# Prevention strategies to reduce future impact of low back pain: a systematic review and meta-analysis

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## ABSTRACT

**Objective** To evaluate the evidence from randomised controlled trials (RCTs) on the effectiveness of prevention strategies to reduce future impact of low back pain (LBP), where impact is measured by LBP intensity and associated disability.

**Design** Systematic review with meta-analysis.

**Data sources** MEDLINE, Embase, CINAHL, PEDro and The Cochrane (CENTRAL) databases from inception to 22 October 2018.

**Eligibility criteria** RCTs evaluating any intervention aiming to prevent future impact of LBP, reporting an outcome measure of LBP intensity and/or disability measured at least 3 months post-randomisation, and the intervention group must be compared with a group that received no intervention/placebo or minimal intervention. Trials restricting recruitment to participants with current LBP were excluded.

**Results** 27 published reports of 25 different trials including a total of 8341 participants fulfilled the inclusion criteria. The pooled results, from three RCTs (612 participants), found moderate-quality evidence that an exercise programme can prevent future LBP intensity (mean difference (MD) −4.50; 95% CI −7.26 to −1.74), and from 4 RCTs (471 participants) that an exercise and education programme can prevent future disability due to LBP (MD −6.28; 95% CI −9.51 to −3.06). It is uncertain whether prevention programmes improve future quality of life (QoL) and workability due to the overall low-quality and very low-quality available evidence.

**Conclusions** This review provides moderate-quality evidence that an exercise programme, and a programme combining exercise and education, are effective to reduce future LBP intensity and associated disability. It is uncertain whether prevention programmes can improve future QoL and workability. Further high-quality RCTs evaluating prevention programmes aiming to reduce future impact of LBP are needed.

## INTRODUCTION

Low back pain (LBP) is the leading cause of global disability and a common reason for work absenteeism, lost productivity and care-seeking.[1–3] Although most people with an episode of LBP improve substantially within 6–12 weeks,[4] most will also experience a recurrence within 12 months.[5] For this reason, LBP is considered to be a chronic condition with recurrent symptomatic episodes. Effective prevention strategies to reduce future LBP intensity and associated disability have the potential to greatly reduce the burden associated with this condition.

A recent systematic review[6] reported moderate-quality evidence that exercise combined with education reduces the risk of a future episode of LBP (relative risk 0.55; 95% CI 0.41 to 0.74), but that most other interventions either lacked evidence or appeared to be ineffective. Importantly, this review took a traditional approach to prevention by only including studies recruiting participants without LBP at baseline. While this approach works well in acute conditions where the onset and the end of the episode are clear, it has limitations for a chronic recurrent condition like LBP. In chronic fluctuating conditions, it is arguably more important to prevent the consequences of the chronic disease (sometimes considered tertiary prevention) than to simply prevent future episodes.

The effectiveness of prevention strategies in terms of reducing future LBP intensity and/or associated disability rather than preventing future episodes of LBP have been explored in previous studies.[7 8] Studies such as these commonly include 'mixed populations' (ie, both asymptomatic and symptomatic patients) at study entry, rather than restricting inclusion to people without LBP. These studies provide important information about the potential effectiveness of prevention strategies on reducing future LBP intensity and associated disability, but were not included in the previous systematic review.[6] Studies including 'mixed populations' also differ from traditional treatment studies that require all participants to have symptoms at study entry. It is timely to conduct a synthesis of randomised controlled trials (RCTs) to enable better understanding of the effects of prevention strategies to reduce future impact of LBP.

Therefore, the primary aim of this systematic review was to investigate the effectiveness of prevention strategies aiming to reduce future impact of LBP, where impact is measured by LBP intensity and associated disability.

## METHODS

### Study reporting and protocol registration

The systematic review adhered to the statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions (Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)).[9] The review protocol was prospectively registered on PROSPERO (CRD42018107946).

### Data sources and searches

A comprehensive search of five electronic databases (MEDLINE via Ovid, EMBASE via Ovid, CINAHL,

Physiotherapy Evidence Database (PEDro) and The Cochrane Central Register of Controlled Trials (CENTRAL) via The Cochrane Library for eligible manuscripts was conducted from the date of inception to 22 October 2018. A sensitive search strategy was used based on the recommendations of the Cochrane Back and Neck Group[10] for 'randomised controlled trials' and 'low back pain', combined with search terms for 'prevention'. The full search strategy for each database is presented in the online supplementary appendix A. In addition, reference lists of relevant reviews and included RCTs were manually searched and citation tracking of all included trials was performed. The searches and inclusion criteria were not restricted by language.

## Study selection and screening criteria

We included published reports of RCTs, including cluster-RCTs, testing the effectiveness of prevention strategies aiming to reduce future impact of LBP. Impact of LBP was measured by LBP intensity and disability. We excluded RCTs that restricted recruitment to participants with current LBP (treatment studies). Eligible interventions included any approach aiming to prevent or reduce future impact of LBP such as workplace interventions to control risk factors or interventions to make people more fit/healthy/resilient. To be eligible, trials needed to compare an intervention group with a group that received no intervention, sham intervention or minimal intervention. We also included RCTs investigating multimodal interventions if the effect of one intervention could be isolated (eg, back exercise and education vs education alone).

Trials needed to report an outcome measure of LBP intensity and/or LBP-associated disability measured at least 3 months postrandomisation. Primary outcomes for this review were: a) pain-intensity measured by a self-reported outcome measure (eg, visual analogue scale, numerical rating scale) and b) disability measured by a self-reported outcome measure (eg, Oswestry Disability Index and Roland-Morris Disability Questionnaire). Other patient-centred outcomes relevant to back pain such as quality of life (QoL) were considered secondary outcomes. Studies that used a quasi-randomised design were excluded.

A three-stage screening process was used to select relevant RCTs for this review. In the first stage, one reviewer (TFdC) screened all titles for eligibility and excluded clearly irrelevant studies. In the second stage, each study title and abstract was independently evaluated by pairs of review authors (TFdC, DS, JTF, MH, SA). In the third stage, the full-text for each potentially eligible study was assessed against the eligibility criteria by a pair of independent review authors (TFdC, DS, JTF, MH, SA). Disagreements were resolved through discussion. We contacted authors for additional information as necessary.

## Data extraction

Data for each included trial were extracted by pairs of independent reviewers (TFdC, DS, JTF, MH, SA) using a standardised data extraction form and discrepancies resolved through discussion. Extracted data included: study characteristics (eg, source, study design, country, participant's characteristics, outcome measure, description of the intervention/control groups and follow-up periods), means and measures of variability for all outcomes. When possible, raw mean and SD outcome data for both the intervention group and control group were extracted. We also estimated raw data from graphs in cases where this information was not presented in tables or text. We attempted to contact authors of included RCTs to clarify any relevant information or request additional data when required.

## Quality appraisal

Risk of bias was assessed using the PEDro scale[11–13] by either downloading the available scores from the PEDro database (http://www.pedro.org.au), or by two experienced PEDro raters rating the report when not available online. The total score on the PEDro scale is the addition of 'yes' (criterion is clearly satisfied) responses for items 2–11 (item 1 is not used for calculation of the total PEDro scale score because it is more related to external validity) and range from 0 (high risk of bias) to 10 (low risk of bias). The PEDro scale total score has acceptably high reliability and validity[11 12] and Rasch analysis has confirmed that it can be used as a continuous scale.[14]

## Quality of evidence assessment

The overall quality of evidence for each intervention contrast was rated as high, moderate, low or very low quality as recommended by the Grading of Recommendations Assessment, Development and Evaluation (GRADE) system.[15] The GRADE classification was downgraded one level per study limitation, from high quality, if any of the following limitations were present: (i) design limitation (more than a quarter of participants from studies with low methodological quality (PEDro score <7)); (ii) inconsistency of results (wide variation of point estimates across individual trials or substantial heterogeneity, $I^2$ >50%); (iii) imprecision (based on a threshold of <400 total participants for each pooled outcome estimate). We did not consider the indirectness criterion in this review as we included a specific population with relevant outcomes. When only a single RCT was available, evidence from RCTs with fewer than 400 participants was downgraded for inconsistency and imprecision; however, evidence from single RCTs presenting >400 participants was only downgraded for inconsistency. Publication bias was not evaluated due to the small number of trials in each meta-analysis.[16]

A GRADE profile was completed for each pooled estimate and for single RCTs comparing a LBP prevention strategy with a control intervention. Two independent reviewers (TFdC and MH) independently performed GRADE assessments for each treatment contrast and disagreements were resolved by discussion.

## Statistical analysis

The between-groups mean difference (MD) and 95% CIs were calculated using the mean final score for the intervention and control groups. We used final scores rather than within group change scores as only one study reported change scores.[16] When possible, we combined results in a meta-analysis using random-effects models. Negative values of the mean difference estimate represent an effect in favour of the intervention group. To accommodate the different scales used for study outcomes, we converted, whenever possible, outcomes to a common 0–100 scale. If conversion was not possible due to the nature of outcome (eg, categorical or ordinal), we did not convert the results but instead presented them as a narrative synthesis. If information regarding SD was missing, we calculated these from CIs, SEs or p values; however, if no measure of variability was presented, we estimated the SD from the most similar and high-quality trial in the review as recommended by *The Cochrane Collaboration*.[16]

Outcome assessment data were extracted for two time periods: short-term follow-up (collected at <12 months postrandomisation); long-term follow-up (collected at ≥12 months postrandomisation). When studies presented multiple follow-up time-points that fell within the same category, we

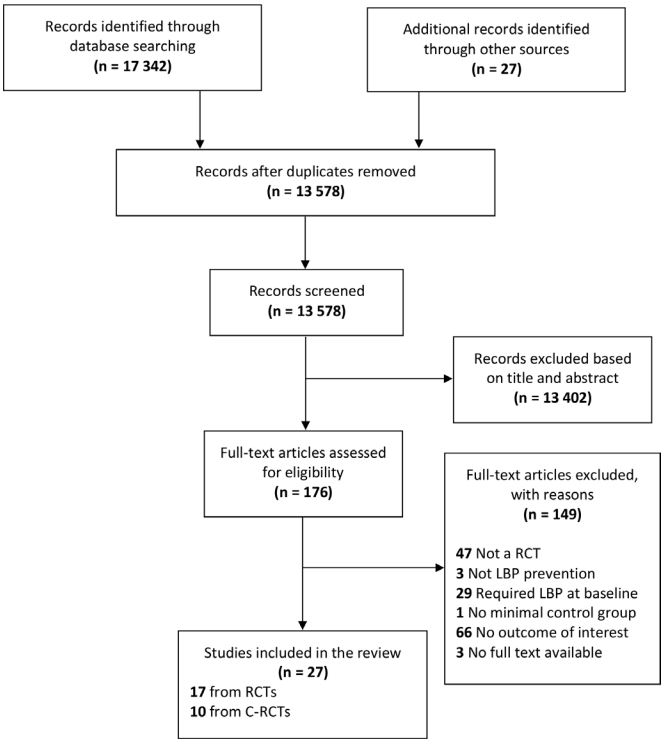


**Figure 1** Flow diagram of study selection. C-RCT, cluster-randomised controlled trial; LBP, low back pain; RCT, randomised controlled trial.

used the time-point that was closest to 6 months for short-term follow-up and one closest to 12 months for long-term follow-up. For RCTs including multiple treatment arms, we extracted data for each comparison that met the inclusion criteria and adjusted the numbers per group as recommended by *The Cochrane Handbook for Systematic Review of Interventions*.[16]

Trials considered homogeneous were grouped, when possible, according to the population (eg, children, pregnant women), intervention strategy, outcome measure and outcome assessment time-points (short-term and long-term). For RCTs not reporting the sample size at the follow-up time-point, we adopted the baseline sample size.

Where we considered study interventions to be sufficiently similar to be combined in meta-analyses, we assessed heterogeneity of treatment effects by visual inspection of effect size with 95% CI and by using the $I^2$ statistic. We used Comprehensive Meta-Analysis, V.2.2.064 (Biostat) for all analyses.

## RESULTS

Of the 17 342 identified records, 176 were considered potentially eligible and we reviewed full-text manuscripts. Of these, 27 published reports (25 different RCTs including 8341 participants) met the inclusion criteria and were deemed eligible for this review.[7 8 17–41] The 25 RCTs included 10 cluster-RCTs.[7 17 20 28 30 34 35 39–41] Two RCTs were reported in four published manuscripts, with two manuscripts[32 36] reporting on short-term follow-up and the other two manuscripts[25 37] reporting on long-term follow-up.[25 32 36 37] An outline of the screening and selection process is provided in figure 1.

The included studies investigated three different populations: general adults, pregnant women and children. Most trials recruited participants who were employees at a hospital (32%) or company (40%) setting while only two trials (8%) recruited people from the general community. Most included trials (8269 participants) examined a working-age population with the mean age of 45.1 years and majority female (75.9%). Six different LBP prevention strategies were investigated: exercise, exercise and education, education, ergonomics, ergonomics and education and lumbar support. Two trials investigated LBP prevention strategies in a population of pregnant women,[21 23] while one trial investigated a sample of primary school children.[22] Eight trials presented two intervention contrasts (three arms).[7 17 19 29 31 35 40 41] Table 1 and online supplementary appendix B provide details of the characteristics of each included trial.

Risk of bias scores for 24[7 8 17–28 30–32 34–37 39–41] of the included studies were found on the PEDro database website. The other three studies[29 33 38] were assessed by two raters. The mean (SD) PEDro score was 5.4 (1.2) with blinding, concealed allocation, intention-to-treat analysis and adequate follow-up being the main items scored as high risk of bias in 92%, 63%, 55% and 52% of included studies, respectively. The PEDro scale ratings for individual items and the total score for each included RCT are available in online supplementary appendix C.

Raw final scores data for intervention and control groups were available for 23 of the 25 included trials. For the remaining two trials, we used the reported MD (95% CI).[17 28] For six trials[21 31 34–36 39] we calculated SD and for two trials[20 38] we imputed data from similar studies. Study design, follow-up time-point, outcome measure, sample size, raw MD and SD for each intervention and between-groups MD (95% CIs) for all included trials are presented in online supplementary appendix D (primary outcomes) and online supplementary appendix E (secondary outcomes). Trials were grouped according to the prevention strategy, outcomes, follow-up time-point (short-term or long-term) and population. Table 2, online supplementary appendix F (primary outcomes), online supplementary appendix G and online supplementary appendix H (secondary outcomes) provide a summary of the findings and the quality of evidence (GRADE) rating.

### Effectiveness of interventions for primary outcomes

#### Exercise

Three trials (612 participants) investigated the short-term effects of exercise programmes on prevention or reduction of future LBP intensity and associated disability.[17 27 34] The pooled results of three trials (four intervention contrasts) provided moderate-quality evidence that exercise is effective for preventing future LBP intensity (MD −4.50; 95% CI −7.26 to −1.74) (tables 2 and 3).

For prevention of associated disability due to LBP, a single trial (189 participants) provided very low-quality evidence of no short-term effect of exercise programmes (MD −2.36; 95% CI −7.11 to 2.39) (tables 2 and 4).[27]

#### Exercise and education

Three trials (184 participants) investigated the effectiveness of an exercise and education prevention programme on reducing future LBP intensity at short-term follow-up,[30 32 36] and four trials[8 32 36 40] (471 participants) at long-term follow-up. The pooled results of the three trials provided low-quality evidence that an exercise and education programme is not effective at short-term follow-up (MD −1.95; 95% CI −10.09 to 6.18). The long-term results are based on pooling for the four trials and provided moderate-quality evidence of no long-term effect (MD −4.37; 95% CI −9.16 to 0.43) (tables 2 and 3).

For prevention of future disability due to LBP, two trials (150 participants) investigated short-term follow-up,[32 36] and four

**Table 1** Characteristic of RCTs included in the systematic review of prevention strategies to reduce future impact of LBP

| Source | Study design | Country | Participants | Outcome measure | Study groups | Time and frequency of interventions | Follow-up period (mo) |
|---|---|---|---|---|---|---|---|
| Barene *et al*[17] | C-RCT | Norway | 118 hospital employees; mean (SD) age, 45.8 (9.3) y; female (91%) | LBP intensity<br>LBP duration | I1: Exercise: soccer<br>I2: Exercise: zumba<br>C: No intervention | Two–three 1 hour sessions per wk over 40 wks for both intervention groups | 10 mo |
| Chaléat-Valayer *et al*[8] | RCT | France | 342 healthcare workers from 10 hospitals; mean (SD) age, 47.2 (8.5) y; female (77%) | LBP intensity (VAS)<br>disability (QBPDS) | I: Education and exercise training sessions<br>C: No intervention | Single 2 hours education session and 5 weekly 90 min group exercise sessions | 18 mo |
| Donaldson *et al*[18] | RCT | Canada | 172 hospital employees; mean (SD) age NR; sex NR | LBP intensity (MPQ) | I: Education course (classes)<br>C: No intervention | 9 classes, 1.5 hours each | 12 mo |
| Donchin *et al*[19] | RCT | Israel | 142 hospital employees; mean (SD) age, 46.0 (NR) y; female (66%) | LBP (painful months) | I1: Exercise: calisthenics<br>I2: Exercise: back school<br>C: No intervention | I1: 45 min sessions, biweekly, for 3 mo<br>I2: 4×90 min sessions during a 2 wks | 12 mo |
| Driessen *et al*[20] | C-RCT | The Netherlands | 3047 workers from 4 Dutch companies; mean (SD) age, 42.0 (10.95) y; female (41%) | LBP intensity (VAS)<br>LBP duration | I: Ergonomics programme<br>C: Minimal intervention | I: Use the ergonomics programme while on duty<br>C: Three short education videos | 12 mo |
| Eggen *et al*[21] | RCT | Norway | 257 healthy pregnant women before gestation week 20; mean (SD) age, 30.3 (4.8) y; female (100%) | LBP intensity (VAS)<br>disability (RMDQ) | I: Exercise: group classes and home exercises<br>C: No intervention | 1× per wk 1 hour group exercise session for 16–20 wks | 4 mo |
| Fanucchi *et al*[22] | RCT | South Africa | 72 children in grade 6 and grade 7 primary school; mean (SD) age, 12.3 (0.7) y; female (46%) | LBP intensity (VAS) | I: Education and exercise sessions<br>C: No intervention | 8× classes 40–45 min each over 8 wks | 6 mo |
| Garshasbi and Faghih Zadeh[23] | RCT | Iran | 212 pregnant women (17–22 weeks of gestation); mean (SD) age, 26.4 (4.6) y; female (100%) | LBP intensity (KQ) | I: Exercise training<br>C: No intervention | 3× per wk for 60 min each for 12 wks | 3 mo |
| Gatty[24] | RCT | USA | 16 clerical and office workers; mean (SD) age, NR; female (100%) | LBP intensity (VAS)<br>LBP duration | I: Ergonomics: implementation of individualised work injury prevention programme<br>C: No intervention | 1 hour session over 4 wks period (four sessions) | 9 mo |
| Glomsrød *et al*[25] | RCT | Norway | 81 community and participants referred from primary care clinicians; mean (SD) age, 39.4 (6.8) y; female (54%) | LBP intensity (VAS)<br>disability (VAS) | I: Exercise and education<br>C: No intervention | 2 sessions per wk for 7 wks;<br>1 session per wk for 6 wks; each session 60 min | 36 mo |
| Gundewall *et al*[26] | RCT | Sweden | 69 hospital nurses/nurse's aides; mean (SD) age, 37.5 (10.5) y; female (98%) | LBP duration | I: Exercise: back muscle exercises<br>C: No intervention | 6× monthly sessions of 20 min each | 13 mo |
| Haufe *et al*[27] | RCT | Germany | 226 workers from three medium-sized companies; mean (SD) age, 42.7 (10.2) y; female (40%) | LBP intensity (VAS)<br>disability (ODI) | I: General exercise training and individual counselling/supervision sessions<br>C: Continue their current lifestyle | I: 20 min non-supervised general exercise session 3× per wk. 5× once monthly counselling session | 5 mo |
| Ijzelenberg *et al*[28] | C-RCT | The Netherlands | 489 workers performing physically demanding jobs in companies; mean (SD) age, 41.3 (9.7) y; female (3%) | LBP intensity (NRS)<br>disability (RMDQ) | I: Education and ergonomics adjustments<br>C: Usual care: healthcare for LBP | 3× group training sessions. Unclear frequency | 12 mo |
| Irvine *et al*[29] | RCT | USA | 597 workers from 4 companies also general work population; mean (SD) age, NR; female (60%) | LBP intensity<br>LBP duration<br>LBP functionality | I1: Education: FitBack website program<br>I2: Education: alternative care<br>C: No intervention | I: Weekly emails and unlimited access to online material during study period | 4 mo |
| Jensen *et al*[7] | C-RCT | Denmark | 210 home care workers, nurses and nurse's aides; mean (SD) age, 44.3 (8.9) y; female (100%) | LBP intensity (NRS) | I1: Education: transfer technique intervention<br>I2: Education: stress management intervention<br>C: No intervention | I1: 2×4 hours classes and 30 hours site education (6 mo)<br>I2: Group sessions every 2 wks for 2 hours (20 wks) | 24 mo |
| Kamioka *et al*[30] | C-RCT | Japan | 88 female caregivers from 4 nursing homes in Tokyo; mean (SD) age, 38.15 (13.75) y; female (100%) | LBP intensity (VAS) | I: Education lecture and stretching exercise<br>C: No intervention | Single lecture of 30 min; 1 hour exercises. Daily stretching (6 min) | 3 mo |
| Ketola *et al*[31] | RCT | Finland | 109 office workers; mean (range) age, 48.0 (29 to 59) y; female (60%) | LBP discomfort | I1: Intensive ergonomics<br>I2: Ergonomics education<br>C: No intervention | I1: Around 2 hours of implementation<br>I2: A single 1 hour session | 10 mo |
| Lønn *et al*[32] | RCT | Norway | 81 community and participants referred from primary care clinicians; mean (SD) age, 39.4 (6.8) y; female (54%) | LBP intensity (VAS)<br>disability (VAS) | I: Exercise and education<br>C: No intervention | 2 sessions per wk for 7 wks<br>1 session per wk for 6 wks; each session 60 min | 12 mo |
| Menzel *et al*[33] | RCT | USA | 31 registered nurses and nursing aides; mean (SD) age, 41.94 (9.0) y; female (97%) | LBP intensity (VAS)<br>disability (ODI) | I: Education: psychoeducational sessions for stress and pain management<br>C: No intervention | 6×1.5 hours group discussion session | 3 mo |
| Pedersen *et al*[34] | C-RCT | Denmark | 537 laboratory technicians; mean (SD) age, 42.0 (10.5) y; female (85%) | LBP intensity (VAS) | I: Exercise training sessions<br>C: No intervention | 3× weekly for 20 min each over 5 mo | 5 mo |
| Pedersen *et al*[35] | C-RCT | Denmark | 549 office workers; mean (SD) age, 45.1 (9.4) y; female (64%) | LBP duration | I1: Specific resistance training<br>I2: All-round physical exercise<br>C: Reference group: group discussion to improve knowledge on health and working conditions | I1: 3× per wk for 20 min 12 mo<br>I2: 1× introductory session at worksite; 1 hour per wk | 12 mo |
| Soukup *et al*[37] | RCT | Norway | 77 community and primary care participants; mean (SD) age, 37.7 (8.0) y; female (53%) | LBP intensity (VAS)<br>Disability (VAS) | I: Mensendieck exercises and ergonomics<br>C: No intervention | 20 sessions for 60 min over a period of 13 wks | 36 mo |

Continued

**Table 1** Continued

| Source | Study design | Country | Participants | Outcome measure | Study groups | Time and frequency of interventions | Follow-up period (mo) |
|---|---|---|---|---|---|---|---|
| Soukup *et al*[36] | RCT | Norway | 77 community and primary care participants; mean (SD) age, 37.7 (8.0) y; female (53%) | LBP intensity (VAS) disability (VAS) | I: Mensendieck exercises and ergonomics education<br>C: No intervention | 20 sessions for 60 min over a period of 13 wks | 12 mo |
| Tuchin[38] | RCT | Australia | 61 employees of a large mailing house; mean (SD) age NR; sex NR | Disability (ODI) | I: A comprehensive spinal pain education lecture including advice on effective exercises<br>C: Advice on stretching procedures used for sports 'warm-up' | I: Single 120 min lecture session<br>C: Daily over 6 mo period | 6 mo |
| van Poppel* *et al*[39] | C-RCT | The Netherlands | 312 airline company workers; mean (SD) age, 35.1 (7.8) y; sex NR | LBP duration | I1: Lumbar support+education<br>I2: Lumbar support only<br>I3: Education only<br>C: No intervention | Lumbar support: wear for 6 mo (work hours)<br>Education (lifting instructions): 1×2 hours; 2×1.5 hours; 3×(12 wks)<br>C: No intervention | 6 mo |
| Warming *et al*[40] | C-RCT | Denmark | 181 hospital nurses; mean (SD) age, 35.2 (10.5) y; female (90%) | LBP intensity (NQ) disability (RS) | I1: Education: transfer technique<br>I2: Education and physical training (TTPT)<br>C: No intervention | I1: 2×6 wks sessions<br>I2: 2× per wk for 1 hour (8 wks) | 12 mo |
| Yassi *et al*[41] | C-RCT | Canada | 346 staff performing patient lifts and transfers (nurses and unit assistants); mean (SD) age NR; sex NR | LBP discomfort disability (ODI) | I1: Education: safe lifting programme (Arm B)<br>I2: Education: no strenuous lifting programme (Arm C)<br>C: Usual practice (Arm A) | I1 and I2: 3 hours single session | 12 mo |

*The study by van Poppel *et al*[39] was analysed as a 2×2 factorial design (ie, four groups) with the following intervention contrasts: lumbar support vs no lumbar support, and education vs no education.
C, control group; C-RCT, cluster randomised controlled trial; I, intervention group; KQ, KEBK Questionnaire; LBP, low back pain; mo, month; MPQ, McGill Pain Questionnaire; NQ, Nordic Questionnaire; NR, not reported; NRS, Numeric Rating Scale; ODI, Oswestry Disability Index; QBPDS, Quebec Back Pain Disability Scale; RCT, randomised controlled trial; RMDQ, Roland-Morris Disability Questionnaire; RS, Rating Scale; TTPT, transfer technique and physical activity; VAS, Visual Analogue Scale; wk, week; y, year.

trials[8 32 36 40] (471 participants) long-term follow-up. Pooled results of the two trials provides low-quality evidence of no short-term effect of an exercise and education programme on reducing future disability associated with LBP (MD −4.94; 95% CI −12.78 to 2.90). For long-term follow-up, four trials were pooled and provided moderate-quality evidence that exercise and education programme is effective to reduce future disability associated with LBP (MD −6.28; 95% CI −9.51 to −3.06) (tables 2 and 4).

### Education

The short-term effect of an education programme on preventing future LBP intensity was investigated in four trials,[18 29 31 33] while two trials[7 40] reported results on long-term effects. The pooled results of three trials (777 participants)[18 29 33] provided moderate-quality evidence that education programmes do not prevent future LBP intensity at short-term follow-up (MD −1.81; 95% CI −4.68 to 1.07). One trial (57 participants)[31] was not included in the meta-analysis as it was not possible to convert data to a 0–100 scale. The long-term results are based on pooling of the two trials (126 participants)[7 40] and provide low-quality evidence of no effect (MD 1.71; 95% CI −6.14 to 9.56) (tables 2 and 3).

For prevention of LBP-associated disability, four trials (804 participants)[29 33 38 41] reported short-term data, and two trials (176 participants)[40 41] reported long-term data. The pooled results of the four trials provide moderate-quality evidence of no short-term effect (MD −2.59; 95% CI −6.15 to 0.96), while pooling of the two trials provide low-quality evidence of no long-term effect (MD −0.29; 95% CI −4.87 to 4.30) (tables 2 and 4).

### Ergonomics intervention

Three trials[20 24 31] investigated the effectiveness of an ergonomics programme on prevention of future LBP intensity at short-term follow-up (619 participants), and a single trial[20] at long-term follow-up (538 participants). It was not possible to pool estimates for the three trials investigating short-term follow-up as we could not convert two trials[24 31] to a 0–100 scale. The results from one trial[20] on short-term (552 participants) (MD 1.40; 95% CI −3.28 to 6.08) and long-term (538 participants) (MD 2.00; 95% CI −2.74 to 6.74) follow-ups provide low-quality evidence of no effect on preventing future LBP intensity (tables 2 and 3).

### Ergonomics intervention and education

The effectiveness of an ergonomics and education programme for preventing future LBP intensity (short-term) and LBP-associated disability (short-term and long-term) was investigated in a single trial.[28] The results from one trial on short-term (192 participants) effect for either prevention of future LBP intensity (MD 1.00; 95% CI −6.93 to 8.93) or disability due to LBP (MD 2.08; 95% CI −1.87 to 6.03), and long-term (184 participants) effect for disability due to LBP (MD 1.25; 95% CI −3.08 to 5.58) provide very low-quality evidence of no preventive effect.[28] The long-term effect on preventing future LBP intensity was investigated in two trials (266 participants)[7 28] and provide low-quality evidence of no effect (MD 0.00; 95% CI −6.70 to 6.70) (tables 2–4).

## Effectiveness of interventions for primary outcomes in special populations

Three trials investigated the short-term effect of two different strategies to prevent future LBP intensity and associated disability in pregnant women and children.[21–23] Pooling of two trials (452 participants) provides moderate-quality evidence that an exercise programme was not effective for prevention of future LBP intensity (MD −2.70; 95% CI −6.56 to 1.17) at short-term follow-up in pregnant women.[21 23] In addition, one trial (240 participants) provides low-quality evidence of no preventive effect on future disability due to LBP (MD −2.91; 95% CI −7.06 to 1.24) in pregnant women.[21]

Furthermore, a single trial (70 participants) shows very low-quality evidence that an exercise and education programme has no effect on preventing future LBP intensity (MD 0.00; 95% CI

**Table 2** Summary of findings for primary outcome and quality of evidence assessment (GRADE)*

| Outcome | Follow-up time-point | Number of participants | MD (95% CI)† | GRADE |
|---|---|---|---|---|
| General population | | | | |
| *Exercise vs control* | | | | |
| Pain intensity | Short-term | 612[17 27 34] | −4.50 (−7.26 to −1.74) | Moderate quality |
| Disability | Short-term | 189[27] | −2.36 (−7.11 to 2.39) | Very low quality‡ |
| *Exercise and education vs control* | | | | |
| Pain intensity | Short-term | 184[30 32 36] | −1.95 (−10.09 to 6.18) | Low quality |
| Pain intensity | Long-term | 471[8 32 36 40] | −4.37 (−9.16 to 0.43) | Moderate quality |
| Disability | Short-term | 150[32 36] | −4.94 (−12.78 to 2.90) | Low quality |
| Disability | Long-term | 471[8 32 36 40] | −6.28 (−9.51 to −3.06) | Moderate quality |
| *Education vs control* | | | | |
| Pain intensity | Short-term | 777[18 29 33] | −1.81 (−4.68 to 1.07) | Moderate quality |
| Pain intensity | Long-term | 126[7 40] | 1.71 (−6.14 to 9.56) | Low quality |
| Disability | Short-term | 804[29 33 38 41] | −2.59 (−6.15 to 0.96) | Moderate quality |
| Disability | Long-term | 176[40 41] | −0.29 (−4.87 to 4.30) | Low quality |
| *Ergonomics vs control* | | | | |
| Pain intensity | Short-term | 552[20] | 1.40 (−3.28 to 6.08) | Low quality‡ |
| Pain intensity | Long-term | 538[20] | 2.00 (−2.74 to 6.74) | Low quality‡ |
| *Ergonomics and education vs control* | | | | |
| Pain intensity | Short-term | 192[28] | 1.00 (−6.93 to 8.93) | Very low quality‡ |
| Pain intensity | Long-term | 266[7 28] | 0.00 (−6.70 to 6.70) | Low quality |
| Disability | Short-term | 192[28] | 2.08 (−1.87 to 6.03) | Very low quality‡ |
| Disability | Long-term | 184[28] | 1.25 (−3.08 to 5.58) | Very low quality‡ |
| Pregnant population | | | | |
| *Exercise vs control* | | | | |
| Pain intensity | Short-term | 452[21 23] | −2.70 (−6.56 to 1.17) | High quality |
| Disability | Short-term | 240[21] | −2.91 (−7.06 to 1.24) | Low quality‡ |
| Children population | | | | |
| *Exercise and education vs control* | | | | |
| Pain intensity | Short-term | 70[22] | 0.00 (−11.68 to 11.68) | Very low quality‡ |

A negative value of the MD estimate represents an effect in favour of the intervention group.
Short-term indicates follow-up assessment of <12 months.
Long-term indicates follow-up assessment of 12 months or more.
*Only studies providing results that could be converted to a 0–100 scale are presented.
†Value presented on 0–100 scale.
‡Quality of evidence assessment based on a single trial.
GRADE, Grading of Recommendations Assessment, Development and Evaluation; MD, mean difference.

−11.68 to 11.68) in children at short-term follow-up.[22] Results are presented in tables 2–4.

### Effectiveness of interventions for secondary outcomes

Four secondary outcome measures (QoL, workability, pain duration and duration of sick leave) were investigated in 18 included trials[8 17 19–22 24–30 32 35–39 41]; however, only two outcomes (QoL and workability) were included in the meta-analysis as we could convert data to a 0–100 scale. Overall, we found the evidence was low quality or very low quality with intervention contrasts suggesting no prevention effect on either QoL or workability at short-term and long-term follow-ups. Results for secondary outcomes are presented in online supplementary appendix G and online supplementary appendix I.

## DISCUSSION

Moderate-quality evidence based on three trials (612 participants) (4 intervention contrasts) indicates that exercise alone can reduce future LBP intensity (MD −4.50; 95% CI −7.26 to −1.74) at short-term follow-up. We found no studies that investigated the long-term prevention effect of exercise. Moderate-quality evidence from four trials (471 participants) indicates that exercise and education programmes can reduce future disability associated with LBP (MD −6.28; 95% CI −9.51 to −3.06) at long-term follow-up. In addition, although not statistically significant, the evidence for exercise and education suggests that at short-term it may reduce future disability associated with LBP (MD −4.94; 95% CI −12.78 to 2.90), and at long-term it may reduce future LBP intensity (MD −4.37; 95% CI −9.16 to 0.43). It is uncertain whether education, ergonomics and ergonomics combined with education or interventions delivered in special populations (ie, pregnant women and children) can reduce future LBP intensity and associated disability due to very low quality to low quality of evidence. The impact of prevention programmes on the outcomes of QoL and workability is also unclear due to very low-quality to low-quality evidence.

Previous research demonstrates that exercise programmes alone or in combination with education have moderate-quality evidence supporting their effectiveness to reduce the risk of a future episode of LBP.[6] Our review investigated different outcomes (pain intensity and disability, rather than episodes of LBP) and different populations (including some people with current LBP), but our results support the evidence that exercise

**Table 3** Individual study results and pooled effects for primary outcome of pain intensity*

| Source | Study design | Follow-up time-point (months) | Number of participants | MD (95% CI)† | Weight, % |
|---|---|---|---|---|---|
| *General population* | | | | | |
| *Exercise vs control (short-term)* | | | | | |
| *Haufe et al*[27] | RCT | 5 | 189 | −6. 6 (−13.38 to 0.18) | 15.08 |
| *Barene et al*[17] | C-RCT (6 clusters) | 3 | 43 | −1.0 (−10.70 to 8.70) | 7.70 |
| *Barene et al*[17] | C-RCT (6 clusters) | 3 | 46 | 2.0 (−6.75 to 10.75) | 9.38 |
| *Pedersen et al*[34] | C-RCT (57 cluster) | 5 | 334 | −5.33 (−7.94 to −2.72) | 67.84 |
| Pooled effect: $I^2$=1.78% | | | | **−4.50 (−7.26 to −1.74)** | |
| *Exercise and education vs control (short-term)* | | | | | |
| *Lønn et al*[32] | RCT | 5 | 81‡ | −8.0 (−14.84 to −1.16) | 41.83 |
| *Soukup et al*[36] | RCT | 5 | 69 | −1.0 (−8.79 to 6.79) | 38.42 |
| *Kamioka et al*[30] | C-RCT (4 clusters) | 3 | 34 | 9.0 (−5.95 to 23.95) | 19.75 |
| Pooled effect: $I^2$=10.23% | | | | **−1.95 (−10.09 to 6.18)** | |
| *Exercise and education vs control (long-term)* | | | | | |
| *Chaléat-Valayer et al*[8] | RCT | 18 | 280 | −0.50 (−5.42 to 4.42) | 43.76 |
| *Glomsrød et al*[25]; *Lønn et al*[32] | RCT | 12 | 73 | −11.00 (−20.18 to −1.82) | 20.44 |
| *Soukup et al*[37]; *Soukup et al*[36] | RCT | 12 | 69 | −6.00 (−15.97 to 3.97) | 18.01 |
| *Warming et al*[40] | C-RCT (11 clusters) | 12 | 49 | −4.60 (−14.64 to 5.44) | 17.80 |
| Pooled effect: $I^2$=0% | | | | **−4.37 (−9.16 to 0.43)** | |
| *Education vs control (short-term)* | | | | | |
| *Donaldson et al*[18] | RCT | 3 | 172‡ | −1.54 (−5.97 to 2.89) | 24.49 |
| *Irvine et al*[29] *(FitBack program)* | RCT | 4 | 288 | −4.20 (−7.04 to −1.36) | 37.15 |
| *Irvine et al*[29] *(alternative care)* | RCT | 4 | 294 | −0.90 (−4.16 to 2.36) | 33.30 |
| *Menzel et al*[33] | RCT | 3 | 23 | 8.50 (−3.72 to 20.72) | 5.07 |
| Pooled effect: $I^2$=17.04% | | | | **−1.81 (−4.68 to 1.07)** | |
| *Education vs control (long-term)* | | | | | |
| *Jensen et al*[7] *(SMI)* | C-RCT (19 clusters) | 24 | 78 | 2.00 (−8.93 to 12.93) | 48.41 |
| *Warming et al*[40] *(TT)* | C-RCT (11 clusters) | 12 | 48 | 1.40 (−9.88 to 12.68) | 51.59 |
| Pooled effect: $I^2$=0% | | | | **1.71 (−6.14 to 9.56)** | |
| *Ergonomics vs control (short-term)* | | | | | |
| *Driessen et al*[20] | C-RCT (37 clusters) | 6 | 552 | **1.40 (−3.28 to 6.08)** | 100 |
| *Ergonomics vs control (long-term)* | | | | | |
| *Driessen et al*[20] | C-RCT (37 clusters) | 12 | 538 | **2.00 (−2.74 to 6.74)** | 100 |
| *Ergonomics and education vs control (short-term)* | | | | | |
| *Ijzelenberg et al*[28] | C-RCT (18 clusters) | 6 | 192 | **1.00 (−6.93 to 8.93)** | 100 |
| *Ergonomics and education vs control (long-term)* | | | | | |
| *Ijzelenberg et al*[28] | C-RCT (18 clusters) | 12 | 184 | 0.00 (−8.38 to 8.38) | 63.82 |
| *Jensen et al*[7] *(TTI)* | C-RCT (19 clusters) | 24 | 82 | 0.00 (−11.14 to 11.14) | 36.18 |
| Pooled effect: $I^2$=0% | | | | **0.00 (−6.70 to 6.70)** | |
| *Pregnant population* | | | | | |
| *Exercise vs control (short-term)* | | | | | |
| *Eggen et al,*[21] | RCT | 8 | 240 | −3.00 (−9.36 to 3.36) | 36.92 |
| *Garshasbi and Faghih Zadeh*[23] | RCT | 3 | 212 | −2.52 (−7.38 to 2.34) | 63.08 |
| Pooled effect: $I^2$=0% | | | | **−2.70 (−6.56 to 1.17)** | |
| *Children* | | | | | |
| *Exercise and education vs control (short-term)* | | | | | |
| *Fanucchi et al*[22] | RCT | 6 | 70 | **0.00 (-11.68 to 11.68)** | 100 |

A negative value of the MD estimate represents an effect in favour of the intervention group.
Short-term indicates follow-up assessment of <12 months.
Long-term indicates follow-up assessment of 12 months or more.
*Only studies providing results that could be converted to a 0–100 scale are presented.
†Value presented on 0–100 scale.
‡Only baseline data were available.
C-RCT, cluster-randomised controlled trial; MD, mean difference; RCT, randomised controlled trial; SMI, stress management intervention; TT, transfer technique; TTI, transfer technique intervention; TTPT, transfer technique and physical activity.

alone and in combination with education can also reduce future LBP intensity and associated disability.

Our finding that exercise alone and exercise combined with education can reduce future LBP intensity and associated disability respectively was based on moderate-quality evidence, which means further high-quality RCTs are needed. The absolute effect sizes for exercise alone (MD −4.50; 95% CI −7.26 to −1.74) and exercise combined with education (MD −6.28; 95% CI −9.51 to −3.06) appear small; however, these effects must be considered in the context of LBP prevention, where these relative effects across large populations may be important. For instance, when we look at the long-term outcome

**Table 4** Individual study results and pooled effects for primary outcome of disability*

| Source | Study design | Follow-up time-point (months) | Number of participants | MD (95% CI)† | Weight, % |
|---|---|---|---|---|---|
| *General population* | | | | | |
| *Exercise vs control (short-term)* | | | | | |
| *Haufe et al*[27] | RCT | 5 | 189 | **−2.36 (−7.11 to 2.39)** | 100 |
| *Exercise and education vs control (short-term)* | | | | | |
| *Lønn et al*[32] | RCT | 5 | 81‡ | −9.00 (−17.91 to −0.09) | 49.28 |
| *Soukup et al*[36] | RCT | 5 | 69 | −1.00 (−9.70 to 7.70) | 50.72 |
| Pooled effect: $I^2$=0% | | | | **−4.94 (−12.78 to 2.90)** | |
| *Exercise and education vs control (long-term)* | | | | | |
| *Chaléat-Valayer et al*[8] | RCT | 18 | 280 | −4.60 (−8.37 to −0.83) | 52.69 |
| *Glomsrød et al*[25]; *Lønn et al*[32] | RCT | 12 | 73 | −15.00 (−25.56 to −4.44) | 8.89 |
| *Soukup et al*[37]; *Soukup et al*[36] | RCT | 12 | 69 | −6.00 (−16.85 to 4.85) | 8.43 |
| *Warming et al*[40] *(TTPT)* | C-RCT (11 clusters) | 12 | 49 | −6.74 (−12.14 to −1.34) | 30.00 |
| Pooled effect: $I^2$=3.41% | | | | **−6.28 (−9.51 to −3.06)** | |
| *Education vs control (short-term)* | | | | | |
| *Irvine et al*[29] *(FitBack program)* | RCT | 4 | 288 | −7.10 (−11.98 to −2.22) | 25.21 |
| *Irvine et al*[29] *(alternative care)* | RCT | 4 | 294 | −4.30 (−9.33 to 0.73) | 24.47 |
| *Menzel et al*[33] | RCT | 3 | 24 | 2.00 (−4.72 to 8.72) | 17.68 |
| *Tuchin*[38] | RCT | 6 | 61 | −5.60 (−15.11 to 3.91) | 10.81 |
| *Yassi et al*[41] *(arm B)* | C-RCT (9 clusters) | 6 | 68 | 2.80 (−6.79 to 12.39) | 10.67 |
| *Yassi et al*[41] *(arm C)* | C-RCT (9 clusters) | 6 | 69 | 1.80 (−7.52 to 11.12) | 11.15 |
| Pooled effect: $I^2$=0% | | | | **−2.59 (−6.15 to 0.96)** | |
| *Education vs control (long-term)* | | | | | |
| *Warming et al*[40] *(TT)* | C-RCT (11 clusters) | 12 | 48 | 0.18 (−6.12 to 6.47) | 50.04 |
| *Yassi et al*[41] *(arm B)* | C-RCT (9 clusters) | 12 | 63 | 0.60 (−9.30 to 10.50) | 21.44 |
| *Yassi et al*[41] *(arm C)* | C-RCT (9 clusters) | 12 | 65 | −2.00 (−11.08 to 7.08) | 25.52 |
| Pooled effect: $I^2$=0% | | | | **−0.29 (−4.87 to 4.30)** | |
| *Ergonomics and education vs control (short-term)* | | | | | |
| *Ijzelenberg et al*[28] | C-RCT (18 clusters) | 6 | 192 | **2.08 (−1.87 to 6.03)** | 100 |
| *Ergonomics and education vs control (long-term)* | | | | | |
| *Ijzelenberg et al*[28] | C-RCT (18 clusters) | 12 | 184 | **1.25 (−3.08 to 5.58)** | 100 |
| *Pregnant population* | | | | | |
| *Exercise vs control (short-term)* | | | | | |
| *Eggen et al*[21] | RCT | 8 | 240 | **−2.91 (−7.06 to 1.24)** | 100 |

A negative value of the mean difference estimate represents an effect in favour of the intervention group.
Short-term indicates follow-up assessment of <12 months.
Long-term indicates follow-up assessment of 12 months or more.
*Only studies providing results that could be converted to a 0–100 points scale are presented.
†Value presented on 0–100 scale.
‡Only baseline data were available.
C-RCT, cluster-randomised controlled trial; MD, mean difference; RCT, randomised controlled trial; TT, transfer technique; TTPT, transfer technique and physical activity.

of disability for exercise combined with education, we found a 20% relative reduction. We suggest that clinicians present to patients the available evidence on strategies to prevent or reduce future LBP, and engage in shared decision making on whether to deliver an exercise and education programme. Factors such as the patient's enthusiasm and available time to engage in an exercise programme, and their underlying risk of future low back pain should be considered.

Some of the strengths of this study include the use of a prespecified protocol registered on PROSPERO; no inclusion restriction on populations, settings and age; sensitive search strategy using multiple electronic databases with supplementary hand searching, following the PRISMA recommendations; the use of the GRADE system to appraise the overall quality of the evidence and the use of PEDro scale to assess risk of bias of included trials.

The following limitations should be considered when interpreting our results. Despite our best efforts, authors for one potentially eligible RCT[42] could not be contacted, and some SDs were not published and had to be estimated from a similar included trial as recommended by *The Cochrane Collaboration*[16]; 9 cluster-RCTs (18 intervention contrasts) required adjustment for clustering; only a small number of trials were included for most intervention contrasts, and some outcome measures (eg, pain duration and duration of sick leave) could not be pooled due to the heterogeneity in measurements. For some trials, the limited descriptions of the experimental intervention and minimal intervention made it difficult to be certain if the control group met our criteria for minimal intervention control. As an example, the control group in the study by Tuchin[38] did some exercises; however, these were limited and appeared to be very broad and not specific to spinal pain ('warm-up stretching

programme for sports'). Data inspection suggested that some data were likely skewed (mean/SD<2).[43] Therefore, we conducted unplanned sensitivity analyses on the study's primary outcomes of pain intensity and disability using the log-transformation methods recommended by Higgins *et al*,[44] and included these as online supplementary appendix J and online supplementary appendix K, respectively. Between-group differences on the log-transformed scale were then back-transformed producing effects as ratios with the 95% CI (see online supplementary appendix J and online supplementary appendix K), enabling comparison with the original effects from raw data. The results of these sensitivity analyses were consistent with the original analyses using raw data in terms of effect direction, size and statistical significance, other than the short-term effect on the disability outcome of the intervention contrast comparing education with control, which changed from a small, non-significant, beneficial effect when using original raw data to a small, significant, beneficial effect when using the log-transformed data (see online supplementary appendix K table). Most studies included in our review had sample sizes >50 participants, and therefore inferences based on means are less problematic due to the central limit theorem.[44 45]

## CONCLUSION

There is moderate-quality evidence indicating that an exercise programme can reduce future LBP intensity at short-term follow-up and that exercise combined with education can reduce future disability due to LBP at long-term follow-up. Interventions including education alone, ergonomics and ergonomics combined with education or interventions for specific populations (ie, pregnant women and children), do not seem to reduce future LBP intensity and associated disability. The impact of prevention programmes on future QoL and workability is unclear due to the low quality to very low quality of available evidence.

### Summary box

**What is already known?**

- The available research suggests exercise combined with education reduces the risk of a future episode of low back pain; however, it is unclear if effective prevention strategies exist to reduce future low back pain intensity and associated disability.

**What are the new findings?**

- We found moderate-quality evidence supporting the effectiveness of exercise as a prevention strategy to reduce future low back pain intensity at short-term follow-up and that exercise combined with education can reduce future disability associated with low back pain at long-term follow-up.
- We are uncertain whether prevention strategies can positively impact quality of life or workability owing the low-quality to very low-quality evidence found.

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## REFERENCES

1 Driscoll T, Jacklyn G, Orchard J, *et al*. The global burden of occupationally related low back pain: estimates from the global burden of disease 2010 study. *Ann Rheum Dis* 2014;73:975–81.
2 Walker BF, Muller R, Grant WD. Low back pain in Australian adults: the economic burden. *Asia Pac J Public Health* 2003;15:79–87.
3 James SL, Abate D, Abate KH, *et al*. Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet* 2018;392:1789–858.
4 da C Menezes Costa L, Maher CG, Hancock MJ, *et al*. The prognosis of acute and persistent low-back pain: a meta-analysis. *CMAJ* 2012;184:E613–24.
5 da Silva T, Mills K, Brown BT, *et al*. Recurrence of low back pain is common: a prospective inception cohort study. *J Physiother* 2019;65:159–65.
6 Steffens D, Maher CG, Pereira LSM, *et al*. Prevention of low back pain: a systematic review and meta-analysis. *JAMA Intern Med* 2016;176:199–208.
7 Jensen LD, Gonge H, Jørs E, *et al*. Prevention of low back pain in female eldercare workers: randomized controlled work site trial. *Spine* 2006;31:1761–9.
8 Chaléat-Valayer E, Denis A, Abelin-Genevois K, *et al*. Long-Term effectiveness of an educational and physical intervention for preventing low-back pain recurrence: a randomized controlled trial. *Scand J Work Environ Health* 2016;42:510–9.
9 Liberati A, Altman DG, Tetzlaff J, *et al*. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration. *BMJ* 2009;339:b2700.
10 Furlan AD, Malmivaara A, Chou R, *et al*. 2015 updated method guideline for systematic reviews in the Cochrane back and neck group. *Spine* 2015;40:1660–73.
11 Macedo LG, Elkins MR, Maher CG, *et al*. There was evidence of convergent and construct validity of physiotherapy evidence database quality scale for physiotherapy trials. *J Clin Epidemiol* 2010;63:920–5.
12 Maher CG, Sherrington C, Herbert RD, *et al*. Reliability of the PEDro scale for rating quality of randomized controlled trials. *Phys Ther* 2003;83:713–21.
13 de Campos TF, Maher CG, Steffens D, *et al*. Exercise programs may be effective in preventing a new episode of neck pain: a systematic review and meta-analysis. *J Physiother* 2018;64:159–65.
14 de Morton NA. The PEDro scale is a valid measure of the methodological quality of clinical trials: a demographic study. *Aust J Physiother* 2009;55:129–33.
15 Guyatt GH, Oxman AD, Vist GE, *et al*. Grade: an emerging consensus on rating quality of evidence and strength of recommendations. *BMJ* 2008;336:924–6.
16 Higgins J, Green S. *Cochrane Handbook for systematic reviews of interventions, version 5.1.0*. The Cochrane Collaboration, 2011. http://handbook-5-1.cochrane.org/
17 Barene S, Krustrup P, Holtermann A. Effects of the workplace health promotion activities soccer and Zumba on muscle pain, work ability and perceived physical exertion among female Hospital employees. *PLoS One* 2014;9:e115059.
18 Donaldson SC, Stanger LM, Donaldson MW, *et al*. A randomized crossover investigation of a back pain and disability prevention program: possible mechanisms of change. *J Occup Rehabil* 1993;3:83–94.
19 Donchin M, Woolf O, Kaplan L, *et al*. Secondary prevention of low-back pain. A clinical trial. *Spine* 1990;15:1317–20.
20 Driessen MT, Proper KI, Anema JR, *et al*. The effectiveness of participatory ergonomics to prevent low-back and neck pain--results of a cluster randomized controlled trial. *Scand J Work Environ Health* 2011;37:383–93.
21 Eggen MH, Stuge B, Mowinckel P, *et al*. Can supervised group exercises including ergonomic advice reduce the prevalence and severity of low back pain and pelvic girdle pain in pregnancy? A randomized controlled trial. *Phys Ther* 2012;92:781–90.
22 Fanucchi GL, Stewart A, Jordaan R, *et al*. Exercise reduces the intensity and prevalence of low back pain in 12-13 year old children: a randomised trial. *Aust J Physiother* 2009;55:97–104.
23 Garshasbi A, Faghih Zadeh S. The effect of exercise on the intensity of low back pain in pregnant women. *Int J Gynaecol Obstet* 2005;88:271–5.

24 Gatty CM. A comprehensive work injury prevention program with clerical and office workers: phase II. *Work* 2004;23:131–7.
25 Glomsrød B, Lønn JH, Soukup MG, *et al*. "Active back school", prophylactic management for low back pain: three-year follow-up of a randomized, controlled trial. *J Rehabil Med* 2001;33:26–30.
26 Gundewall B, Liljeqvist M, Hansson T. Primary prevention of back symptoms and absence from work. A prospective randomized study among hospital employees. *Spine* 1993;18:587–94.
27 Haufe S, Wiechmann K, Stein L, *et al*. Low-Dose, non-supervised, health insurance initiated exercise for the treatment and prevention of chronic low back pain in employees. results from a randomized controlled trial. *PLoS One* 2017;12:e0178585.
28 Ijzelenberg H, Meerding W-J, Burdorf A. Effectiveness of a back pain prevention program: a cluster randomized controlled trial in an occupational setting. *Spine* 2007;32:711–9.
29 Irvine AB, Russell H, Manocchia M, *et al*. Mobile-Web APP to self-manage low back pain: randomized controlled trial. *J Med Internet Res* 2015;17:e1.
30 Kamioka H, Okuizumi H, Okada S, *et al*. Effectiveness of intervention for low back pain in female caregivers in nursing homes: a pilot trial based on multicenter randomization. *Environ Health Prev Med* 2011;16:97–105.
31 Ketola R, Toivonen R, Häkkänen M, *et al*. Effects of ergonomic intervention in work with video display units. *Scand J Work Environ Health* 2002;28:18–24.
32 Lønn JH, Glomsrød B, Soukup MG, *et al*. Active back school: prophylactic management for low back pain. A randomized, controlled, 1-year follow-up study. *Spine* 1999;24:865–71.
33 Menzel NN, Lilley S, Robinson ME. Interventions to reduce back pain in rehabilitation Hospital nursing staff. *Rehabil Nurs* 2006;31:138–47.
34 Pedersen MT, Andersen CH, Zebis MK, *et al*. Implementation of specific strength training among industrial laboratory technicians: long-term effects on back, neck and upper extremity pain. *BMC Musculoskelet Disord* 2013;14:287.
35 Pedersen MT, Blangsted AK, Andersen LL, *et al*. The effect of worksite physical activity intervention on physical capacity, health, and productivity: a 1-year randomized controlled trial. *J Occup Environ Med* 2009;51:759–70. -.
36 Soukup MG, Glomsröd B, Lönn JH, *et al*. The effect of a Mensendieck exercise program as secondary prophylaxis for recurrent low back pain. A randomized, controlled trial with 12-month follow-up. *Spine* 1999;24:1585–91.
37 Soukup MG, Lönn J, Glomsröd B, *et al*. Exercises and education as secondary prevention for recurrent low back pain. *Physiother Res Int* 2001;6:27–39.
38 Tuchin PJ. Spinal care education as a preventative strategy for occupational health & safety: A New Role for Chiropractors. *Australas Chiropr Osteopathy* 1998;7:8–14.
39 van Poppel MN, Koes BW, van der Ploeg T, *et al*. Lumbar supports and education for the prevention of low back pain in industry: a randomized controlled trial. *JAMA* 1998;279:1789–94.
40 Warming S, Ebbehøj NE, Wiese N, *et al*. Little effect of transfer technique instruction and physical fitness training in reducing low back pain among nurses: a cluster randomised intervention study. *Ergonomics* 2008;51:1530–48.
41 Yassi A, Cooper JE, Tate RB, *et al*. A randomized controlled trial to prevent patient lift and transfer injuries of health care workers. *Spine* 2001;26:1739–46.
42 Sihawong R, Janwantanakul P, Jiamjarasrangsi W. A prospective, cluster-randomized controlled trial of exercise program to prevent low back pain in office workers. *Eur Spine J* 2014;23:786–93.
43 Altman DG, Bland JM. Statistics notes: detecting skewness from summary information. *BMJ* 1996;313:1200.
44 Higgins JPT, White IR, Anzures-Cabrera J. Meta-Analysis of skewed data: combining results reported on log-transformed or RAW scales. *Stat Med* 2008;27:6072–92.
45 Kwak SG, Kim JH. Central limit theorem: the cornerstone of modern statistics. *Korean J Anesthesiol* 2017;70:144–56.