Comparing the effectiveness of group-based exercise to other non-pharmacological interventions for chronic low back pain: A systematic review

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Abstract

Background

Low back pain (LBP) is the leading cause of disability worldwide with a substantial financial burden on individuals and health care systems. To address this, clinical practice guidelines often recommend non-pharmacological, non-invasive management approaches. One management approach that has been recommended and widely implemented for chronic LBP is group-based exercise programs, however, their clinical value compared with other non-pharmacological interventions has not been investigated systematically.

Objective

To compare the effectiveness of group-based exercise with other non-pharmacological interventions in people with chronic LBP.

Methods

Four electronic databases were searched by two independent reviewers. Only randomized controlled trials that compared group-based exercise with other non-pharmacological interventions for chronic LBP were eligible. Study quality was assessed using the Cochrane Handbook for systematic reviews of Interventions by two independent reviewers.

Results

Eleven studies were eligible. We identified strong evidence of no difference between group exercise and other non-pharmacologic interventions for disability level and pain scores 3-month post-intervention in people with chronic LBP. We could not find any strong or moderate evidence for or against the use of group-based exercise in the rehabilitation of people with chronic LBP for other time-points and health measurement outcomes. We found no statistically significant differences in disability and quality of life and pain between the group and individual non-pharmacological interventions that included exercise.
Conclusion
With this equivocal finding, group-based exercise may be a preferred choice given potential advantages in other domains not reviewed here such as motivation and cost. Further research in this area is needed to evaluate this possibility.

Introduction
Low back pain (LBP) is the leading cause of disability globally with a substantial financial burden on individuals, families, communities and governments worldwide [1]. At an individual level, LBP diminishes quality of life by limiting activities of daily living, deteriorating mental health, decreasing life span [2] and inducing financial hardships [3]. Therefore, LBP is thought to be the most costly disability of the working-age population [4]. The nature of LBP is highly prevalent and recurrent: the lifetime occurrence is estimated to be 85%, and ~50% of people will have at least 10 episodes in their lifetime [1].

In addressing chronic LBP, clinical practice guidelines often recommend non-pharmacological and non-invasive management approaches for chronic LBP [3]. Specifically, these guidelines recommend education and exercise as first-line interventions [5–7]. While many randomised controlled trials have provided scientific evidence supporting the benefits of exercise in chronic LBP [8], how to best deliver exercise interventions is less clear. Individual exercise programs are the most widely implemented approach for addressing chronic LBP [9]. In contrast, group exercise-based classes have been found to be beneficial [10–12], but are not as widely used. Group exercise may be an equally effective alternative to individual exercise with potentially lower healthcare costs [8]. The potential for social support and better social interaction in groups should also be considered a potential advantage [8]. With this in mind, group exercise approaches have been recommended by the National Institute of Health and Care Excellence [12].

Given the above, we could not identify any prior systematic reviews that compared group-based exercise to other non-pharmacological interventions that may include education and/or exercise in people with LBP. Therefore, we conducted this review to evaluate the comparative effectiveness of group-based exercise to other non-pharmacological interventions that may or may not include education and exercise on pain and disability in patients with chronic LBP.

Methods
In this systematic literature review, we considered group exercise as the intervention and employed the Cochrane Handbook for Systematic Reviews of Interventions [13]. Our reporting was planned according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [14].

Literature search and study selection
A systematic search was conducted on June 26, 2020, using MEDLINE®, EMBASE, CINAHL, and Scopus. Search terms were selected through consultation between two rehabilitation experts and a university librarian. References cited within included articles were reviewed to identify additional studies. Two authors (JL and VA) selected studies up until June 26, 2020 that compared group exercise with other forms of intervention programs for people with LBP. Results from each database were uploaded to Covidence (www.covidence.org) and duplicates were excluded after software review.
Group-based exercise programs were defined as a group of three or more participants taking part in an exercise class supervised by a health care provider. A non-pharmacological intervention was defined as one-on-one care between a health care provider and their patient that did not involve pharmaceuticals. The intervention programs were identified using the search terms “group exercise”, “GLA:D Back”, “group strengthening”, “group physical activity”, or “group strength training”. Low back pain was identified using the search terms “chronic back pain”, “persistent back pain”, “long-standing back pain”, “long-duration back pain”, “long-standing lumbar pain”, “long-duration lumbar pain”, “chronic low back pain”, “persistent low back pain”, “long-standing low back pain”, or “long-duration low back pain”.

Eligibility criteria

Only peer-reviewed, randomized, controlled trials comparing group-based exercise including strengthening, physical activity, and strength training with other types of non-pharmacologic interventions for chronic LBP were included. We excluded reports related to conference proceedings, specific low back pain diagnoses, case series of fewer than ten subjects, case studies, systematic reviews, and protocol papers.

Selection of studies

Two investigators (JL and VA) with more than 10 years of cumulative experience in reviewing literature screened all titles and abstracts independently and retrieved the full text of the potentially eligible studies. Disagreements at the titles and abstracts stage were resolved through consensus.

Data extraction

A standard form (S2 Appendix) was developed to extract data based on published guidelines [15–17]. Data for each study were extracted and cross-checked by two investigators (JL and VA). Disagreements were resolved by a third investigator (GK). The following information was extracted for each study: 1) characteristics of the participants: sample size, age, gender, height, diagnosis, pain duration, location and intensity; 2) inclusion and exclusion criteria; 3) characteristics of the interventions: the type, length of the program, mode of application, frequency and duration of group and individual exercise based physiotherapy; 4) characteristics of the outcomes: pain and disability outcomes measures, follow-up times.

Methodological quality

The quality of included studies was assessed as outlined by PRISMA, and the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines [18]. The quality appraisal focused on seven categories: subject recruitment, examiners, methodology, outcomes, handling of missing data, statistical analysis, and results (S3 Appendix). Two reviewers (JL, VA) conducted critical appraisal separately on each of the papers and decisions were verified through consensus. Practice appraisals and discussion of five full-text papers occurred for calibration before the full review. Studies with a minimum score of 70% were considered to be of high quality and those with a lower score to be of low quality [19].

Data synthesis and analysis

A PRISMA flowchart was constructed to summarise the article selection process (Fig 1) [14]. Agreement between reviewers on article selection at each stage and on the quality appraisal of the included full-text articles was described using percentages. The level of evidence (strong,
Fig 1. Search strategy guided by the PRISMA flow diagram.

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moderate, limited, no, and conflicting evidence) for the effect of interventions was determined according to the consistency of the research findings and the methodological quality of the included studies [19]. The level of evidence was considered strong if there was more than 75% agreement between at least two high-quality studies and more than two low-quality studies on the outcome of the interest (Table 1) [19].

The evidence was considered moderate if there was more than 75% agreement between a high-quality study and at least three low-quality studies (Table 1) [19]. The evidence was considered limited if only one high-quality study reported that outcome or at least three out of four low-quality studies (75%) reported the same outcome (Table 1) [19]. The evidence was considered conflicting if there was less than 75% agreement among the studies irrespective of study quality (Table 1) [19].

Summary tables were prepared for participants' descriptions (Table 2), intervention used (Table 3), quality appraisal scores (Table 4), the level of evidence summary statements and outcomes extracted (Table 5).

Results

Studies included

The search identified 639 references after removing duplicates (Fig 1). Following title and abstract screening, 628 papers were excluded. One paper was identified by manual searching. This resulted in a total of 11 papers meeting the selection criteria. The most frequent reason for exclusion was inappropriate study design (e.g. did not carry out between-group comparisons).

Pain information

Of the 11 studies meeting the inclusion criteria, all enrolled participants reported chronic LBP. All but one of the 11 studies reported on pain chronicity [20] (Table 2) Seven of the included studies reported pre-intervention and post-intervention pain intensity [20–26].

Intervention used in the included studies

Table 3 summaries the intervention, duration, metric, and data collection time points used in the included studies. From the resulting 11 studies, 27 different outcome measurements were identified (Table 3).

Methodological quality

Five studies met the methodological high-quality threshold of 70% (Table 4) [20, 22, 25, 28, 30]. Five studies scored between 60% and 69% [23, 24, 26, 27], and one scored 50% [21]. The major source of bias in the resulting 11 papers was the failure to formulate correlation and

| Level     | Description                                                                 |
|-----------|-----------------------------------------------------------------------------|
| Strong    | Consistent results (≥75%) from at least 2 high-quality* studies              |
| Moderate  | 1 high-quality* study and consistent findings (≥75%) in 1 or more low-quality studies |
| Limited   | Findings in 1 high-quality* study or consistent results (≥75%) among low-quality studies |
| No        | No study identified                                                         |
| Conflicting | Inconsistent results irrespective of study quality                          |

*Studies with quality scores over 70% were deemed high quality.

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Table 2. Description of study type and study participants in the included studies.

| Authors            | Study Type                              | Recruitment Strategy and Selection Criteria                                                                 | Number of Subjects and Participants | Diagnosis                                                                 | Pain (Duration)          |
|--------------------|-----------------------------------------|-------------------------------------------------------------------------------------------------------------|-------------------------------------|---------------------------------------------------------------------------|--------------------------|
| Dua et al. [21]    | Permuted Blocks, Single Blinded, Two-arm RCT with 6-month follow-up | Male and female, Spinal Rehabilitation: Spinal Rehabilitation: Chronic LBP referred from General Physicians | Groups (years): 15f, 20M: 46 ± 12.7 | Chronic LBP referred from General Physicians | Median (Interquartile Range): 36.0 (61) Months | Spinal Rehabilitation: Back to Fitness: 21.5 (62) Months |
| Sahin et al. [22]  | Three-arm RCT with at least 50% sick leave due to unspecified LBP, Mechanical-Chronic LBP (>3 months), Motivated and willing to attend both the physiotherapy group programmes | Male and female, Group Exercise: Group Exercise: Non-specific LBP | 3f, 2M: 44 ± 9.7 | Non-specific LBP | Brief Intervention: 12.5 ± 11.3 years |
| Lewis et al. [23]  | Two-arm RCT with Aged between 18–75 years, Group exercise Group exercise Non-radiating mechanical LBP | 16f, 24M: 43 ± 12.7 | 16f, 24M: 44 ± 9.7 | Brief Intervention: 12.5 ± 11.3 years |
| Johnson et al. [24] | Two-arm RCT with 15-month follow-up | Consulting General Physicians with LBP between January 2002 and July 2003 | 45f, 71M: 67 ± 10.9 | Active intervention: 7.8 ± 8.0 years |
| Lewis et al. [25]  | Two-arm RCT with Aged between 18–75 years, Group exercise Group exercise Non-radiating mechanical LBP | 2f, 7M: 48 ± 11.4 | 2f, 7M: 66 ± 11.3 | Walking: 7.9 ± 9.0 years |
| Masharawi & Nashal [26] | Single-blind, pilot, Two-arm RCT with 12-week follow up | Female, Group Exercise Group Exercise: Non-specific LBP Minimum of 12 weeks, | 24f, 12M: 45 ± 12.7 | Walking: 7.9 ± 9.0 years |
| O’Keefe et al. [27] | Pragmatic, Two-arm RCT with 12 months post-randomization | Chronic LBP | 3f, 7M: 45 ± 12.7 | Exercise: 10.3 ± 9.8 years |
| Ryan et al. [28]   | Single-blind, Two-arm RCT with 3-month follow up | Male and female, Group Exercise: Education + Exercise: Non-specific LBP | 6f, 3M: 65 ± 11.3 | Exercise: 28.1 ± 20.4 |
| Sahin et al. [29]  | Two-arm, RCT 3-month follow-up | Non-specific LBP (>12 weeks) without neurological deficits | 16f, 3M: 51 ± 19.6 | Non-specific LBP | 6.5 ± 5.3 months |

(Continued)
mean difference-testing hypotheses (i.e. a priori). These studies did not provide any information regarding the expected direction of correlations or if the mean differences met the original hypotheses. All studies clearly described 1) their sample size estimation for each experimental group and 2) their main findings.

Measurement outcomes
From the resulting 11 studies, 47 different outcome measurements were identified with the resulting level of evidence and summary statements described in Table 5.

Primary outcome measures

Self-administered disability measures. Low back pain associated disability was evaluated in 10 studies. Five studies used the Roland-Morris Disability Questionnaire [20, 25, 26, 29, 30]; four used the Oswestry Disability Index Questionnaire [22, 24, 27, 28] and one used Quebec back pain disability scale [23]. There was strong evidence of no difference between groups 3-month post-intervention from 3 high-quality studies and a study with moderate quality [20, 22, 26, 30]. Likewise, there was limited evidence of no difference between groups for 9-month and 15-month post-intervention [20] and another study for 6-month post-randomization [24]. Two studies compared the post-intervention disability level with pre-intervention disability level [23, 26]. There was limited evidence of lower disability scores in people who received individual intervention compared to group exercise immediately and 6-month post-intervention. Results indicated limited evidence of no difference between exercise and education vs. education group only at 3-month and 6-month post-intervention compared to the baseline group [26]. The results were inconsistent from two studies 6-month post-intervention [23], from two studies 3-month post-randomization [24, 29], and three studies 6-month post-randomization [24, 28, 29]. There was limited evidence from one study for lower disability scores 4-week post-intervention (Table 5). People in the group exercise (intervention group) had a lower disability score than people in the waiting list (control) 4-week post-intervention [25]. Likewise, there was limited evidence from one study for lower disability scores 6-week post-randomization [29]. In this study, people in the yoga intervention group had a lower disability score than people in the booklet only group 6-week post-intervention.
### Table 3. Description of the intervention used in the included studies.

| Authors          | Groups                          | Intervention                                                                 | Duration                                                                                     | Metric                                      | Data Collection Timepoints |
|------------------|--------------------------------|-------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|---------------------------------------------|---------------------------|
| Daulat [21]      | Experimental                    | Group multimodal exercise therapy + one-to-one education and/or manual therapy sessions | Six 1-hour treatment sessions over a 3-month period                                          | Functional Rating Index, NPRS, EQ-5D-5L    | BL                        |
|                  | Control                         | General exercise sessions using a circuit-based exercise format + weekly group education sessions at the end of the exercise period. |                                                                                              | Participant Satisfaction Reporting Scale   | POI                       |
|                  |                                 |                                                                                |                                                                                              | Group interviews                           | 6M POI                     |
| Harris et al.    | Brief cognitive intervention    | Brief cognitive, clinical examination program based on a non-injury model addressing pain and fear avoidance, where return to normal activity and work is the main goal. | Two sessions over a period of 5 days with the choice of two booster sessions.                | Increased work participation, ODI, Hospital Anxiety and Depression Scale | BL                        |
| [27]             |                                 | Cognitive-behavioural treatment manual adopted from the CINS trial [31]       | 7 session at 90min for a total of 10.5 hours over a 3-month period                           | Subjective Health Complaints Inventory, Utrecht Coping List, Instrumental Mastery-Oriented Coping | Monthly POI up to 12 months |
| Hurley et al.    | Brief cognitive intervention    | Strength and endurance training + relaxation                                   | 90 min, Three times/week over a 3-month period                                               | Fear-Avoidance Beliefs Questionnaire        | BL                        |
| [24]             | Walking                         | Walking                                                                       | 10-min walk at least 4 days per week proceed to                                          | ODI, NPRS                                   | BL                        |
|                  |                                 | 30 min of moderate-intensity PA for 5 days per week at week 5 for a total of 8 weeks |                                                                                              | Back Beliefs Questionnaire, International Physical Activity Questionnaire, Exercise Self-efficacy Questionnaire, Readiness to Change Questionnaire | 3M POR, 6M POR, 12M POR   |
|                  | Exercise class                  | A programme of progressive or graded exercises + a back-care education message | 1-hour weekly class up to 8 weeks                                                          |                                            |                           |
|                  |                                 |                                                                                |                                                                                              |                                            |                           |
|                  | Usual physiotherapy             | Individualized education/advice, exercise therapy + manipulative therapy       | ?                                                                                            | Patient Satisfaction Questionnaire          | 3M POR                    |
| Johnson et al.   | Active intervention             | Booklet and audiocassette + community-based treatment program (problem-solving, pacing and regulation of activity, challenging distorted cognitions about activity and harm, and helping patients to identify helpful and unhelpful thoughts about pain and activity) | Eight 2-hour group sessions over a 6-week period                                             | VAS, RMDQ                                  | BL                        |
| [20]             |                                 |                                                                                |                                                                                              | General Health Questionnaire, EQ-5D        | 3M POI, 9M POI, 15M POI   |
| Lewis et al.     | Exercise class                  | 10 station exercise class involving aerobic exercises, spinal stabilization exercises, and manual therapy | 8 treatments over 8 weeks                                                                  | Lumbar flexion, Lumbar extension            | POI                       |
| [23]             |                                 |                                                                                |                                                                                              | Side flexion, Straight leg raising test     | 6M POI, 12M POI           |
|                  | Individual treatment            | One-to-one intervention, 30 minutes of manual therapy (mobilizations to the spine) and spinal stabilization exercises |                                                                                              | Quebec back pain disability scale          |                           |

(Continued)
| Authors                  | Groups                                | Intervention                                                                                                                                  | Duration                                                                                                                                  | Metric                  | Data Collection Timepoints |
|-------------------------|---------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|---------------------------|
| Masharawi & Nadaf [25]  | Group exercise                        | 10 repetitions of 10 exercises aimed at improving lumbar mobility/flexibility and stability                                                 | 45 min group exercise session twice a week, over 4 weeks, Thereafter, monthly meetings took place to review and reinforce program consistency. | VAS, RMDQ, Flexion ROM  | BL                        |
|                         | Control group                         |                                                                                |                                                                                                                                          |                         |                           |
| O’Keeffe et al. [28]    | Group-based exercise and education     | Three components to the intervention: 1) pain education; 2) exercise; and 3) relaxation.                                                      | Up to six classes over 6–8 weeks, each lasting –1 hour and 15 min, with up to 10 participants in each class. | ODI, Numerical Rating Scale, Fear-avoidance using the physical activity subscale of the Fear Avoidance Beliefs Questionnaire | BL                        |
| Cognitive functional    | Comprehensive one-to-one interview and physical examination by physiotherapists. |                                                                                                                                             | Length varied in a pragmatic manner based on the clinical progression of participants.                                              | Coping subscale of the Coping Strategies Questionnaire, Pain Self-Efficacy Questionnaire, Nordic Musculoskeletal Questionnaire | 6M POR, 12M POR           |
| therapy                 |                                                                                     |                                                                                                                                             |                                                                             |                                                                                     |                           |
| Ryan et al. [26]        | Education and exercise group           | Pain biology education + “The Back Book” + group exercise (Back to the Fitness exercise program, circuit-based, graded, aerobic exercise with some core stability exercises) | six classes, once a week for six weeks                                                                                                    | RMDQ, NPRS, Repeated sit-to-stand test, Fifty-foot walk test                       | BL                        |
|                         | Education only group                  | Pain biology education cognitive behavioural intervention + “The Back Book”                                                                |                                                                                                                                          | 5-min walk test                                                                     | POI                       |
|                         |                                                                                     |                                                                                                                                             |                                                                             |                                                                                     |                           |
| Sahin et al. [22]       | Back school + Exercise + Physical therapy | Didactic and practical training, Lumbar flexion exercises, Lumbar extension, Lumbar stretching exercises, and strengthening exercises, Transcutaneous electrical nerve stimulation, ultrasound, and hot pack | 1 hour, 2 times a week for 2 weeks, 5 times a week for 2 weeks                                                                            | VAS, ODI, Subjective Health Complaints Inventory, Depression, Anxiety and Stress Scale, Pain self-efficacy questionnaire | BL, 3M POI               |
|                         | Control                               | Lumbar flexion exercises, Lumbar extension, Lumbar stretching exercises, and strengthening exercises, Transcutaneous electrical nerve stimulation, ultrasound, and hot pack |                                                                                                                                          |                         |                           |

(Continued)
In this study, the difference was not significant between yoga and conventional therapeutic exercise classes vs. self-care book [29]. There was limited evidence from one study for lower disability scores 12-month post-randomisation (Table 5). Cognitive functional therapy led to greater reductions in disability compared with the group exercise intervention [28].

Table 3. (Continued)

| Authors            | Groups                      | Intervention                                                                 | Duration                  | Metric            | Data Collection Timepoints |
|--------------------|-----------------------------|------------------------------------------------------------------------------|---------------------------|-------------------|----------------------------|
| Sherman et al. [29]| Yoga                        | Yoga session + auditory compact discs to guide them through the sequence of postures with the appropriate mental focus | 75 min weekly for 12 weeks | Telephone interviews | BL                         |
|                    | Conventional therapeutic exercise classes | short educational talk + exercise class (7 aerobic exercises and 10 strengthening exercises that emphasized leg, hip, abdominal, and back muscles) |                          |                   |                            |
|                    | Self-care book              | The Back Pain Help book                                                      | ?                         |                   |                            |
| Carr et al. [30]   | Back to Fitness Program     | Low impact aerobics, strengthening and stretching exercises for the main muscle groups, and relaxation + A cognitive-behavioural approach underpinned messages | 8 hrs. over a 4-week period | RMDQ              | 3M                         |
|                    | Physiotherapy               | One (or a combination) of McKenzie exercises, strengthening exercises, stretching exercises, spinal stabilizations, other exercises, manipulation, mobilizations, traction, Short wave diathermy, ultrasound, interferential, TENS, other treatment (including massage, heat, laser, advice/education). | ?                         | SF12, EQ5D          | 12M                        |

BL: baseline; min: minutes, hrs.: hours, POI: post-intervention; POR: post-randomization, W: Week; M: Month; VAS: Visual Analogue Scale; ODI: Oswestry Disability Index; NPRS: Numerical Pain Rating Scale; RMDQ: Roland and Morris Disability Questionnaire; ROM: range of motion.

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Table 4. Quality appraisal of the studies included.

| Authors            | Recruitment | Examiners | Methodology | Outcomes | Missing Data | Statistical Analysis | Results | Overall Score | Overall Score (%) |
|--------------------|-------------|-----------|-------------|----------|--------------|----------------------|---------|---------------|-------------------|
|                    | /7 /4 /5 /2 /8 /5 /2 /33 |           |             |          |              |                      |         |               |                   |
| Daulat [21]        | 5 1 5 2 2 1 2 1 | 18       | 56%         |
| Harris et al. [27] | 6 2 2 5 3 1 21 | 66%      |
| Hurley et al. [24] | 6 2 4 1 4 3 2 22 | 69%      |
| Johnson et al. [20] | 6 0 4 2 6 4 1 23 | 63%      |
| Lewis et al. [23]  | 6 2 3 2 4 4 1 20 | 63%      |
| Masharawi & Nadaf [25] | 6 1 4 1 6 4 1 23 | 63%      |
| O'keeffe [28]      | 5 4 5 2 4 5 2 27 | 82%      |
| Ryan et al. [26]   | 7 0 3 1 4 4 2 21 | 66%      |
| Sahin et al. [22]  | 5 2 4 1 5 5 2 24 | 75%      |
| Sherman et al. [29] | 6 3 4 1 4 4 2 24 | 75%      |
| Carr et al. [30]   | 6 2 4 2 5 4 1 24 | 75%      |

Overall score: the sum of all scores.

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Table 5. Levels of evidence for summary statements for each intervention.

| Level of evidence | From n studies | Changes | Data Collection Time-point | Groups compared |
|-------------------|----------------|---------|---------------------------|-----------------|
| **Pain (Numeric pain Rating Scale and Visual Analogue Scale)** |
| Limited           | 1 [21]         | No difference | Post-intervention | Exercise Group vs. Individual Treatment |
| Limited           | 1 [25]         | A lower score for Group Exercise | 4-week post-intervention | Group Exercise vs. Control group |
| Conflicting       | 3 [20, 22, 26] | Inconsistent | 3-month post-intervention | Exercise &Education vs. Education Group Exercise vs. Pain Biology |
| Limited           | 1 [21]         | No difference | 6-month post-intervention | Exercise Group vs. Individual Treatment |
| Limited           | 1 [26]         | A lower score for Group Exercise | 0, 3, & 6-month post-intervention | Exercise &Education vs. Education |
| Limited           | 1 [20]         | No difference | 9-month post-intervention | Active Intervention vs. Control |
| Limited           | 1 [20]         | No difference | 15-month post-intervention | Active Intervention vs. Control |
| Limited           | 1 [24]         | No difference | 3-month post-randomization | Walking vs. Exercise Class vs. Usual Physiotherapy |
| Moderate          | 2 [24, 28]     | No difference | 6-month post-randomization | Group-based exercise + education vs. Cognitive functional therapy |
| Moderate          | 2 [24, 28]     | No difference | 12-month post-randomization | Walking vs. Exercise Class vs. Usual Physiotherapy |
|                   |                |          |                           | Group-based exercise + education vs. Cognitive functional therapy |
| **Disability**    |
| Limited           | 1 [23]         | A lower score for individual intervention | Post-intervention | Group Intervention vs. Individual Intervention |
| Limited           | 1 [25]         | A lower score for Group Exercise | 4-week post-intervention | Group Exercise vs. Control group |
| Strong            | 4 [20, 22, 26, 30] | No difference | 3-month post-intervention | Active Intervention vs. Control |
|                   |                |          |                           | Group Exercise vs. Pain Biology |
|                   |                |          |                           | Back school + Exercise + Physical therapy vs. Control |
|                   |                |          |                           | Group Exercise vs. Individual Physical Therapy |
| Limited           | 1 [23]         | A lower score for individual intervention | 6-month post-intervention | Group Intervention vs. Individual Intervention |
| Limited           | 1 [26]         | No difference | 0, 3-month, & 6-month post-intervention | Exercise &Education vs. Education |
| Limited           | 1 [20]         | No difference | 9-month post-intervention | Active Intervention vs. Control |
| Limited           | 1 [23]         | Lower scores in Yoga group | 6-week post-randomization | Yoga vs. Conventional Therapeutic Exercise Classes vs. Self-care Book |
| Conflicting       | 2 [24, 29]     | Inconsistent | 3-month post-randomization | Walking vs. Exercise Class vs. Usual Physiotherapy |
|                   |                |          |                           | Yoga vs. Conventional Therapeutic Exercise Classes vs. Self-care Book |
| Conflicting       | 3 [24, 28, 29] | Inconsistent | 6-month post-randomization | Walking vs. Exercise Class vs. Usual Physiotherapy |
|                   |                |          |                           | Yoga vs. Conventional Therapeutic Exercise Classes vs. Self-care Book |
| Limited           | 1 [28]         | A lower score for Cognitive functional therapy | 12-month post-randomization | Group-based exercise + education vs. Cognitive functional therapy |

**Lumbar Spine Flexibility (Flexion, Extension, and Lateral Flexion)**

(Continued)
| Level of evidence | From n studies | Changes | Data Collection Time-point | Groups compared |
|------------------|----------------|---------|---------------------------|-----------------|
| Limited 1 [23]   | No difference  | Post-intervention | Exercise Class vs. Individual Treatment |
| Limited 1 [25]   | A higher score for Group Exercise | 4-week post-intervention | Group Exercise vs. Control group |
| Limited 1 [25]   | A higher score for Group Exercise | 8-week post-intervention | Group Exercise vs. Control group |
| Limited 1 [23]   | Higher ROM for lumbar extension and side bending and no difference for flexion | 6-month post-intervention | Exercise Class vs. Individual Treatment |
| Limited 1 [23]   | No difference  | 12-month post-intervention | Exercise Class vs. Individual Treatment |

**Fear Beliefs**

| Level of evidence | From n studies | Changes | Data Collection Time-point | Groups compared |
|------------------|----------------|---------|---------------------------|-----------------|
| Limited 1 [26]   | No difference  | 0, 3-month, & 6-month post-intervention | Exercise & Education vs. Education |
| Limited 1 [24]   | No difference  | 3-month post-intervention | Walking vs. Exercise Class vs. Usual Physiotherapy |
| Limited 1 [24]   | No difference  | 6-month post-intervention | Walking vs. Exercise Class vs. Usual Physiotherapy |
| Limited 2 [24, 27]| No difference  | 12-month post-intervention | Brief Intervention vs. Brief Intervention + Cognitive Behavioral Therapy vs. Bl + Physical Group Exercise |
| Limited 1 [26]   | No difference  | 0, 3-month & 6-month post-randomization | Walking vs. Exercise Class vs. Usual Physiotherapy |
| Limited 1 [28]   | No difference  | 6-month post-randomization | Group-based exercise + education vs. Cognitive functional therapy |
| Limited 1 [28]   | No difference  | 12-month post-randomization | Group-based exercise + education vs. Cognitive functional therapy |

**Health Surveys**

| Level of evidence | From n studies | Changes | Data Collection Time-point | Groups compared |
|------------------|----------------|---------|---------------------------|-----------------|
| Limited 1 [21]   | No difference  | Post-intervention | Exercise Group vs. Individual Treatment |
| Strong 2 [20, 30]| No difference  | 3-month post-intervention | Active Intervention vs. Individual Physical Therapy |
| Limited 1 [21]   | No difference  | 6-month post-intervention | Exercise Group vs. Individual Treatment |
| Limited 1 [20]   | No difference  | 9-month post-intervention | Active Intervention vs. Control |
| Limited 1 [30]   | No difference  | 9-month post-intervention | Active Intervention vs. Control |
| Limited 1 [20]   | No difference  | 12-month post-intervention | Group Exercise vs. Individual Physical Therapy |
| Limited 1 [29]   | No difference  | 6-week post-randomization | Yoga vs. Conventional Therapeutic Exercise Classes vs. Self-care Book |
| Limited 1 [29]   | No difference  | 3-month post-randomization | Yoga vs. Conventional Therapeutic Exercise Classes vs. Self-care Book |
| Limited 1 [29]   | No difference  | 6-month post-randomization | Yoga vs. Conventional Therapeutic Exercise Classes vs. Self-care Book |

**Functional Rating Index**

| Level of evidence | From n studies | Changes | Data Collection Time-point | Groups compared |
|------------------|----------------|---------|---------------------------|-----------------|
| Limited 1 [21]   | No difference  | Post-intervention | Exercise Group vs. Individual Treatment |
| Limited 1 [21]   | No difference  | 6-month post-intervention | Exercise Group vs. Individual Treatment |

**Participant Satisfaction Reporting Scale**

| Level of evidence | From n studies | Changes | Data Collection Time-point | Groups compared |
|------------------|----------------|---------|---------------------------|-----------------|
| Limited 1 [21]   | No difference  | Post-intervention | Exercise Group vs. Individual Treatment |
| Limited 1 [21]   | No difference  | 6-month post-intervention | Exercise Group vs. Individual Treatment |

**Pain Self-efficacy**

| Level of evidence | From n studies | Changes | Data Collection Time-point | Groups compared |
|------------------|----------------|---------|---------------------------|-----------------|
| Limited 1 [20]   | No difference  | 3-month post-intervention | Group Exercise vs. Individual Physical Therapy |
| Limited 1 [20]   | No difference  | 12-month post-intervention | Group Exercise vs. Individual Physical Therapy |
| Limited 1 [28]   | No difference  | 6-month post-randomization | Group-based exercise + education vs. Cognitive functional therapy |

(Continued)
| Level of evidence | From n studies | Changes | Data Collection Time-point | Groups compared |
|-------------------|----------------|---------|----------------------------|-----------------|
| Limited           | 1 [28]         | A lower score for Cognitive functional therapy | 12-month post-randomization | Group-based exercise + education vs. Cognitive functional therapy |

**Risk of Chronicity**

| Limited           | 1 [28]         | No difference | 6-month post-randomization | Group-based exercise + education vs. Cognitive functional therapy |
| Limited           | 1 [28]         | A lower score for Cognitive functional therapy | 12-month post-randomization | Group-based exercise + education vs. Cognitive functional therapy |

**Coping**

| Limited           | 1 [28]         | No difference | 6-month post-randomization | Group-based exercise + education vs. Cognitive functional therapy |
| Limited           | 1 [28]         | A lower score for Cognitive functional therapy | 12-month post-randomization | Group-based exercise + education vs. Cognitive functional therapy |

**Number of Pain Sites**

| Limited           | 1 [28]         | No difference | 6-month post-randomization | Group-based exercise + education vs. Cognitive functional therapy |
| Limited           | 1 [28]         | No difference | 12-month post-randomization | Group-based exercise + education vs. Cognitive functional therapy |

**Risk of Chronicity**

| Limited           | 1 [28]         | No difference | 6-month post-randomization | Group-based exercise + education vs. Cognitive functional therapy |
| Limited           | 1 [28]         | No difference | 12-month post-randomization | Group-based exercise + education vs. Cognitive functional therapy |

**Sleep, Depression, and Anxiety**

| Limited           | 1 [28]         | No difference | 6-month post-randomization | Group-based exercise + education vs. Cognitive functional therapy |
| Limited           | 1 [28]         | No difference | 12-month post-randomization | Group-based exercise + education vs. Cognitive functional therapy |

**Stress**

| Limited           | 1 [28]         | No difference | 6-month post-randomization | Group-based exercise + education vs. Cognitive functional therapy |
| Limited           | 1 [28]         | No difference | 12-month post-randomization | Group-based exercise + education vs. Cognitive functional therapy |

**Satisfaction**

| Limited           | 1 [28]         | No difference | 6-month post-randomization | Group-based exercise + education vs. Cognitive functional therapy |
| Limited           | 1 [28]         | No difference | 12-month post-randomization | Group-based exercise + education vs. Cognitive functional therapy |

**Short Form Health Survey–Physical Component**

| Limited           | 1 [20]         | No difference | 3-month post-intervention | Group Exercise vs. Individual Physical Therapy |
| Limited           | 1 [20]         | No difference | 12-month post-intervention | Group Exercise vs. Individual Physical Therapy |

**Short Form Health Survey–Mental Component**

| Limited           | 1 [20]         | No difference | 3-month post-intervention | Group Exercise vs. Individual Physical Therapy |
| Limited           | 1 [20]         | No difference | 12-month post-intervention | Group Exercise vs. Individual Physical Therapy |

**Increased work participation**

| Limited           | 1 [27]         | No difference | 12-month post-intervention | Brief Intervention vs. Brief Intervention + Cognitive Behavioral Therapy vs. Brief Intervention + Physical Group Exercise |

**Hospitality Anxiety and Depression Scale**

(Continued)
| Level of evidence | From n studies | Changes | Data Collection Time-point | Groups compared |
|-------------------|----------------|---------|--------------------------|-----------------|
| Limited           | 1 [27]         | No difference | 12-month post-intervention | Brief Intervention vs. Brief Intervention + Cognitive Behavioral Therapy vs. Brief Intervention + Physical Group Exercise |
| Subjective Health Complaints Inventory | | | | |
| Limited           | 1 [27]         | No difference | 12-month post-intervention | Brief Intervention vs. Brief Intervention + Cognitive Behavioral Therapy vs. Brief Intervention + Physical Group Exercise |
| Utrecht Coping List | | | | |
| Limited           | 1 [27]         | No difference | 12-month post-intervention | Brief Intervention vs. Brief Intervention + Cognitive Behavioral Therapy vs. Brief Intervention + Physical Group Exercise |
| Instrumental Mastery-Orientated Coping | | | | |
| Limited           | 1 [27]         | No difference | 12-month post-intervention | Brief Intervention vs. Brief Intervention + Cognitive Behavioral Therapy vs. Brief Intervention + Physical Group Exercise |
| Physical activity (International Physical Activity Questionnaire) | | | | |
| Limited           | 1 [24]         | No difference | 3-month post-randomization | Walking vs. Exercise Class vs. Usual Physiotherapy |
| Limited           | 1 [24]         | No difference | 6-month post-randomization | Walking vs. Exercise Class vs. Usual Physiotherapy |
| Limited           | 1 [24]         | No difference | 12-month post-randomization | Walking vs. Exercise Class vs. Usual Physiotherapy |
| Exercise Self-efficacy Questionnaire | | | | |
| Limited           | 1 [24]         | No difference | 3-month post-randomization | Walking vs. Exercise Class vs. Usual Physiotherapy |
| Limited           | 1 [24]         | No difference | 6-month post-randomization | Walking vs. Exercise Class vs. Usual Physiotherapy |
| Limited           | 1 [24]         | No difference | 12-month post-randomization | Walking vs. Exercise Class vs. Usual Physiotherapy |
| Readiness to Change Questionnaire | | | | |
| Limited           | 1 [24]         | No difference | 3-month post-randomization | Walking vs. Exercise Class vs. Usual Physiotherapy |
| Limited           | 1 [24]         | No difference | 6-month post-randomization | Walking vs. Exercise Class vs. Usual Physiotherapy |
| Limited           | 1 [24]         | No difference | 12-month post-randomization | Walking vs. Exercise Class vs. Usual Physiotherapy |
| Patient Satisfaction Questionnaire | | | | |
| Limited           | 1 [24]         | No difference | 3-month post-randomization | Walking vs. Exercise Class vs. Usual Physiotherapy |
| Left and Right Straight leg raising test | | | | |
| Limited           | 1 [23]         | No difference | 6-month post-randomization | Exercise Class vs. Individual Treatment |
| Limited           | 1 [23]         | No difference | 12-month post-randomization | Exercise Class vs. Individual Treatment |
| Repeated sit-to-stand test/ Fifty-foot walk test/ 5-minute walk test/ Step-count for 1 Week | | | | |
| Limited           | 1 [26]         | No difference | Post-intervention | Exercise &Education vs. Education |
| Limited           | 1 [26]         | No difference | 6-month post-intervention | Exercise &Education vs. Education |
| Pain self-efficacy Questionnaire | | | | |
| Limited           | 1 [26]         | More favourable results for the ED group | Post-intervention | Exercise &Education vs. Education |
| Limited           | 1 [26]         | More favourable results for the ED group | 6-month post-intervention | Exercise &Education vs. Education |

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Pain. Pain level was measured in three studies using the Visual Analogue Scale [22, 23, 25] and using the Numeric Pain Rating Scale in four studies [21, 24, 26, 28] (Table 5). There was moderate evidence of no difference between groups for 6-month post-randomization and 12-month post-randomization [24, 28]. There was limited evidence of a lower pain score of people in the group exercise and education compared to people of the education group 3-month and 6-month post-intervention compared to baseline [26]. There was limited evidence of non-difference between groups for immediately and 6-month post-intervention [21], 9-month and 15-month post-intervention [20], and 3-month post-randomization [24]. There was limited evidence of a lower pain score of people in the group exercise compared to people of the individual intervention group 4 week post-intervention [25].

Secondary outcome measures

Quality of life. Quality of life was evaluated in four studies. Two studies used the EQ-5D quality of life scale [20, 30], one used the EQ-5D-5L, one used the EQ-VAS [30] and one study used the short form SF-36 Health Survey [29]. There was strong evidence of no difference between groups in health surveys scores from two high-quality studies [20, 30]. Likewise, there was limited evidence of no difference among groups for all measurement time points [20, 21, 29, 30].

Lumbar spine flexibility (flexion, extension, and lateral flexion). There was limited evidence for no difference between groups post-intervention and 12-month post-intervention [23] with respect to group exercise vs. individual intervention on lumbar spine flexibility, however, there was limited evidence for more flexion, extension, and lateral bending range of motion in people of the group exercise group compared to the controls 4-week and 8-week post-intervention [25]. Likewise, there was limited evidence of a higher range of motion for lumbar extension and lateral bending 6-month post-intervention [23]. Differences in the flexion range of motion between these groups were not significant [23].

Fear beliefs. Low back pain associated fear beliefs were evaluated in three studies [24, 26, 27] with inconsistent results irrespective of the quality of the studies included. One study evaluated pain-related fear with the Tampa Scale of Kinesiophobia-13 (TSK-13, a modified version of the original Tampa scale of Kinesiophobia) [26], one used the Fear-avoidance Beliefs Questionnaire (FABQ) [27] and one used the Fear Avoidance Beliefs Questionnaire-PA subscale and Back Beliefs Questionnaire [24]. There was limited evidence of no difference among groups for fear beliefs 3-month post-intervention [24], 3-month and 6-month post-randomization [26], either 6-month post-intervention [24] or post-randomisation [28], and either 12-month post-intervention [24, 27] or post-randomisation [28].

Other outcome comparisons. Most studies reported outcome measures in addition to those describing disability, quality of life and pain (Table 5). One study showed limited evidence that cognitive functional therapy was superior in pain self-efficacy, risk of chronicity, and coping compared to group-based exercise [28]. The remaining other outcome measures had limited evidence of no difference between the group and individual programs (Table 5).

Discussion

Main findings

The present systematic review identified strong evidence of no difference in disability level and pain scores 3-month post-intervention in people with chronic low back pain group-based exercise compared with controls that underwent other non-pharmacologic interventions. We also identified moderate evidence of no difference between group exercise and cognitive functional therapy for 6-month post-randomization and 12-month post-randomization. We could
not find any strong or moderate evidence for or against the use of group-based exercise in the rehabilitation of people with chronic LBP for other time-points and health measurement outcomes.

These findings are consistent with findings of a recent systematic review conducted by O’Keeffe et al. [8] that compared individual exercise to group exercise for all musculoskeletal conditions including LBP. O’Keeffe et al. [8] found that for disability and pain, no clinically significant differences were found between the group and individual physiotherapy including exercise for all musculoskeletal conditions. They also found seven studies that specifically related to LBP that also noticed no clinically significant differences in disability and pain when comparing group and individual physiotherapy involving exercise [8].

While our results suggest there is no difference between group exercise and non-pharmacological interventions, there was one study that demonstrated limited evidence that cognitive functional therapy was superior in self-administered disability measures 6 and 12-month post-randomization compared to baseline. The same study indicated that cognitive functional therapy was superior in pain self-efficacy, risk of chronicity, and coping compared to group-based exercise 12-month post-randomization compared to 6-month post-randomization [28].

Some secondary outcomes demonstrated interesting findings but were not frequently used in the included studies. These included fear-avoidance, QoL and cost. Based on one study investigated here, group-based exercise reduced fear-avoidance scores [32], improved quality of life measures compared to usual general practitioner care [20] and lowered costs [23]. Based on these studies, further exploration of these outcomes in relation to group-based exercise performance is warranted.

Study limitations
This review solely included studies published in English, and no search was conducted of the grey literature. These two factors may have caused a potential bias in selecting relevant studies. As discussed previously, the papers identified here were highly heterogeneous which prevented meta-analysis. Unfortunately, the literature was not sufficiently rich to focus our review on head-to-head comparisons of group-based exercise with individual-based exercise and other specific interventions.

Further, in terms of our specific summary statements, some of these studies conflicted with each other depending on the time-points compared (Table 5). The majority of conflicts were observed for timepoints with two or three studies (each study weighted 50% or 33.33% in the summary statement, respectively). This indicates that even a different observation from a low-quality study could drastically change the level of evidence for a specific summary statement. The limited evidence summary statements often showed no difference among interventions. The studies compared were heterogeneous in terms of the population studied (different ages, different time points, different pain and disability level among participants) or because of other methodological considerations, which may have contributed to the frequent conflicting evidence summary statements and limited our ability to observe consistent effects of group-based exercise.

Conclusion
We identified strong evidence of no difference between group exercise and other non-pharmacological LBP interventions for disability level, quality of life, and pain. The remaining evidence was not of sufficiently high quality to permit further conclusions. With this equivocal finding, group-based exercise may be a preferred choice given potential advantages in other domains not reviewed here such as motivation and cost. Further research in this area is needed to evaluate this possibility.
Supporting information

S1 Checklist. PRISMA 2009 checklist.
(DOC)

S1 Appendix. Library search keywords.
(DOCX)

S2 Appendix. Systematic literature review data extraction form.
(DOCX)

S3 Appendix. Appraisal form.
(DOCX)

S4 Appendix.
(DOCX)

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References

1. Hoy D, March L, Brooks P, Blyth F, Woolf A, Bain C, et al. The global burden of low back pain: Estimates from the Global Burden of Disease 2010 study. Ann Rheum Dis. 2014; 73: 968–974. https://doi.org/10.1136/annrheumdis-2013-204428 PMID: 24665116

2. Fernandez M, Ordoñana JR, Hartvigsen J, Ferreira ML, Refshauge KM, Sanchez-Romera JF, et al. Is chronic low back pain associated with the prevalence of coronary heart disease when genetic susceptibility is considered? A co-twin control study of Spanish twins. PLoS One. 2016; 11: 1–15. https://doi.org/10.1371/journal.pone.0155194 PMID: 27171210

3. Froud R, Patel S, Rajendran D, Bright P, Bjorkil T, Buchbinder R, et al. A systematic review of outcome measures use, analytical approaches, reporting methods, and publication volume by year in low back pain trials published between 1980 and 2012: Respice, adspice, et prospece. PLoS One. 2016; 11: 1–16. https://doi.org/10.1371/journal.pone.0164573 PMID: 27776141

4. Bussières AE, Stewart G, Al-Zoubi F, Decina P, Descarreaux M, Haskell D, et al. Spinal Manipulative Therapy and Other Conservative Treatments for Low Back Pain: A Guideline From the Canadian Chiropractic Guideline Initiative. J Manipulatve Physiol Ther. 2018; 41: 265–293. https://doi.org/10.1016/j.jmpt.2017.12.004 PMID: 29606335
5. Wong JJ, Côté P, Sutton DA, Randhawa K, Yu H, Varatharajan S, et al. Clinical practice guidelines for the noninvasive management of low back pain: A systematic review by the Ontario Protocol for Traffic Injury Management (OPTIMA) Collaboration. Eur J Pain (United Kingdom). 2017; 21: 201–216. https://doi.org/10.1002/ejp.931 PMID: 27712027

6. Bernstein IA, Malik Q, Carville S, Ward S. Low back pain and sciatica: Summary of NICE guidance. BMJ. 2017; 356: 1–5. https://doi.org/10.1136/bmj.i6748 PMID: 28062522

7. Stockkendahl MJ, Kjaer P, Hartvigsen J, Kongsted A, Aaboee J, Andersen M, et al. National Clinical Guidelines for non-surgical treatment of patients with recent onset low back pain or lumbar radiculopathy. Eur Spine J. 2018; 27: 60–75. https://doi.org/10.1007/s00586-017-5099-2 PMID: 28429142

8. O’Keeffe M, Hayes A, McCreesh K, Purtle H, O’Sullivan K. Are group-based and individual physiotherapy exercise programmes equally effective for musculoskeletal conditions? A systematic review and meta-analysis. Br J Sports Med. 2017; 51: 126–132. https://doi.org/10.1136/bjsports-2015-095410 PMID: 27343238

9. Hayden JA, Van Tulder MW, Tomlinson G. Systematic review: Strategies for using exercise therapy to improve outcomes in chronic low back pain. Ann Intern Med. 2005; 142: 776–785. https://doi.org/10.7326/0003-4819-142-9-200505030-00014 PMID: 15867410

10. Frost H, Moffett J. A. K, Moser JS, Fairbank JCT. Randomised controlled trial for evaluation of fitness programme for patients with chronic low back pain. Brmj. 1995; 310: 151. https://doi.org/10.1136/bmj.310.6973.151 PMID: 7833752

11. Frost H, Lamb SE, Moffett JAK, Fairbank JCT, Moser JS. <Frost-1998-A fitness programme.pdf>. 1998; 75: 273–279.

12. Underwood M. United Kingdom back pain exercise and manipulation (UK BEAM) randomised trial: Effectiveness of physical treatments for back pain in primary care. Br Med J. 2004; 329: 1377–1381. https://doi.org/10.1136/bmj.38282.669225.AE PMID: 15556955

13. Higgins JPT, Green S, Collaboration C. Cochrane handbook for systematic reviews of interventions. Chichester, England; Hoboken, NJ: Wiley-Blackwell; 2008.

14. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Ioannidis JP, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. J Clin Epidemiol. 2009; 62: e1–34. https://doi.org/10.1016/j.jclinepi.2009.06.006 PMID: 19631507

15. Mokkink LB, Terwee CB, Patrick DL, Alonso J, Stratford PW, Knol DL, et al. The COSMIN study reached international consensus on taxonomy, terminology, and definitions of measurement properties for health-related patient-reported outcomes. J Clin Epidemiol. 2010; 63: 737–745. https://doi.org/10.1016/j.clinepi.2010.02.006 PMID: 20494804

16. Jerosch-Herold C. An Evidence-Based Approach to Choosing Outcome Measures: A Checklist for the Critical Appraisal of Validity, Reliability and Responsiveness Studies. Br J Occup Ther. 2005; 68: 347–353. https://doi.org/10.1177/030802260506800803

17. Bialocerkowski A, Klupp N, Bragge P. How to read and critically appraise a reliability article. Int J Ther Rehabil. 2010; 17: 114–120.

18. Vandenbroucke JP, von Elm E, Altman DG, Gotzsche PC, Mulrow CD, Pocock SJ, et al. The STROBE statement: explanation and elaboration. Ann Intern Med. 2007; 147: W163–94. https://doi.org/10.7326/0003-4819-147-8-200710160-00010-w1[pii] PMID: 17938389

19. Cornelius LR, van der Klink JJ, Groothoff JW, Brouwer S. Prognostic factors of long term disability due to mental disorders: a systematic review. J Occup Rehabil. 2011; 21: 259–274. https://doi.org/10.1007/s10926-010-9261-5 PMID: 21057974

20. Johnson RE, Jones GT, Wiles NJ, Chaddock C, Potter RG, Roberts C, et al. Active exercise, education, and cognitive behavioral therapy for persistent disabling low back pain: A randomized controlled trial. Spine (Phila Pa 1976). 2007; 32: 1578–1585. https://doi.org/10.1097/BRS.0b013e318074890 PMID: 17621203

21. Daulat A. A pragmatic randomized controlled trial to compare a novel group physiotherapy programme with a standard group exercise programme for managing chronic low back pain in primary care. Int Musculoskelet Med. 2016; 38: 97–108. https://doi.org/10.1080/17536146.2016.1261234

22. Sahin N, Albayrak I, Durmus B, Ugurlu H. Effectiveness of back school for treatment of pain and functional disability in patients with chronic low back pain: A randomized controlled trial. J Rehabil Med. 2011; 43: 224–229. https://doi.org/10.2340/16501977-0650 PMID: 21305238

23. Lewis JS, Hewitt JS, Billington L, Cole S, Byng J, Karayiannis S. A randomized clinical trial comparing two physiotherapy interventions for chronic low back pain. Spine (Phila Pa 1976). 2005; 30: 711–721. https://doi.org/10.1097/01.brs.0000157469.27779.de PMID: 15903071
24. Hurley DA, Tully MA, Lonsdale C, Boreham CAG, Van Mechelen W, Daly L, et al. Supervised walking in comparison with fitness training for chronic back pain in physiotherapy: Results of the SWIFT single-blinded randomised controlled trial (ISRCTN17592092). Pain. 2015; 156: 131–147. https://doi.org/10.1016/j.pain.2015.03.003 PMID: 25599309

25. Masharawi Y, Nadaf N. The effect of non-weight bearing group-exercising on females with non-specific chronic low back pain: A randomized single blind controlled pilot study. J Back Musculoskeletal Rehabil. 2013; 26: 353–359. https://doi.org/10.3233/BMR-130391 PMID: 23948819

26. Ryan CG, Gray HG, Newton M, Granat MH. Pain biology education and exercise classes compared to pain biology education alone for individuals with chronic low back pain: A pilot randomised controlled trial. Man Ther. 2010; 15: 382–387. https://doi.org/10.1016/j.math.2010.03.003 PMID: 20359937

27. Harris A, Moe TF, Eriksen HR, Tangen T, Lie SA, Tveito TH, et al. Brief intervention, physical exercise and cognitive behavioural group therapy for patients with chronic low back pain (The CINS trial). Eur J Pain (United Kingdom). 2017; 21: 1397–1407. https://doi.org/10.1002/ejp.1041 PMID: 28449303

28. O’Keeffe M, O’Sullivan P, Purtill H, Bargary N, O’Sullivan K. Cognitive functional therapy compared with a group-based exercise and education intervention for chronic low back pain: A multicentre randomised controlled trial (RCT). Br J Sports Med. 2019; 54. https://doi.org/10.1136/bjsports-2019-100780 PMID: 31630089

29. Sherman KJ, Cherkin DC, Erro J, Miglioretti DL, Deyo RA. Comparing yoga, exercise, and a self-care book for chronic low back pain: A randomized, controlled trial. Ann Intern Med. 2005; 143: 849–856. https://doi.org/10.7326/0003-4819-143-12-200512200-00003 PMID: 16365466

30. Carr JL, Klaber Moffett JA, Howarth E, Richmond SJ, Torgerson DJ, Jackson DA, et al. A randomized trial comparing a group exercise programme for back pain patients with individual physiotherapy in a severely deprived area. Disabil Rehabil. 2005; 27: 929–937. https://doi.org/10.1080/0963828050030639 PMID: 16096246

31. Reme SE, Tveito TH, Chalder T, Bjørkjær T, Indahl A, Brox JI, et al. Protocol for the Cognitive Interventions and Nutritional Supplements (CINS) trial: A randomized controlled multicenter trial of a brief intervention (BI) versus a BI plus cognitive behavioral treatment (CBT) versus nutritional supplements for patients wit. BMC Musculoskeletal Disord. 2011; 12. https://doi.org/10.1186/1471-2474-12-152 PMID: 21736730

32. Moffett JAK, Carr J, Howarth E. High fear-avoiders of physical activity benefit from an exercise program for patients with back pain. Spine (Phila Pa 1976). 2004; 29: 1167–1172. https://doi.org/10.1097/00007632-200406010-00002 PMID: 15167652