-2.73)	2
van Poppel et al,[41] 1998	48	134	51	148	1.04 (0.76-1.43)	98
Pooled effect: I^2 = 40.6%					1.01 (0.71-1.44)	
Back belt vs control (long-term)						
Kraus et al,[34] 2002	77	3837[a]	109	4635[a]	0.85 (0.64-1.14)	100
Shoe insoles vs control (short-term)						
Schwellnus et al,[38] 1990	2	237	24	1151	0.40 (0.10-1.70)	4
Larsen et al,[36] 2002	9	58	9	63	1.09 (0.46-2.55)	10
Milgrom et al,[24] 2005	16	51	18	53	0.92 (0.53-1.61)	23
Mattila et al,[23] 2011	24	73	42	147	1.15 (0.76-1.74)	40
Pooled effect: I^2 = 0%					1.01 (0.74-1.40)	



Studies are ordered chronologically within prevention strategies. Short-term indicates follow-up of 12 months or less; long-term, follow-up evaluation of more than 12 months.

[a] Only the baseline sample size was available.

whether the effects persist beyond 1 year. Education alone, back belts, shoe insoles, and ergonomic adjustments probably do not prevent an episode of LBP or sick leave due to LBP. It is uncertain whether education, training, or ergonomic adjustments prevent LBP owing to the very low quality of evidence.

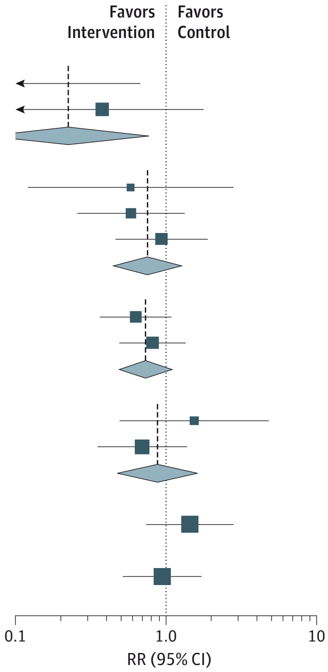
Strengths and Weaknesses of the Study

The strengths of this review include the use of a prespecified protocol registered on PROSPERO, inclusion of all prevention strategies from any setting, the use of the GRADE system to evaluate the overall quality of the evidence, and the use of a highly sensitive search strategy to identify LBP prevention trials. We assessed trials' methodologic quality with the PEDro scale, which has been shown to have acceptable reliability and validity.[15,16,44] All scores were available online at the PEDro website. These scores were rated by experienced PEDro researchers, which provided less chance of errors.

This review was designed to be comprehensive with a robust search strategy; however, it is possible that not all studies were identified. Some identified trials did not have the term *prevention* in either the title or the abstract.[27,33,34] For several

Figure 3. Relative Risk for Sick Leave in Controlled Trials on Efficacy of Low Back Pain Prevention Strategies

Source	Intervention No. of Events	Intervention No. of Patients	Control No. of Events	Control No. of Patients	RR (95% CI)	Weight, %
Exercise vs control (long-term)						
Gundewall et al,[31] 1993	1	28	12	32	0.10 (0.01-0.69)	39
Warming et al,[42] 2008	2	35	5	33	0.38 (0.08-1.81)	61
Pooled effect: I^2 = 11.7%					0.22 (0.06-0.76)	
Exercise and education vs control (short-term)						
Lønn et al,[22] 1999	7	38	11	35	0.59 (0.26-1.34)	39
Soukup et al,[39] 1999	10	34	11	35	0.94 (0.46-1.91)	51
Warming et al,[42] 2008	2	35	5	51	0.58 (0.12-2.84)	11
Pooled effect: I^2 = 0%					0.74 (0.44-1.26)	
Exercise and education vs control (long-term)						
Glomsrød et al,[30] 2001	12	37	18	35	0.63 (0.36-1.11)	47
Soukup et al,[39] 1999	13	31	18	35	0.82 (0.48-1.38)	53
Pooled effect: I^2 = 0%					0.72 (0.48-1.08)	
Education vs control (short-term)						
van Poppel et al,[41] 1998	12	142	17	140	0.70 (0.35-1.40)	73
Warming et al,[42] 2008	5	33	5	51	1.55 (0.48-4.93)	27
Pooled effect: I^2 = 22.5%					0.87 (0.47-1.60)	
Back belts vs control (short-term)						
van Poppel et al,[41] 1998	17	134	13	148	1.44 (0.73-2.86)	100
Education, training, and ergonomics vs control (short-term)						
IJzelenberg,[32] 2007	18	185	18	175	0.95 (0.51-1.76)	100



Studies are ordered chronologically within prevention strategies. Short-term indicates follow-up of 12 months or less; long-term, follow-up evaluation of more than 12 months.

prevention strategies, we could identify only a small number of trials; this combined with the quality of the trials means the level of evidence for several prevention strategies is very low or low.

Comparison With Other Studies

To our knowledge, this review is the first to have included a variety of LBP prevention strategies and conducted a meta-analysis of RCTs. Several reviews have investigated the effectiveness of an exercise and/or education program on LBP prevention. All are out-of-date, included at least 1 RCT with symptomatic participants at baseline (ie, the trial evaluated treatment, not prevention), and presented data descriptively.[7-9,45-49] The most recent review we know of investigating the effectiveness of exercise for preventing a LBP episode,[11] presented data from 3 trials. One was included in the meta-analysis of the current review (ie, exercise vs control),[33] one was excluded because the trial included symptomatic participants at baseline,[50] and one was included in a different LBP prevention strategy (ie, exercise and education vs control).[39] That review by Choi et al[11] reported a 50% (2 RCTs with 130 patients) reduction in future LBP episodes when compared with no intervention, which is a larger effect than our estimate of a 35% reduction (4 RCTs with 898 patients).

Previous reviews investigating the efficacy of exercise on the prevention of LBP episodes have not distinguished between studies that included education with the exercise from those just including exercise.[11,45,46] In our review, the combination of exercise and education was effective at long-term follow-up (RR, 0.73 [95%CI, 0.55 to 0.96]), while exercise alone was not (RR, 1.04 [95% CI, 0.73 to 1.49]), suggesting that the distinction between exercise alone and exercise combined with education may be important.

The present review's finding that back belts do not prevent LBP is consistent with results of a previous systematic review.[51] There are a few previous systematic reviews[10,45,52] investigating the use of shoe insoles in the prevention of an LBP episode. Findings from these reviews are in line with the results of our study: shoe insoles are not effective for the prevention of back pain. The most recent review by Chuter et al[10] included 6 trials; our review included 4. We excluded 2 trials because the participants were symptomatic at the time of study entry.[53,54]

Meaning of the Study

Although our review found evidence for both exercise alone (35% risk reduction for an LBP episode and 78% risk reduction for sick leave) and for exercise and education (45% risk reduction for an LBP episode) for the prevention of LBP up to 1 year, we also found the effect size reduced (exercise and education) or disappeared (exercise alone) in the longer term (>1 year). This finding raises the important issue that, for exercise to remain protective against future LBP, it is likely that ongoing exercise is required. Prevention programs focusing on long-term behavior change in exercise habits seem to be important.

Conclusions

The results of this systematic review and meta-analysis of RCTs indicate that exercise in combination with education is likely to reduce the risk of LBP and that exercise alone may reduce the risk of an episode of LBP and sick leave due to LBP, at least for the short-term. The available evidence suggests that education alone, back belts, shoe insoles, and ergonomics do not prevent LBP. It is uncertain whether education, training, or ergonomic adjustments prevent sick leave due to LBP because the quality of evidence is very low.

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Administrative, technical, or material support: Steffens, Oliveira, Teixeira-Salmela, Hancock.
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Invited Commentary

Exercise and the Prevention of Low Back Pain
Ready for Implementation

Timothy S. Carey, MD, MPH; Janet K. Freburger, PhD

Acute low back pain (LBP) is common, with more than 80% of us experiencing at least one episode in our lives. It is painful, a common cause of time off work, and interferes with our ability to perform daily activities. Fortunately, most episodes of acute LBP are self-limited and improve with time and conservative treatments. However, recurrence is common, with estimates ranging from 24% to 80% in the first year.[1]

After recovery, patients often query their health care professional on how to avoid future episodes of LBP. The well-conducted systematic review by Steffens and colleagues[2] provides us with concrete evidence on the value of exercise. They summarize several low- to moderate-quality trials that examine the benefits of exercise and education on primary and secondary prevention of LBP and sick leave due to LBP. The benefits were fairly consistent across studies, and the effect size was large enough to have clinical and policy importance. Exercise alone or in combination with education is effective for preventing LBP. The authors also assessed other interventions, including education without specific exercise instruction, orthotic insoles, and back belts. These other interventions demonstrated minimal, if any, evidence of benefit. The types of exercise instruction across these studies were variable, encompassing core exercises emphasizing the strengthening of back and abdominal muscles, stretching and spine range-of-motion exercises, and more general instruction in aerobic conditioning. Almost all of the education and exercise regimens assessed were substantial regarding the frequency and duration of the sessions. The effect size of the reduction in risk for subsequent LBP was impressive (approximately 25%-40%), with some evidence of reduced use of sick leave. Long-term benefits were less certain, with several studies showing no effect after 1 year. This diminished benefit may be the result of reduced adherence to continued exercise beyond the intervention period.

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If a medication or injection were available that reduced LBP recurrence by such an amount, we would be reading the marketing materials in our journals and viewing them on television. However, formal exercise instruction after an episode of LBP is uncommonly prescribed by physicians. This pattern is, unfortunately, similar to other musculoskeletal problems in which effective but lower-technology and often lower-reimbursed activities are underused. In one study,[3] fewer than half of the patients with chronic LBP or neck pain who were surveyed received exercise instruction despite a good evidence base for its effectiveness. Passive treatments (eg, physical modalities) with limited evidence of effectiveness were rela-