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Exercise interventions for the treatment of chronic low back pain: a systematic review and meta-analysis of randomised controlled trials

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Abstract

Objective: To determine, for adults with chronic low back pain, which exercise interventions are the most effective at reducing pain compared to other treatments.

Data sources: A search of MEDLINE, CINAHL, EMBASE, SPORTDiscus, PsycINFO and The Cochrane Library was conducted up to October 2014.

Review methods: Databases were searched for published reports of randomised trials that investigated the treatment of chronic low back pain of non-specific origin with an exercise intervention. Two authors independently reviewed and selected relevant trials. Methodological quality was evaluated using the Downs and Black tool.

Results: Forty-five trials met the inclusion criteria and thirty-nine were included in the meta-analysis. Combined meta-analysis revealed significantly lower chronic low back pain with intervention groups using exercise compared to a control group or other treatment group (Standard Mean Deviation (SMD) =-0.32, CI 95% -0.44 to -0.19, $P<0.01$). Separate exploratory subgroup analysis showed a significant effect for strength/resistance and coordination/stabilisation programs.

Conclusions: Our results found a beneficial effect for strength/resistance and coordination/stabilisation exercise programs over other interventions in the treatment of chronic low back pain and that cardiorespiratory and combined exercise programs are ineffective.

Keywords

Chronic low back pain, exercise, systematic review, meta-analysis

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Introduction

Low back pain is an extremely common problem that is estimated to affect up to 70% of adults.[1] In up to 85% of all cases of low back pain the mechanism of the pain is poorly understood and is classified as non-specific i.e. of unknown origin.[2] However, low back pain is understood to have a multifactorial aetiology with individual characteristics (age, physical fitness), psychosocial factors (stress, anxiety and depression) and occupational factors (heavy physical work, bend and twist motions and vibration) implicated in its development.[3,4] Treatment of chronic low back pain is difficult and many of the established interventions have limited efficacy.[5]

There is some evidence from a Cochrane review that shows exercise is effective at slightly reducing pain and improving physical function in patients with non-specific chronic low back pain.[6] This evidence is reflected in a recent literature review of current national and international guidelines for chronic low back pain which consistently recommend exercise therapy as a treatment for chronic low back pain.[7] Exercise has been proposed to improve back strength, flexibility, range of motion and fitness,[4,8] and to provide an acute improvement in mood and protection from depression.[9] However, as a number of reviews have noted, clinical implementation of the guidelines is difficult due to the wide variety of exercise interventions used, the effect of co-interventions, inconsistent recommendations regarding the intensity and duration of exercise required, and insufficient data on particular types of exercise.[7,10,11] At present the role of exercise and whether specific exercises are beneficial are both uncertain. One review sought to better inform clinical practice by identifying particular exercise characteristics, such as stretching or supervision that decrease pain and improve function in adults with non-specific chronic low back pain.[12] There are no recent systematic reviews which provide clinicians with information regarding which groups or types of exercise interventions are most effective. The aim of this analysis is to systematically review the current literature and ascertain for adults with non-specific chronic low back pain which type of stand-alone exercise interventions are most effective in reducing pain compared to another intervention or a control intervention, and, to evaluate study findings by meta-analysis where appropriate.

Methods

An electronic database search of MEDLINE, EMBASE, CINAHL, SPORTDiscus, PsycINFO and The Cochrane Library was conducted from inception until 30 October 2014. Search terms used were back pain, backache, lumbago, exercise, train, rehabilitation, stabilise, strength, trunk, core, motor, spinal or pelvic (Appendix 1). No language restrictions were used. Reference lists of included trials, clinical guidelines and review articles were also searched.

Only published reports of randomised controlled trials that investigated the treatment of chronic low back pain of non-specific origin with another intervention or control intervention were included in this review. For the purpose of this review the definition of chronic low back pain is pain and discomfort, localised below the costal margin and above the inferior gluteal folds, with or without leg pain that has been present for three months or longer.[13] Non-specific chronic low back pain is further defined as chronic low back pain not attributed to recognisable, known specific pathology (e.g. infection, tumor, osteoporosis, ankylosing spondylitis, fracture, inflammatory process, radicular syndrome or cauda equina syndrome).[13] Exercise interventions were defined as planned, structured and repetitive activities that result in bodily movement and energy expenditure by activation of skeletal muscles.[14] Trials were also required to report an outcome measure for low back pain.

Studies were excluded if the individuals involved had acute or sub-acute low back pain or chronic low back pain caused by specific pathologies or conditions. Studies were also excluded where the effect of exercise could not be isolated as it was given as part of a Back School Program or multidisciplinary program. Multidisciplinary programs were defined as those where exercise was combined with manipulations, mobilisations, psychology, counselling, cognitive based training or ergonomics.

One reviewer conducted the electronic searches (AS). Titles and abstracts were independently assessed by two reviewers (AS and VC). Disagreements were resolved by consensus and a third reviewer where necessary (MS). A standardised data extraction form was used to collect population characteristics, trial inclusion and exclusion criteria, intervention details, outcome data and overall conclusions from each trial.

Methodological assessment was performed independently by two reviewers (AS, VC). Methodological quality was assessed using a modified version of the Quality Index as described by Downs and Black.[15] The final question (question 27) which is scored on a scale of 0 to 5 was simplified, and a score of 0 or 1 was allocated depending on whether the trial reported a power or sample size calculation. Therefore, our modified index could result in a score between 0 and 28, with a higher score reflecting a superior methodological quality.

Meta-analysis was performed to compare pain-related outcome measures between an exercise intervention and other treatment methods. All data analyses were performed using STATA version 12.1 software. A random effects model was used as the underlying assumptions are believed to be better suited to deal with the clinical heterogeneity of back pain literature.[16] Standardised mean differences (SMD) were calculated where different scales were used to measure continuous pain outcomes, and a Hedges g correction was used to reduce bias.[17] An effect size of greater than or equal to 0.8 was considered to represent a large effect, 0.5 a moderate effect and 0.2 a small effect.[18] Statistical heterogeneity between studies was assessed by use of the Q and I^2 statistic, and for this review heterogeneity scores were interpreted as low (25%), moderate (50%), and high (75%).[19] As heterogeneity tests tend to be lower in power, $P<0.1$ is used to indicate heterogeneity rather than $P<0.05$.[20]

Because some studies compared multiple exercise interventions with a single control group, we conducted an exploratory subgroup analysis, based on exercise types as described by the American College of Sports Medicine (ACSM),[21] to determine the most effective exercise interventions for the treatment of chronic low back pain. The trials were separated into four groups: coordination/stabilisation, strength/resistance, cardiorespiratory and combined trials. The strength/resistance group included trials that used the motions of major muscle groups to improve strength, while the coordination/stabilisation group involved programs with balance, agility, coordination, gait and proprioceptive components. The cardiorespiratory group used regular, purposeful, continuous exercise involving major muscle groups. The combined group comprised exercise programs with multiple components such as strengthening, stretching, endurance and aerobic training. This group included modalities such as yoga, pilates and cesar therapy (a whole body posture and movement therapy). Publication bias was assessed using the Copas Selection model analysis.[22] The PRISMA checklist was used to check the reporting quality of the meta-analysis.

Results

The initial database search resulted in a total of 1757 citations of which 149 were appropriate for full review (Figure 1). After review 45 trials were included (supplementary material Table 1), while 76 trials were rejected on the basis of exclusion criteria (Appendix 2), and 28 trials comparing two or more types of exercise were rejected as the general effect of exercise could not be isolated (Appendix 2). The 45 trials assessing the effectiveness of exercise interventions on chronic low back pain included a total of 4462 participants aged between 30 and 63 years old (supplementary material Table 1). The trials were between 1.5 and 18 weeks in duration. The majority of the exercise interventions (n=40) were supervised programs. Comparisons included wait list or usual activities, general practitioner care, electrotherapies (ultrasound, laser) and manipulative therapies (physiotherapy, massage, osteopathy).

The modified Downs and Black[15] quality index scores ranged from 54% to 96% (mean = 76%) (Appendix 3). Thirteen of the trials did not provide

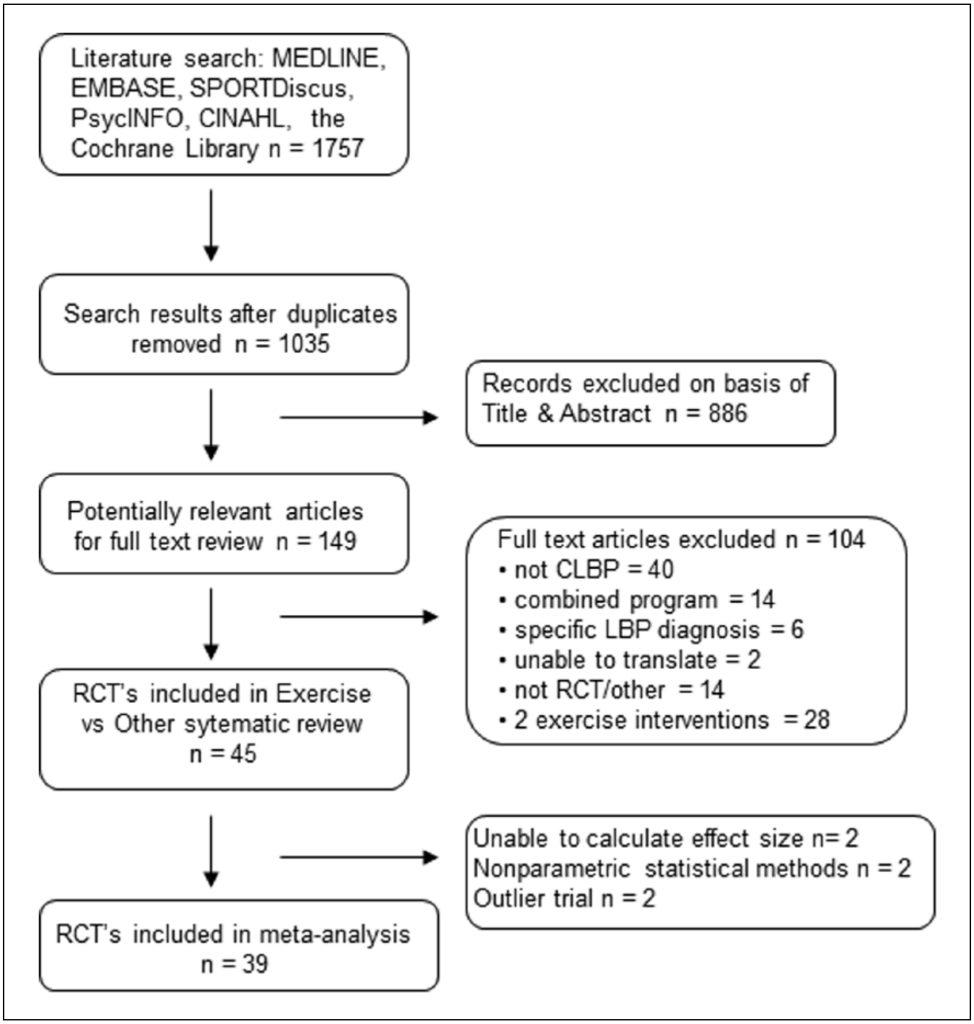

Figure 1. Flow diagram of systematic review inclusion or exclusion.

details of the randomisation method used, and just over half of the trials reported power calculations to detect relevant changes between the groups. Only eleven of the trials provided details of any adverse events related to the exercise interventions. A further twelve trials did not report details of adherence to the exercise intervention with some noting that monitoring of adherence to home-based components of the exercise intervention was particularly difficult. Two trials required participants to sign written agreements to perform the home-based exercises and eleven trials relied on self-reporting of adherence, while ten trials did not report on home based adherence.

As the interventions and outcome measures of the studies were found to be similar, meta-analysis was considered appropriate. Four studies were excluded as they did not report enough detail to compute effect sizes [23,24] or used nonparametric statistical methods.[25,26] After the initial meta-analysis was completed, two outlier studies[27,28] with large positive results were excluded as they increased the heterogeneity and may have had a disproportionate influence on the analysis. Therefore, 39 studies

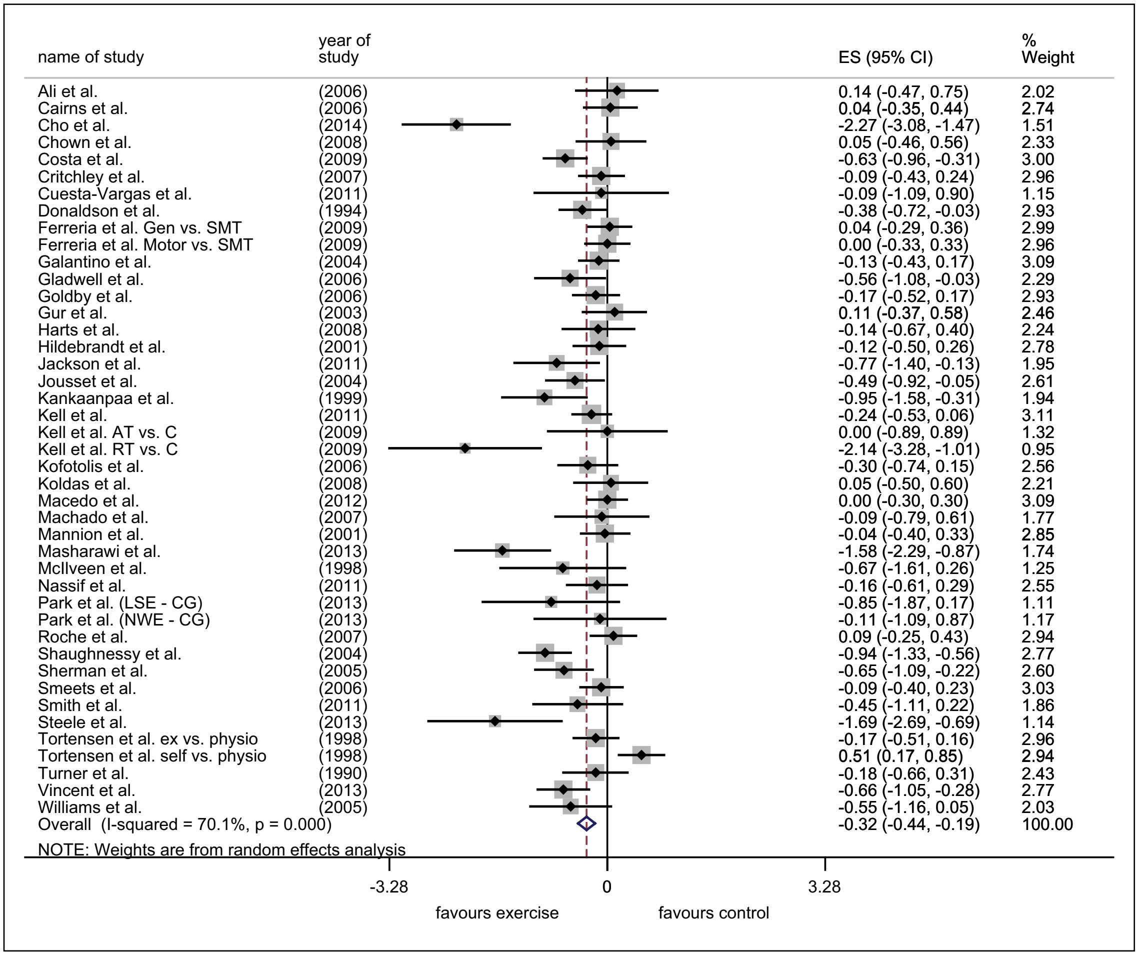

Figure 2. Forest plot of the treatment of chronic low back pain with exercise vs other interventions.

with 4109 participants were included in the meta-analysis (Figure 2). Most studies, 30 of 39 (76.9%), showed a positive result in favour of the exercise groups resulting in lower chronic low back pain. A small effect (SMD=-0.32, CI 95%: -0.44 to -0.19) was found in intervention groups using exercise compared to other treatments/control. Asymmetry displayed in the Copas funnel plot suggested that some potential bias was present, however, the summary effect after adjustments was still significant (SMD=-0.15, CI95%: -0.25 to -0.05) with no significant residual publication bias present ($P > 0.1$).

To determine the most effective exercise interventions for the treatment of chronic low back pain an exploratory subgroup analysis was conducted based on exercise types as described by the American College of Sports Medicine (ACSM).[21] The trials were separated into four groups: coordination/stabilisation (n=12), strength/resistance (n=11), cardiorespiratory (n=6) and combined trials (n=14). Some of the trials appear in two subgroups. These trials had two or more intervention groups that were compared with another or control intervention, and the separate intervention groups were allocated to different subgroup analysis as determined by our exercise groupings.

Twelve trials with 1343 participants were included in the coordination/stabilisation exercise

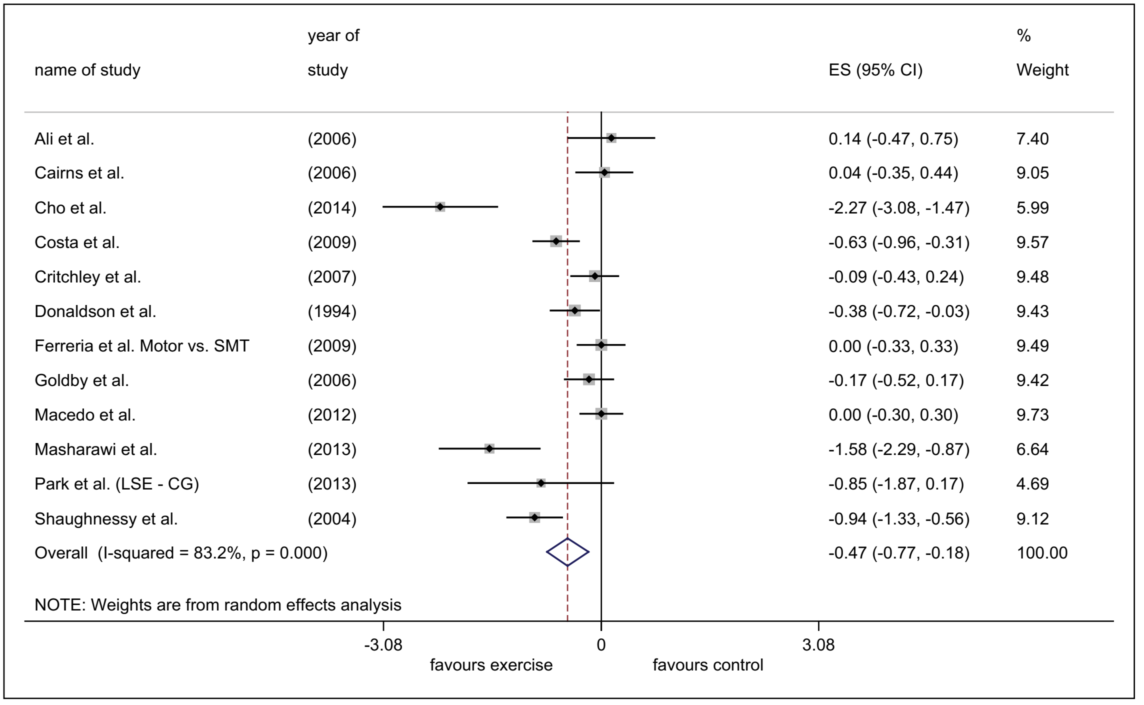

Figure 3. Forest plot of the treatment of chronic low back pain with coordination/stabilisation exercise.

trials subgroup meta-analysis (Figure 3). The analysis demonstrated a small but significant effect (SMD=-0.47, CI 95%: -0.77 to -0.18) although high heterogeneity was present (I^2=83.2%, *P*<0.01). The coordination/stabilisation treatment group generally showed a positive effect, with eight of the twelve trials reporting results that favour the exercise intervention over the control treatment.[29-36] However, only five of these trials reported results with statistical significance (Costa et al.[29] (SMD=-0.63, CI 95%: -0.96 to -0.31), Donaldson et al.[31] (SMD=-0.38, CI 95%: -0.72 to -0.03), Shaughnessy et al.[33] (SMD=-0.94, CI 95%: -1.33 to -0.56), Cho et al.[35] (SMD=-2.27, CI 95%: -3.08 to -1.47), Masharawi et al.[36] (SMD = -1.58, CI 95%: -2.29 to -0.87)).

Eleven trials with 885 participants were included in the strength/resistance exercise trials subgroup meta-analysis (Figure 4). The analysis demonstrated a small but significant effect (SMD=-0.50, CI 95%: -0.77 to -0.24) with moderate heterogeneity (I^2=66.4%, *P*<0.01). The strength/resistance treatment group also generally showed a positive effect, with ten of the eleven trials reporting results that favour the exercise intervention over the control treatment.[37-46] However, only five of these trials reported results with statistical significance. (Jackson et al.[38] (SMD=-0.77, CI 95%: -1.40 to -0.13), Kanaanpaa et al.[39] (SMD=-0.95, CI 95%: -1.58 to -0.31), Kell et al.[40] resistance group vs control (SMD=-2.14, CI 95%: -3.28 to -1.01), Vincent et al.[46] (SMD=-0.66, CI 95%: -1.05 to -0.28), Steele et al.[45] (SMD = -1.69, CI 95% -2.69 to -0.69)).

Six trials with 469 participants were included in the cardiorespiratory exercise trials subgroup meta-analysis (Figure 5). Three of the trials showed results that favour the exercise intervention over the control treatment,[47-49] but none of these three trials reported results with statistical significance. The analysis demonstrated no significant effect (SMD=-0.04, CI 95%: -0.31 to 0.39) with moderate heterogeneity present (I^2=47.4%, *P*=0.09).

Fourteen trials with 1566 participants were included in the combined exercise trials subgroup

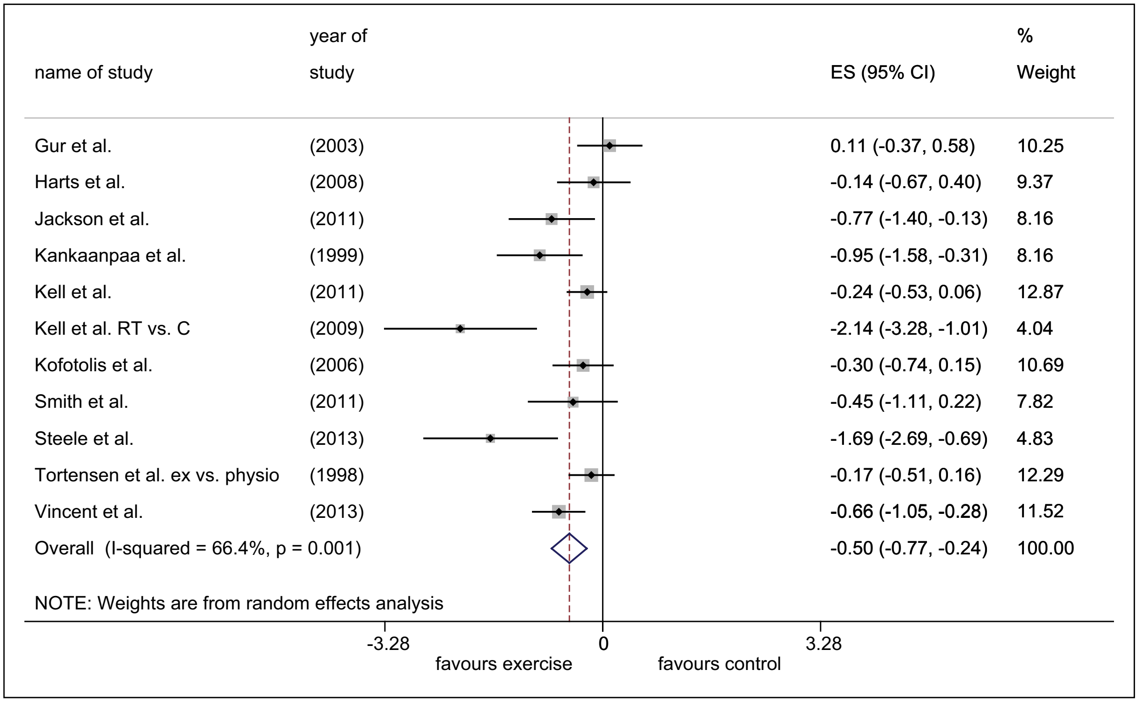

Figure 4. Forest plot of the treatment of chronic low back pain with strength/resistance exercise.

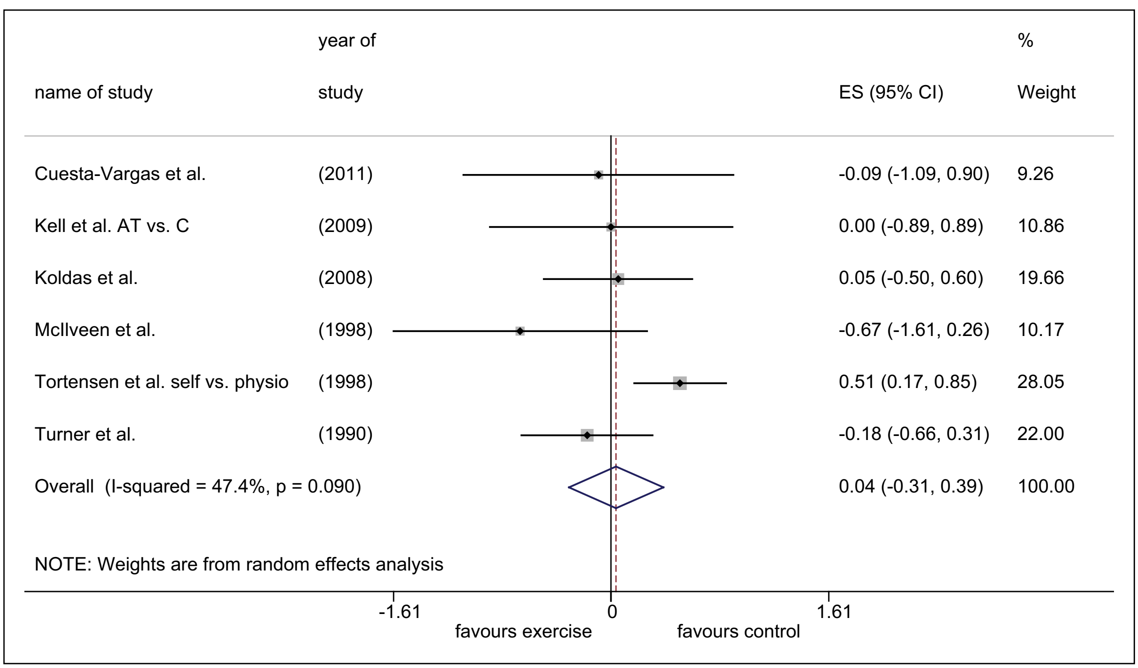

Figure 5. Forest plot of the treatment of chronic low back pain with cardiorespiratory exercise.

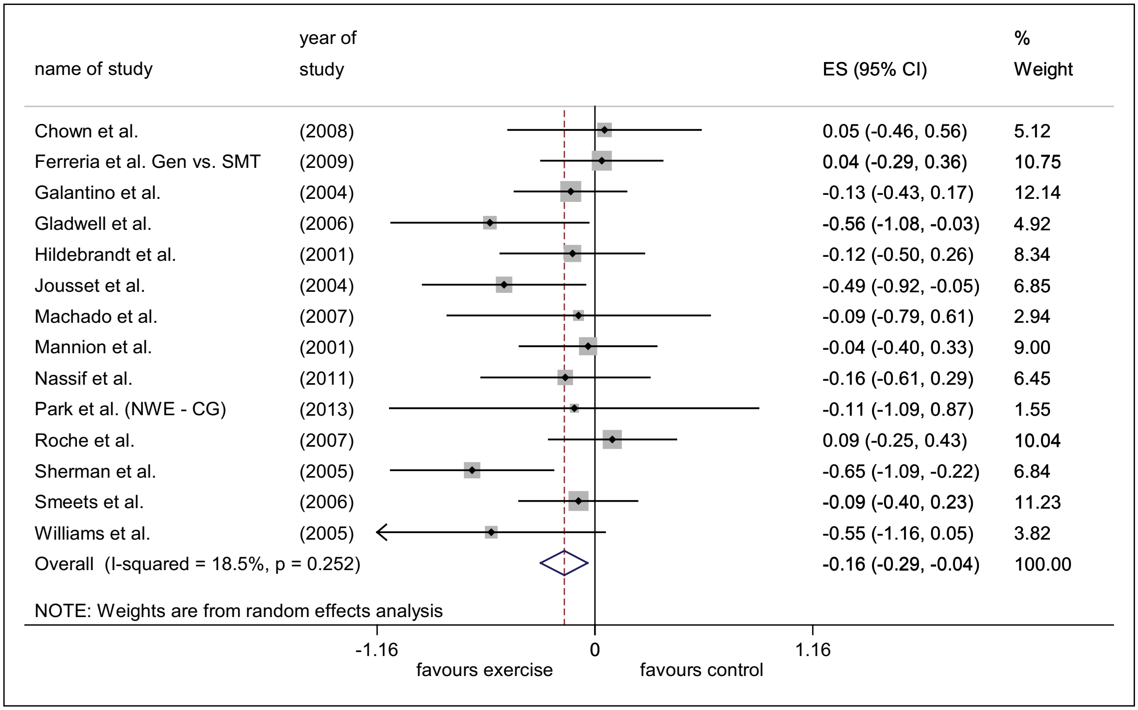

Figure 6. Forest plot of the treatment of chronic low back pain with combined exercise.

meta-analysis (Figure 6). The analysis demonstrated no significant effect (SMD=-0.16, CI 95%: -0.29 to -0.04) and low heterogeneity (I^2=18.5%, *P*=0.25). The combined exercise treatment group generally showed a positive effect, with 11 of the 14 trials reporting results that favour the exercise intervention over the control treatment.[34,50-59] However, only three of these trials reported results with statistical significance (Gladwell et al.[51] (SMD=-0.56, CI 95%: -1.08 to -0.03), Jousset et al.[53] (SMD= -0.49, CI 95%: -0.92 to -0.05), Sherman et al.[57] (SMD=-0.65, CI 95%: -1.09 to -0.22).

Discussion

Based on the combined results of these moderate to high quality randomised controlled trials, exercise has a small but significant benefit for the treatment of non-specific chronic low back pain and is more effective than conservative therapies. This current finding is consistent with the advice provided in current low back pain guidelines.[6,60] However, the lack of consistency in outcomes following exercise intervention makes clinical implementation of this recommendation challenging. The variability in clinical efficacy of exercise programs may be associated with several factors including the wide variety of exercise interventions available, use of supervised or unsupervised programs, patient adherence to the exercise programs, inconsistent recommendations regarding the intensity and duration of exercise required and heterogeneous characteristics of chronic low back pain patients.

In order to assist clinicians in providing advice to patients regarding the most effective type of exercise intervention for chronic low back pain, an exploratory subgroup analysis was undertaken which grouped exercise interventions by exercise type and examined their efficacy. Based on the results of this analysis, a small but significant effect was observed for the strength/resistance and coordination/stabilisation exercise interventions. Although our meta-analysis suggests these should be preferred treatment options, the included trials differed in duration, intensity and method of training and it is unknown how these factors may impact results.

The largest effect size of all the exercise groupings was noted in the strength/resistance trials that concentrated on whole body and trunk. Chronic low back pain is associated with disturbance of muscle activation patterns and weakness and increased fatigability of both trunk and extremity muscles.[61] It is believed that these deficiencies can lead to a loss of lumbar stability and recurrent injuries to the lumbar spine. Some studies have shown that no single muscle is key to achieving lumbar spine stability[62,63] and based on this, recommendations have been made for rehabilitation programs to involve the entire spinal musculature.[63] The results of our sub-group analysis show preliminary support for exercises that target multiple muscle groups. The larger effect size associated with the strength/resistance programs may have been due to the wide range of muscles trained and the improvements in muscle strength, power and functional abilities seen after resistance training.[64]

The coordination/stabilisation exercise programs in this review typically focused on strengthening muscles considered to be essential for core stability including the lumbar multifidus and transversus abdominus.[65,66] There is evidence that these muscles contribute to lumbo-pelvic stability and segmental stiffness and assist with support of the spine when stability is challenged.[65] People with chronic low back pain have demonstrated delayed or decreased activation of these muscles[66,67] and a loss of the normal tonic activation of tranversus abdominus during gait and extremity movement.[68] Dysfunction of these muscles is postulated to lead to decreased support for the lumbar spine and increased stress and load on the joints and ligaments of the spine.[66] Studies have shown that isolated motor training of the tranversus abdominus leads to earlier onset of tranversus abdominus activation and a more constant activation pattern which approximates the responses seen in healthy individuals.[69] This enhanced motor control during functional tasks may contribute to reduction in pain.

The participants in the combined exercise trials undertook programs that included strength, endurance, stretch and aerobic components. Impairments in trunk strength, flexibility and endurance are present in many people with chronic low back pain,[8] so it would be expected that an exercise program that addresses these deficiencies would lead to an improvement in symptoms. However, no particular modality showed consistent results, and the three trials that displayed outcomes with statistical significance [51,53,57] used pilates, an individualised exercise program and yoga respectively.

This review found that cardiorespiratory exercise programs showed no effect in reducing chronic low back pain. Prior studies[70,71] have shown that people with chronic low back pain have lower physical fitness levels than healthy subjects. If this is the case, the cardiorespiratory interventions in this review may have been of insufficient duration or intensity to have a therapeutic effect. ACSM guidelines[72] recommend a cardiorespiratory program should be undertaken 3 to 5 times per week, for 20 to 60 minutes and that a 15 to 20 week timeframe is appropriate to evaluate the efficacy of an intervention. Only two of the six trials included in our analysis met these requirements. The use of measures of low back pain to determine treatment efficacy in this review may also have affected the outcome relating to cardiorespiratory exercise. A previous review[6] has indicated that some exercise modalities may have greater impacts on particular outcomes, for example stretching exercises demonstrated a larger improvement in pain outcomes, while strengthening exercises were more effective in improving function outcomes. It may be the case that cardiorespiratory exercise has a greater effect on chronic low back pain comorbidities, such as quality of life and depression, or that there is no correlation between aerobic capacity and pain caused by chronic low back pain.[73]

Our findings show that there is lower chronic low back pain with intervention groups using an exercise intervention compared to other treatments, and that the strength/resistance and coordination/stabilisation interventions had the greatest effect in reducing pain associated with chronic low back pain. These findings may be combined with other current recommendations, such as advice to undertake a supervised, structured group program,[74] to better assist clinicians when advising exercise interventions to patients with chronic low back pain. More evidence is required regarding whether particular groups of patients might respond better to certain exercise interventions[75] as this would allow clinicians to further tailor exercise recommendations for individual patients.

Although this review was designed to be comprehensive with a robust search strategy, it is possible that that not all studies were identified. In addition, only RCTs were considered to have appropriate levels of evidence, so studies with lesser levels of evidence such as case series have been excluded. The findings also need to be interpreted in the context of a number of specific limitations. Firstly, the heterogeneity present in the both the exercise interventions and in the trial participants may have impacted the results. The exercise interventions varied from 1.5 to 18 weeks in duration. It is possible that some of the time-frames were too short for a therapeutic effect. In addition, the sample could have been biased as the volunteers recruited by advertisement may have a heightened interest and commitment to the intervention. Secondly, while our sub group analysis was based on groupings from the ACSM guidelines and intended to be easily understood by clinicians, this arbitrary categorisation may have affected the results. Finally the evaluation of pain as the only outcome measure may be underestimating the effect of the exercise intervention. A number of researchers[76,77] have noted that low back pain has a wide range of personal and societal impacts that are not always adequately captured by traditional pain and symptom measurement tools. They recommend that outcome measures in back pain research should be broadened to include related variables such as functional status, work disability, wellbeing and satisfaction with care. However, as the included trials did not report a standard set of outcome measures we were unable to assess the effect of exercise in these other domains.

Consistent with current evidence, our results indicate that there is significantly lower chronic low back pain with intervention groups using an exercise intervention compared to other treatments. Our exploratory subgroup analysis also revealed that exercise programs consisting of coordination or stabilisation and strength or resistance are effective in reducing chronic low back pain, and that cardiorespiratory and combined exercise programs showed no effect in reducing chronic low back pain. These exploratory findings may assist clinical decisions regarding recommendations for appropriate exercise strategies for patients with chronic low back pain.

Clinical messages

- Exercise has a beneficial effect on chronic low back pain when compared with other treatments.
- Our results suggest programs consisting of coordination/stabilisation and strength/resistance exercises have a small but significant effect on reducing low back pain.
- Based on current evidence cardiorespiratory exercise has no effect on reducing low back pain

Conflict of interest

The authors declare that there is no conflict of interest.

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