Summarizing the Effects of Different Exercise Types in Chronic Low Back Pain – A Systematic Review of Systematic Reviews

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Abstract

Background

Recently, a review of reviews concluded that exercise therapy of any type makes no difference to the effect on pain or disability in adult patients with acute low back pain (LBP). Whether this is also the case for exercise therapy in chronic LBP is still unknown.

Objectives

To summarize and synthesize systematic reviews (SR) and meta-analyses (MA) investigating the effects on pain and disability of common exercise types used in chronic LBP.

Methods

We included systematic reviews from several databases in which ≥ 75% of the studies were RCTs on adults between 18 and 70 years of age suffering from chronic or recurrent LBP for a period of at least 12 weeks. These were grouped into nine exercise types: *Aerobic training*, *Aquatic exercises*, *Motor control exercises (MCE)*, *Resistance training*, *Pilates*, *Sling exercises*, *Traditional Chinese Exercises (TCE)*, *Walking*, and *Yoga*. The study quality was assessed with AMSTAR-2. For each type of exercise, a narrative analysis was performed, and the levels of evidence for the effects of exercise were assessed through GRADE.

Results

The wide search resulted in 2,345 studies, and out of the 246 full texts that were screened, 41 SR/MA were included. Of these, 10 SR/MA were of high quality, 15 of moderate, 14 of low, and two of critically low quality. We found low to moderate evidence of mainly short-term and small beneficial effects on pain and disability for *MCE*, *Resistance training*, *Pilates*, *TCE*, and *Yoga* compared to no intervention. Few reviews were found for *Aerobic*, *Aquatic*, *Sling*, and *Walking exercises*, but with promising results. Aquatic exercises seem to be more beneficial compared to land exercises (low level of evidence).

Conclusions

In line with previous studies but in a broader perspective, this systematic review of reviews showed that there is low to moderate evidence that exercises are effective for reducing pain and disability compared to no or minimal interventions, but that no exercise type is more effective than other conservative interventions (very low to moderate evidence).

Systematic review registration number

PROSPERO: https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=190409

Introduction

Low back pain (LBP) continues to be the number one disorder with most years lived with disability, meaning huge personal suffering and high socioeconomical costs (1–3). Up to 85% of all people will, at some time during their lifespan, experience LBP, and for most, the pain will subside within a couple of weeks (4). Low back pain is common in all ages, from younger to older, and is also one of the most common reasons to seek primary care (4, 5). The etiology for LBP is mostly non-specific; however, LBP is a complex disorder affected by physical and psychosocial, as well as psychological factors (3). Guideline-endorsed treatment in persistent LBP is to stay active, to return to normal activity and to exercise (6). Exercise therapy is commonly recommended to treat chronic LBP; it is an intervention that is reportedly moderately effective in reducing pain and disability (7, 8) and is, in addition, cost effective (9). Overall, exercise has recently been proposed as a polypill to prevent and/or treat almost every chronic disease, with obvious benefits such as its low cost and almost lack of adverse effects (10). In addition, new recommendations from WHO state the importance of regular physical activity for all (11).

Exercise therapy is defined as “a regimen or plan of physical activities designed and prescribed for specific therapeutic goals, with the purpose to restore normal musculoskeletal function or to reduce pain caused by diseases or injuries” (12). People with LBP seeking primary care are prescribed various training and exercise programs by, for example physiotherapists (5, 13). However, based on what rationale a specific exercise type is chosen for the individual patient suffering from LBP, has hitherto been unclear in clinical practice. Additionally, todate, there is no solid evidence that one exercise type is more effective in improving pain and disability in LBP than another (14).

The effect of physical activity or exercises in LBP have various explanations, of which exercise-induced hypoalgesia is one (15, 16). This could be the case with aerobic exercises and with, for example, strengthening training of large muscle groups (15, 17). Other exercise types, such as motor control exercises (MCE) (18) and Pilates (19), aim to increase the stability and robustness of the lumbar spine, to improve the posture, or to affect the motor control of the spinal stabilizing muscles, while Yoga (20) aims to increase physical and mental relaxation, including improved flexibility and muscular strength. A recent review summarized which rationales the various exercise interventions in LBP are based on; neuromuscular and psychosocial mechanisms were proposed most often, whereas neurophysiological, cardiometabolic, and tissue healing mechanisms were proposed less often (21).

Since 2005, several systematic reviews and meta-analyses on the effectiveness of various exercise types prescribed in LBP have been published and presented with various levels of risk of bias (8, 14, 18–20, 22–24). The reviews report all in all small effect sizes comparing exercises to various non-pharmacological interventions. In addition, a recent individual participant data (IPD) meta-analysis, presenting data from 27 randomized controlled trials on the effect of exercises in LBP, concluded that exercise therapy was minimally effective for chronic non-specific LBP outcomes (25). It also reported that individuals using medication for LBP, and fr those with no heavy physical demands at work, may benefit more from exercise compared with other treatments (25).

Recently a review of review of exercise therapies used in acute LBP was published and concluded that there is very low-to-moderate evidence that exercise therapy of any type results in any important difference in pain or disability in adult patients with acute LBP (26). Whether this is also the case in exercise types used and prescribed in chronic LBP has not, to the best of our knowledge, been investigated in a review of reviews. The evidence to date is regarding whether one exercise type used in chronic or persistent LBP is more effective than another is low or non-existent. We therefore aimed to summarize and synthesize systematic reviews (SR) and meta-analyses (MA) of the effects on pain and disability of common exercise types used in chronic LBP.

Material And Methods

We conducted this systematic review of systematic reviews (SRs) according to a protocol registered in PROSPERO (CRD46146), available at: https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=190409 using the methods as proposed by the Cochrane Collaboration's recommendations for conducting an overview of systematic reviews (27), and the PRISMA checklist (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) is presented in APPENDIX 1.

Eligibility criteria

Included were systematic reviews of randomized controlled trials and meta-analyses, in which the effect of exercise therapy, training, or rehabilitation is studied as the main (single) intervention. We set a cut-off that at least 75% of the included studies must have an RCT design. We included systematic reviews in which ≥ 75% of the studies were performed on adults between 18 and 70 years of age who suffered from chronic or recurrent unspecific LBP for a period of at least 12 weeks. The interventions of interest were different types of exercise treatment, but we excluded reviews on multimodal/multi or interdisciplinary rehabilitation, back schools, general physical activity recommendations, and occupational physical activity (graded activity), and reviews in which exercise was used as a complementary intervention. Excluded were patients with specific LBP, pelvic pain, pregnancy-caused, malign or systematic-caused pain, fractures, rheumatologic-caused, wide-spread chronic pain, multiple sclerosis or other neurologic diseases and neuropathic illnesses, pain in the thoracic or cervical regions, or LBP due to psychiatric diagnoses. Our primary outcomes were pain and disability, but in our initial literature search we did not exclude on outcome. However, studies on outcomes not relevant for the patient, such as health economics, were excluded in a later stage. The literature search was performed in English. No language restrictions were used, and neither were studies excluded on treatment duration, frequency or intensity, control group intervention, or year of publication.

Search

Together with a medical librarian we (authors WG and ERB) developed a comprehensive search strategy based on earlier published search strategies in Cochrane Reviews regarding exercise therapy and low back pain in the following databases: OVID MEDLINE, EMBASE, COCHRANE LIBRARY and WEB OF SCIENCE Core collection. We combined search terms and MESH terms in a search strategy developed for OVID MEDLINE and adapted this strategy for the other databases. Search strategies are presented in APPENDIX 2. The search was performed on 28 January 2020. After removing all doublets, the papers were imported into RAYYAN QCRI (28). All papers were alphabetically divided over five teams with two reviewers each. The reviewer pairs screened titles and abstracts retrieved from the searches, independently from each other, and assessed these for eligibility against the predetermined inclusion criteria (PICOS). At this stage of the process, regular reviewer meetings were held to reach consensus. All titles and abstracts meeting the inclusion criteria were retrieved in full text. In each pair, both reviewers checked independently the full text articles to assess eligibility for the final inclusion in this review. Reasons for exclusion were noted in this stage, and if more than one reason for exclusion was available, the study was excluded in PICO-order; i.e. a paper with wrong intervention, wrong publication type, and wrong population was classified only as excluded based on population. We scrutinized the reference lists of the included systematic reviews for additional potentially relevant studies.

Overlap

We calculated total overlap (studies in included reviews) for each type of exercise therapy independent on outcome, following the formula proposed by Pieper et al. (29). We presented overlap with percentage of corrected covered area (CCA). Interpretation of CCA: 0–5% = slight overlap, 6–10% = moderate overlap, 11–15% = high overlap, and > 15 = very high overlap.

Assessment of methodological quality of included reviews

The updated valid and reliable tool, AMSTAR-2 (A MeaSurement Tool to Assess systematic Reviews) is recommended to assess methodological quality of SRs and MAs (30). The study quality was categorized into four levels, based on all the 16 AMSTAR-2 items: critically low (1–4), low (5–8), moderate (9–12), and high (13–16), depending on the number of fulfilled criteria. Each "Yes" was given 1 point, while each "Partial yes" was given 0.5 points. Before the actual assessment started, a pilot test was carried out on one specific paper in which each reviewer learned how to use AMSTAR-2. The two reviewers from each of the five pairs performed, independently, their assessments and compared these with each other. Disagreements in the assessments were handled in a consensus dialogue after comparing discrepancies between assessors, and discussed in the total group, guided by WG and ERB.

Data extraction and synthesis

One reviewer per pair extracted data from the included reviews and the other reviewer from the same pair checked the extraction for accuracy. We extracted the data into a data extraction form, adapted from a Cochrane form (27). We extracted data primarily at the systematic review level, but if necessary, the original RCTs were checked for further details. The data were synthesized by presenting PICO. The results of each included systematic review were separated on the primary outcomes, pain and disability, if possible. We did not perform a meta-analysis, since clinical homogeneity was not present due to the large variation in exercise dosages, combinations of interventions, differences between the studies in controls groups as well as outcome measures, and follow-up times.

Assessment of certainty of evidence

We used the GRADE approach (47) to evaluate certainty of the level of evidence for each exercise type and primary outcomes. In this systematic review, we used the conclusions by the authors as the main source, but we also checked if the results were statistically significant compared to a control intervention. When possible, we also used the established minimal important difference (MID) as a specified threshold in our evaluation of the level of evidence. In short, the first step of GRADE is to choose the start point of the level of evidence, and since we included (mostly) RCTs we decided to set this at the highest level. Thereafter, we lowered this level of evidence by appraising the potential limitations due to study limitations (high risk of bias/AMSTAR points), inconsistency (in results), imprecision (large confidence intervals, heterogeneity), indirectness (poor measurement quality), and publication bias. The level was increased if large effects or a "dose-response" were seen based on the reports of the systematic reviews. We did not include residual confounding factors for upgrading, due to the inclusion criteria to include mainly RCTs. In this way, we express our findings together with the confidence on the results, using four levels of evidence: "high" (++++), "moderate" (+++), "low" (++) or "very low (+) (31).

Results

The search results are summarized in Fig. 1. The literature search returned a total of 2,345 studies. Following removal based on duplicates, a review of title and abstracts (n = 1654) was performed, and 246 full texts were screened. After checking against our inclusion and exclusion criteria, we included in total 41 publications in the final review. A list of excluded studies and reasons is included in APPENDIX 3.

Except for *resistance training* (CCA 4%), in all exercise types with more than one review included, there was a high or very high overlap of the included studies (*walking:* CCA 38%).

Summary results

The narrative analyses of included SRs/MAs showed large effects when comparing the exercise interventions with minimal or no intervention and are summarized in table 2. For most exercise types, there were no differences when different exercise types were compared with each other. Mostly small or non-significant effects on pain and disability were found in favour of the various exercise types compared with other control interventions, such as usual care. We found low to moderate evidence that any exercise type is effective for reducing pain and disability compared to no or minimal intervention, but that no exercise type is more effective than another.

a) Aerobic exercise

Aerobic exercises aim to improve the efficiency and capacity of the cardiorespiratory system (70). Our search resulted in one meta-analysis on the effects of *aerobic exercise* which covered a literature search up to March 2016 and included six studies with 333 subjects (36). The methodological quality varied across the studies. The review reached 13 points on AMSTAR-2 and was rated as having high quality (Table 1). Aerobic exercise was compared to resistance training, or combined aerobic and resistance training versus exercise advice, maintained normal activity, or waiting list (APPENDIX 4).

The results showed that *aerobic exercise* reduced pain, although neither aerobic nor resistance training proved to be superior to the other (Table 3a). No significant differences were reported for disability.

The GRADE analysis showed moderate quality evidence that *aerobic exercise* is as effective for the reduction of pain and disability compared to resistance training (Table 4). We downgraded due to possible publication bias, since only one review was identified.

b) Aquatic exercise

Aquatic exercises are any exercises performed in water, such as running, active range of motion, or strengthening (50). The literature search identified only one SR about the effectiveness of aquatic exercises, compared to land-based or no exercises (50). The review included eight RCTs with a total of 311 participants (Table 3b). The review was published in 2018, conducted its search in November 2016, and included a meta-analysis. The included RCTs were of moderate to high quality. The review reached 9 out of 16 points on AMSTAR-2, indicating moderate quality (Table 1). The reasoning of the study design was not reported, no list of excluded studies was provided, no reporting of funding, and RoB was not considered in the MA.

The MA found a statistically significant, but clinically questionable, reduction in pain and disability in patients treated with *aquatic therapy* compared to patients treated with land-based therapy (Table 3b). No information about the time point of outcome reporting was provided (APPENDIX 4).

The GRADE analysis showed that there is low quality evidence that *aerobic exercise* is superior in reduction of pain and disability compared to land-based exercise (Table 4). The evidence was downgraded due to study limitations and possible publication bias, since only one review was identified.

c) Motor control exercises

Motor control exercises aim to restore the neuromuscular control of the muscles stabilizing the spine, and are graded from low load exercises into activation during functional exercises and activities (71). We included 11 reviews (18, 35, 40, 42, 45, 46, 48, 55-57, 65) on *motor control exercises* (MCE), including one review on *movement control exercises* (45). All but one (57) had conducted a meta-analysis. The publication year ranged from 2008 to 2020 and the last updated search was October 2018 (48). The reviews included between four to 34 low to high quality RCT's and included between 209 to 2514 participants. There was a high overlap of the included studies (CCA 14%). AMSTAR-2 ranged from 4 to 16 points out of 16 (Table 1). Only two of the reviews were rated with an overall high quality (18, 35). Several of the reviews reported "nearly yes" on the item "presenting a protocol", and most of the reviews reported a "No" on items "presenting a list of the excluded studies" and "presenting the source of funding and conflicts of interest".

The reviews reported outcomes of pain and disability in the short, intermediate and long-term (Table 3c). Control interventions were general exercises (GE), spinal manual therapy (MT), multimodal treatment (MMT), or information/minimal intervention/usual care (MI) (APPENDIX 4). The narrative synthesis on pain in the included reviews showed a small but non-significant effect for *motor control exercises* over general exercises in some of the reviews mainly in the short and intermediate term (18, 35, 40, 42, 55, 56, 65). Compared to manual therapy, none of the nine reviews presented any results on differences to *motor control exercises* for pain (18, 35, 40, 42, 45, 46, 55, 56, 72). Four reviews, however, reported significant and clinically relevant results showing that *motor control exercises* were more effective in short, intermediate and long-term compared to minimal intervention (18, 40, 46, 55).

The narrative synthesis on disability in the included reviews showed a small but nonsignificant effect for *motor control exercises* over general exercises (18, 35, 40, 42, 46, 55, 65), while Niederer et al. (2020) presented results of no difference at any time points (48). *Motor control exercises* showed small and non-clinically relevant results compared to manual therapy in two reviews (40, 46). Compared to minimal intervention *motor control exercises* showed significant and clinically significant differences in the short (18, 40, 55), intermediate (18, 40, 46, 55), and long-term (18, 40).

The GRADE analyses showed that there is a moderate level of evidence on the effect of *motor control exercises* on pain compared to minimal intervention, and a low level of evidence that there is an effect on disability (Table 4). Downgrading was based on the inconsistency of the results, and for disability also on imprecision due to significant heterogeneity.

d) Resistance training

Resistance training includes exercises to improve the strength, power, endurance and size of skeletal muscles (70). The interventions included resistance training, back muscle training and medical training therapy. We included three SR's on the effect of *resistance training* (66, 67, 69), but none conducted a meta-analysis. Publication year ranged from 2001 to 2012 and the last updated search was performed in April 2010. In one review, only two RCTs were included (67), while the other two reviews included 12 and seven RCTs, respectively, with a small overlap (CCA 4%) (66, 69). Two reviews reported moderate to high quality of the included RCTs (66, 67), while one review did not report on study quality (69). AMSTAR-2 scores were very low and ranged from 1.5 to 5, indicating critically low, and low-quality reviews (Table 1). *Resistance training* was compared with passive treatments, fitness training, no treatment placebo, or cognitive interventions (APPENDIX 4).

All included reviews reported on decreased pain scores in the included studies compared to passive or no intervention (66, 67), but it was unclear if the effect was clinically relevant or what time-period was used. One review found no difference compared to a cognitive behavioural intervention, and the effect disappeared at the long-term follow-up (67), while another review reported no difference in pain scores when compared to fitness training (66) (Table 3d). *Resistance training* was found effective for the reduction of disability in all reviews compared to passive or no intervention in one review (66), but it was unclear what comparison groups were used in the other two (67, 69) (Table 2d).

The GRADE analyses showed that there was a very low level of evidence that *resistance training* has positive effects on pain and disability, but not compared to fitness training and cognitive behavioural intervention (Table 4). The level of evidence was downgraded due to low study quality, inconsistency, imprecision, and an increased risk of publication bias.

e) Pilates

Pilates exercises follow the traditional Pilates principles such as centring, concentration, control, precision, flow and breathing (52).The literature search resulted in nine systematic reviews (19, 32, 39, 44, 47, 52, 61, 62, 64), of which five had performed an MA on the effect of *Pilates* (19, 32, 44, 47, 62). The reviews included between four to 14 RCTs, published between 2005 and 2016, and included between 134 (62) to 708 participants (39). There was a very high overlap of the included studies (CCA 32%). Publication years ranged from 2011 (44, 64) to 2018 (39); the last updated search was April 2016 (39). The studies included in the reviews were graded with different types of quality scores and were rated as being of moderate quality, with some exceptions to both low and high quality. The study quality ranged from low, 7 points (64) to 16 points (19) out of 16 points of AMSTER-2 (Table 1). Most of the reviews did not present the source of funding or conflict of interest (Item 10). All studies with MAs significant large heterogeneity. The intervention dosage varied greatly between the studies, and due to poor reporting, it was impossible to summarize a typical exercise duration, frequency, or intensity. The control interventions also varied greatly between the different studies, and contained treatments such as other exercise types, McKenzie, massage, back school programs, or information/minimal intervention/usual care (APPENDIX 4).

The narrative synthesis on the outcome pain showed significant (but mostly small) effects for *Pilates* over no or minimal intervention in eight reviews (19, 32, 39, 44, 47, 52, 61, 64). In all included reviews there were no differences compared to other types of exercises, except for one review that found a superiority for *Pilates exercises* compared to physical activity (52). Similar results were found in the narrative synthesis on disability. Six of the included reviews reported on non-significant effects for *Pilates* over minimal intervention (19, 39, 47, 52, 61, 64), and the majority of the reviews pointed out that *Pilates exercises* were as effective compared to other types of exercises, mainly with short-time effects (Table 3e). Most outcomes were of short or intermediate term and most often the effect was lower than the recommended minimal clinical important difference (MCID) for pain and disability measures.

The GRADE analyses showed a moderate level of evidence on the short-term effects of *Pilates* compared to minimal intervention and no effect if compared with other types of exercise concerning pain (Table 4). For disability, the level of evidence was low for this comparison. For both pain and disability, the evidence was downgraded due to the low and moderate quality of most of the reviews. Moreover, an additional down-grading for disability was added, since the results were conflicting concerning the conclusion on the effectiveness of *Pilates* over minimal interventions.

f) Sling exercises

Sling exercises use slings and elastic bands to offset body weight and progress the exercises without pain (73). We found two systematic reviews on the effect of *sling exercises* (37, 60) including one meta-analysis (37). In total, 16 studies were included, but there was a very high overlap between the two reviews (CCA 23%). The last updated search in the systematic review was August 2013. The methodological quality of the included studies according to PEDro assessments was moderate and low. The AMSTAR-2 ratings for these two studies was 8 (60) and 14 points (37), indicating low and high quality studies, respectively (Table 1). The interventions in both reviews were primarily sling exercise based; however, the *sling exercises* were also combined with e.g. passive modalities and with other kind of exercises, back school, contemporary treatment, and drugs. The control groups received other forms of exercise, passive modalities, manipulation, contemporary treatment, and drugs (APPENDIX 4).

The narrative analyses of the reviews showed that *sling exercises* are no more effective in reducing pain or improving disability compared with other types of exercise (Table 3f). However, in comparison to passive modalities or the combination of physical agents and drug therapy, *sling exercises* were more effective in decreasing pain and improving disability, but only sling exercise vs thermomagnetic therapy showed clinically relevant differences between the groups in favour of *sling exercise*. In addition, *sling exercises* were found to be not more effective compared to traditional Chinese medical therapies (37). *Sling exercises* in addition to acupuncture therapy were as effective as acupuncture therapy alone for reduction of pain and improvement of disability.

The GRADE analyses showed that there is moderate and low level of evidence for short-term and long-term effects on pain and disability, respectively, for *sling exercises* over thermomagnetic therapy; however, the evidence is only based on two RCTs (Table 4). We downgraded due to lack of precision and, for disability, also for inconsistency of the results.

g) Traditional Chinese Exercises (Tai chi/Qigong)

Tai chi and Qigong, two common types of traditional Chinese mind-body techniques, also referred to as *Traditional Chinese Exercises* (TCE), include low to moderate intensity exercises coordinated with slow body movement and focus on physical- mental connection (38). Two reviews were identified evaluating the efficacy of Tai Chi and Qigong, and both performed a meta-analysis. Included were 10-11 RCT's published between 2008 and 2019, and the total sample size ranged between 886 and 959 participants. There was a high overlap of the studies investigating *Traditional Chinese Exercises* (CCA 13%). The studies included in the reviews were rated as having fair to good quality. The risk of bias was assessed to 11.5 and 13 out of 16 AMSTAR-2 points, indicating moderate to high quality (Table 1). Both reviews compared the efficacy of either Tai Chi or various types of Qigong (Wuqinxi, Baduanjin, Liuzijue) to either no treatment, active treatment (strength exercise, backwards walking, or other physiotherapy), or usual care, with or without the experimental component (APPENDIX 4).

The narrative synthesis on pain showed small to moderate effects for *Traditional Chinese Exercises* over no treatment, active treatment, or usual care only. Subgroup analyses revealed a larger effect when Tai Chi was compared to no treatment, than to active control interventions or to routine care (without an added Tai Chi component) (Table 3g). Only short-term effects seem to have been evaluated, but exact follow-up time was not reported. The synthesis on disability showed a variability in effect, from small to large effect for *Traditional Chinese Exercises* over no treatment, active treatment or usual care only (Table 3g). In both systematic reviews, the effects differed depending on outcome measure used (38, 49).

The GRADE analyses for pain showed a moderate level of evidence concerning pain and a low level of evidence for disability on the short-term effects of *Traditional Chinese Exercises* compared to no intervention (passive control), various active treatments or usual care in chronic LBP patients concerning pain (Table 4). The evidence was downgraded for imprecision due to heterogeneity (pain, disability) and additionally due to large confidence intervals of the effects (disability).

h) Walking

Walking interventions use outdoor walking (with or without supervision), treadmill walking, and/or Nordic walking as therapeutic programs in chronic LBP (51). The literature search identified three systematic reviews (34, 43, 51) of the effectiveness of *walking* interventions, two of which performed a meta-analysis (34, 51). The reviews included five to nine studies with 329 to 869 participants with a very high overlap of the studies (CAA 37.5%). The reviews were published between 2016 and 2019, with the last updated search up in October 2017 (34). The quality of the included studies was low (43) to high (34). Two reviews achieved 10.5 out of 16 AMSTAR-2 points, indicating moderate quality (43, 51), and one achieved 15 out of 16 AMSTAR-2 points, indicating high quality (34). Two reviews (43, 51) did not report excluded studies, the source of funding, and did not investigate the impact of study quality on summary estimates (Table 1). All reviews compared the effectiveness of *walking* interventions (overland and/or treadmill, and/or Nordic walking) to non-pharmacological interventions (e.g. other types of exercise, physical therapy, education), and two additionally compared walking and exercise to exercise alone (34, 51) (APPENDIX 4).

Both the meta-analyses (34, 51) for either pain or disability and the SR (43) for disability found no significant differences between *walking* and the comparison groups that received other interventions (Table 3-H). Neither did adding walking to the comparison groups induce a statistical improvement.

The GRADE analysis showed that there is a low quality of evidence that *walking* is as effective as other non-pharmacological interventions for pain and disability improvement in chronic LBP patients, and adding walking to exercise does not increase effectiveness (Table 4). The evidence was downgraded due to study limitations and for imprecision due to large confidence intervals of the effect, and a large overlap of the reviews.

i) Yoga

Yoga exercises follow the traditional Yoga principles with a physical component (41). We included nine systematic reviews on *Yoga* (20, 33, 41, 53, 54, 58, 59, 63, 68). Five out of nine conducted a meta-analysis (20, 33, 41, 53, 59). The reviews included between four to 14 RCTs and 403 to 1444 participants, with a very high overlap (CCA 28%). The publication year ranged from 2011 (63) to 2019 (53), and the last updated search was in 2018 (53). The included studies were graded with varied quality. The study quality ranged from 3 (68) to 16 points (20) on AMSTAR-2 (Table 1). Only two reviews were rated as having high quality (20, 33). Only one study presented a list of the excluded studies (20). The *Yoga* interventions were highly heterogenous, not only in terms of which kind of *Yoga* was used, but also in the length, frequency, and intensity of the sessions. Some interventions were combined with other physical therapy modalities, with book readings or usual treatments. There were no clear manuals or protocols that described the *Yoga* interventions. The control interventions were treatment such as physical therapy, waitlist control, stabilizing exercise and physical therapy, conventional exercise therapy, usual care, educational control group, and self-directed medical care (APPENDIX 4).

The narrative synthesis on both pain intensity and disability in the included reviews showed a short-term effect for *Yoga*, especially compared to no or minimal intervention, but also compared to general exercises. Three MAs showed medium, and medium-to-large effects, indicating that the effects of *Yoga* may be of clinical importance (33, 41, 59). However, the long-term effects did not seem to demonstrate better effects than usual care (Table 3i).

The Grade analyses showed a low level of evidence for a short-term effect in pain and disability for *Yoga* over general exercises; however, the long-term effects did not seem to demonstrate better effects than usual care or compared to usual care or compared to other types of exercises (Table 4). We downgraded due to large heterogeneity between the studies and inconsistent results. Although the risk of bias was high in most of the reviews, two reviews had low risk of bias (16 points); hence we decided not to downgrade due to study limitations.

Discussion

We aimed to summarize and synthesise systematic reviews and meta-analyses of the effects on pain and disability of common exercise types used in chronic LBP treatment. All in all, we included 41 reviews on various exercise types in chronic LBP and based on data searches up until November 2018. We found low to moderate evidence that participating in any exercise type is effective for reducing pain and disability compared to no or minimal intervention, but that no exercise type is more effective than another (very low to moderate evidence).

The results from this review of reviews are mainly in keeping with previously published reviews on the effects of exercise in chronic LBP, adding to the existing evidence and that no type of exercise seems to have a better effect over another (8, 14, 23, 24). Overall, exercises seem to have a better effect on pain and disability than minimal intervention or usual care, but show no difference compared to other non-pharmacological interventions. This seems to be true in both the short and long-term. A Cochrane review on exercises in several chronic musculoskeletal disorders concluded that physical activity and exercise is an intervention with few adverse events that may improve pain and physical function, and consequently quality of life (14). Geenen et al. (2017), further concluded that the quality of evidence on included studies is low, and that future studies should focus on increasing participant numbers and lengthening both the intervention itself and the follow-up period (14). In addition, Hayden et al. (2005) summarized in a Cochrane review including 61 studies, that exercise therapy seems to be slightly effective at decreasing pain and improving function in adults with chronic LBP, concurring with our study findings (8). Five years later, Van Middelkoop et al. (2010) reviewed studies on exercises in chronic LBP also concluded that no evidence exists that one exercise type is more effective than others, and that it remains unclear which subgroups of patients benefit most from a specific type of treatment (24). However, recently, a network analysis of the effectiveness of exercises in LBP suggested that there is low quality evidence that Pilates, MCE, resistance training and aerobic exercises are the most effective treatments (23). The authors compared various types of common exercises with no or minimal interventions and their results are partly in line with ours. In addition, our review included results on less studied exercise types such as aquatic training, walking, Traditional Chinese Exercises, and sling exercises, which all also showed consistency with previous results that no exercise type seems to be more beneficial than another.

Apparently, some exercise types prescribed in chronic LBP are more studied than others. There has obviously been a research focus on MCE, Pilates and Yoga, based on the number of published reviews we found in our data base searches (MCE n = 11; Pilates n = 9; Yoga n = 9) compared to the other exercise types included in our study. Eleven reviews showed mainly consistent results that MCE is as effective as manual therapy regarding pain and disability, and showed overall statistically significant but clinically not relevant findings that MCE is more effective than general exercise. However, in comparison with minimal intervention, our results showed a clinically important difference. As most of the included reviews showed small effects for MCE in comparison with other interventions on pain and disability, we suggest – based on our findings – that no future studies will change the current evidence. However, Saragiotti et al. (2016) (18) suggested that there might be sub-groups in LBP for which MCE might be more beneficial. This might, of course, be the case regarding all exercise types. For Pilates, there was low to moderate evidence that it is no better than other exercises, however better it is than minimal interventions; small effect sizes were found. Pilates and MCE might be comparable as exercise types but differ in that MCE seems to be more often supervised and also performed as a graded program, starting with low load and specific exercises. Hayden et al (74) concluded that exercise therapy that consists of individually designed programs, and is delivered with supervision may improve pain and function in chronic nonspecific LBP. Moreover, adherence to exercise programs has been shown to be highly correlated with positive outcomes (74, 75). We did not, however, summarize adherence to exercises or if a program was performed individually or in group. This might be of value for future reviews. Sling exercises is also an exercise type that aims to stabilize the spine and the results for this type of exercise are consistent with previous literature.

Yoga showed some effects compared to general exercises in the short and long-term. Yoga is an exercise that also includes breathing training and covers mental aspects, which probably affects several systems in the mind and body (20). As the included Yoga interventions were heterogenous in terms not only of what type of Yoga was used, but also in length, frequency and intensity of the sessions, specific evidence is hard to establish.

For some exercise types, such as resistance training, we found few, and mainly older systematic reviews, perhaps because the trend in how to exercise in LBP has affected the number of studies. Three reviews published between 2010 and 2012 (66, 67, 69), showed that there is very low evidence that resistance training is no more effective than other interventions. To use and to investigate more loaded training in chronic LBP has seemingly not been on the research agenda over the last decade; however, recently, a new interest in studying loaded exercise in LBP seems to have appeared (76, 77), perhaps as a reaction to two decades of study interest in low load exercises such as MCE.

For walking, aerobic, aquatic, and Traditional Chinese Exercises we found only few reviews. Walking was investigated in three systematic reviews and showed a moderate certainty evidence of no effect on pain and disability compared to other exercises or physiotherapy. This was also the case with aerobic exercises only investigated in one review (36). For aquatic exercises, the only review showed a pain reduction in the intervention group compared to the comparison group performing land-based or no exercises, but with low quality evidence and questionable clinical relevance (50). In Chinese Traditional Exercises, two MAs showed that these are more effective than no treatment, but only short-term effects were found. In our review, we chose to analyse these exercise types, while other reviews have compiled them into wider categories, i.e. walking could also be seen as an aerobe exercise intervention (23). We believe that in future research, one should keep these exercise types separate in order to be able to establish the level of evidence for specific exercise types.

To date, exercises are suggested by most clinical guidelines in chronic LBP and commonly used, but with no clear recommendation for one type of exercise over another (6, 78–80). Instead, it is recommended that exercise be prescribed based on patient preference and clinician experience (6). This broad recommendation probably reflects uncertainty about the mechanism(s) through which exercise yields positive effects on pain and function (21). It could also be that physiotherapists prescribing exercise programs have different preferences for specific exercise types based on education and interest, or non-awareness of clinical guidelines (81). To decide on what exercise should be chosen for an individual patient suffering from chronic LBP, the patient should be included in the decision-making process. Gardner et al (82) propose better goal setting in chronic LBP patients to determine treatment interventions that are driven by patient preference. Thus, our research might increase the current knowledge of effectiveness of various exercise types.

Strengths and limitations

A strength of our study is that, to our knowledge, this is the first review of reviews on various types of exercise used for treatment of chronic LBP, including exercise types that have not been studied in this way previously. We did not limit our search but included reviews in all languages without any restrictions on publishing year or comparators. Furthermore, we followed and complied with the PRISMA guidelines, and graded the study quality using the recommended instrument AMSTAR-2 (30), and summarized the graded evidence of the different exercise types. Two-thirds of the included reviews were of moderate to high quality, and 12 studies were assessed as having a critically low or low quality. Still, the evidence for the included reviews was mostly downgraded due to study limitations, and further high-quality reviews are therefore warranted. Our study is a collaboration of 10 researchers, which brings both advantages and disadvantages. We worked in pairs to include the reviews, to draw the data to the tables, and to assess the RoB. A third arbitrary party was always used when no consensus could be reached. This procedure was necessary in order to manage the enormous number of studies, and of course could have led to differences in how the various exercise types were judged. However, wesolved this by changing the pairs so that in all the processes more or less four researchers were involved in the studying and extracting of data for each exercise type. There are other limitations that need to be discussed, such as inclusion bias, since we might have missed some important reviews to include in our database search. However, the data basesearches were conducted using relevant search strategies in several databases by a librarian from the Karolinska Institutet. Moreover, the reference lists of the included reviews were studied for additional reviews to include. A publication bias might be that we did not perform any further search of the grey literature on, for example, web pages. We still consider that we found most relevant literature in our searches. We thus considered that additional reviews would probably not have changed our main findings to a large extent.

The results are based on several reviews and meta-analyses with a high or very high overlap of included studies. Overlap could be a problem if one study that is included in all reviews drives the results in the review in one direction. This could have been the case in the reviews of Yoga and Pilates, where one high-qualitative study with beneficial results was included in all reviews and might have affected the overall results (83, 84). It might be discussed whether a review of reviews is the best way to summarize the evidence as the results from a review of reviews summarize and mirror the risk of bias in all of the included reviews. Might it be more relevant to include all studies in one large review instead, to cope with problems such as overlap? Such a network review on chronic low back pain was recently published by Owen et al. (2020), including 89 studies. However, to conduct a review of review is a more feasible way to, in one large publication, summarize the existing evidence on the effectiveness of various and specific exercise types used and prescribed in chronic LBP.

Clinical and future perspectives

Exercise is recommended in most guidelines (6, 11). Our study findings showed that all nine exercise types could be as useful as each other in rehabilitation of chronic low back pain. Since no exercise type shows any better effect than any other the choice of exercise type should therefore be based on patient preference. Patient preference has been reported to have an even better effect on pain and disability measures than following guidelines (85). In this review, the primary outcomes studied were pain and disability. Further studies should therefore incorporate other outcomes that reflect additional effects of exercise, e.g. fear-avoidance, quality of life, pain catastrophizing. Moreover, the choice of outcome should also be more specifically related to the goals of the exercises. For some exercise types, such as aquatic and sling exercises, more high-quality research is warranted, but for others, such as MCE there is a need for specifically analyzing different sub-groups.

Conclusion

Looking at exercise from a broad perspective, we found low to moderate evidence that participating in any exercise type is effective for reducing pain and disability compared to no or minimal intervention, but that no exercise type is more effective than another (very low to moderate evidence).

Declarations

***Ethics approval and consent to participate**:* N/A

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References

1. Hoy D, March L, Brooks P, Woolf A, Blyth F, Vos T, et al. Measuring the global burden of low back pain. Best Pract Res Clin Rheumatol. 2010;24(2):155-65.
2. GBD 2015 Disease and Injury Incidence and Prevalence Collaborators. Global, regional, and national incidence, prevalence, and years lived with disability for 310 diseases and injuries, 1990-2015: a systematic analysis for the Global Burden of Disease Study 2015. Lancet. 2016;388(10053):1545-602.
3. Hartvigsen J, Hancock MJ, Kongsted A, Louw Q, Ferreira ML, Genevay S, et al. What low back pain is and why we need to pay attention. Lancet. 2018;391(10137):2356-67.
4. Balague F, Mannion AF, Pellise F, Cedraschi C. Non-specific low back pain. Lancet. 2012;379(9814):482-91.
5. Jordan KP, Kadam UT, Hayward R, Porcheret M, Young C, Croft P. Annual consultation prevalence of regional musculoskeletal problems in primary care: an observational study. BMC Musculoskelet Disord. 2010;11:144.
6. Oliveira CB, Maher CG, Pinto RZ, Traeger AC, Lin CC, Chenot JF, et al. Clinical practice guidelines for the management of non-specific low back pain in primary care: an updated overview. Eur Spine J. 2018;27(11):2791-803.
7. Chou R, Deyo R, Friedly J, Skelly A, Hashimoto R, Weimer M, et al. Nonpharmacologic Therapies for Low Back Pain: A Systematic Review for an American College of Physicians Clinical Practice Guideline. Ann Intern Med. 2017;166(7):493-505.
8. Hayden JA, van Tulder MW, Malmivaara A, Koes BW. Exercise therapy for treatment of non-specific low back pain. Cochrane Database Syst Rev. 2005(3):CD000335.
9. Miyamoto GC, Lin CC, Cabral CMN, van Dongen JM, van Tulder MW. Cost-effectiveness of exercise therapy in the treatment of non-specific neck pain and low back pain: a systematic review with meta-analysis. Br J Sports Med. 2019;53(3):172-81.
10. Pareja-Galeano H, Garatachea N, Lucia A. Exercise as a Polypill for Chronic Diseases. Prog Mol Biol Transl Sci. 2015;135:497-526.
11. Bull FC, Al-Ansari SS, Biddle S, Borodulin K, Buman MP, Cardon G, et al. World Health Organization 2020 guidelines on physical activity and sedentary behaviour. Br J Sports Med. 2020;54(24):1451-62.
12. Exercise Therapy [Internet] 2021 [Available from: https://www.ncbi.nlm.nih.gov/mesh/?term=exercise+therapy.
13. Olafsson G, Jonsson E, Fritzell P, Hagg O, Borgstrom F. A health economic lifetime treatment pathway model for low back pain in Sweden. J Med Econ. 2017;20(12):1281-9.
14. Geneen LJ, Moore RA, Clarke C, Martin D, Colvin LA, Smith BH. Physical activity and exercise for chronic pain in adults: an overview of Cochrane Reviews. Cochrane Database Syst Rev. 2017;4:CD011279.
15. Rice D, Nijs J, Kosek E, Wideman T, Hasenbring MI, Koltyn K, et al. Exercise-Induced Hypoalgesia in Pain-Free and Chronic Pain Populations: State of the Art and Future Directions. J Pain. 2019;20(11):1249-66.
16. Vaegter HB, Jones MD. Exercise-induced hypoalgesia after acute and regular exercise: experimental and clinical manifestations and possible mechanisms in individuals with and without pain. Pain Rep. 2020;5(5):e823.
17. Vaegter HB, Lyng KD, Yttereng FW, Christensen MH, Sorensen MB, Graven-Nielsen T. Exercise-Induced Hypoalgesia After Isometric Wall Squat Exercise: A Test-Retest Reliabilty Study. Pain Med. 2019;20(1):129-37.
18. Saragiotto BT, Maher CG, Yamato TP, Costa LO, Menezes Costa LC, Ostelo RW, et al. Motor control exercise for chronic non-specific low-back pain. Cochrane Database Syst Rev. 2016(1):CD012004.
19. Yamato T, Maher C, Saragiotto B, Hancock M, Ostelo R, Cabral C, et al. Pilates for low back pain. Cochrane Database of Systematic Reviews. 2015(7).
20. Wieland LS, Skoetz N, Pilkington K, Vempati R, D'Adamo CR, Berman BM. Yoga treatment for chronic non-specific low back pain. Cochrane Database of Systematic Reviews. 2017;1:CD010671.
21. Wun A, Kollias P, Jeong H, Rizzo RR, Cashin AG, Bagg MK, et al. Why is exercise prescribed for people with chronic low back pain? A review of the mechanisms of benefit proposed by clinical trialists. Musculoskelet Sci Pract. 2020;51:102307.
22. Choi BK, Verbeek JH, Tam WW, Jiang JY. Exercises for prevention of recurrences of low-back pain. Cochrane Database Syst Rev. 2010(1):CD006555.
23. Owen PJ, Miller CT, Mundell NL, Verswijveren S, Tagliaferri SD, Brisby H, et al. Which specific modes of exercise training are most effective for treating low back pain? Network meta-analysis. Br J Sports Med. 2020;54(21):1279-87.

24. van Middelkoop M, Rubinstein SM, Verhagen AP, Ostelo RW, Koes BW, van Tulder MW. Exercise therapy for chronic nonspecific low-back pain. Best Pract Res Clin Rheumatol. 2010;24(2):193-204.
25. Hayden JA, Wilson MN, Stewart S, Cartwright JL, Smith AO, Riley RD, et al. Exercise treatment effect modifiers in persistent low back pain: an individual participant data meta-analysis of 3514 participants from 27 randomised controlled trials. Br J Sports Med. 2020;54(21):1277-8.
26. Karlsson M, Bergenheim A, Larsson MEH, Nordeman L, van Tulder M, Bernhardsson S. Effects of exercise therapy in patients with acute low back pain: a systematic review of systematic reviews. Syst Rev. 2020;9(1):182.
27. Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, et al. Cochrane Handbook for Systematic Reviews of Interventions version 6.1 (updated September 2020) 2020. Available from: www.training.cochrane.org/handbook.
28. Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan-a web and mobile app for systematic reviews. Syst Rev. 2016;5(1):210.
29. Pieper D, Antoine SL, Mathes T, Neugebauer EA, Eikermann M. Systematic review finds overlapping reviews were not mentioned in every other overview. J Clin Epidemiol. 2014;67(4):368-75.
30. Shea BJ, Reeves BC, Wells G, Thuku M, Hamel C, Moran J, et al. AMSTAR 2: a critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both. BMJ. 2017;358:j4008.
31. Schünemann H, Brozek J, Oxman Ae. GRADE handbook for grading quality of evidence and strength of recommendation. Version 3.2 [update Oct. 2013]. The GRADE Working Group, 2009. 2013 2021-03-03.
32. Aladro-Gonzalvo AR, Araya-Vargas GA, Machado-Diaz M, Salazar-Rojas W. Pilates-based exercise for persistent, non-specific low back pain and associated functional disability: a meta-analysis with meta-regression. Journal of Bodywork & Movement Therapies. 2013;17(1):125-36.
33. Bussing A, Ostermann T, Ludtke R, Michalsen A. Effects of yoga interventions on pain and pain-associated disability: a meta-analysis. Journal of Pain. 2012;13(1):1-9.
34. Sitthipornvorakul E, Klinsophon T, Sihawong R, Janwantanakul P. The effects of walking intervention in patients with chronic low back pain: A meta-analysis of randomized controlled trials. Musculoskeletal Science & Practice. 2018;34:38-46.
35. Smith BE, Littlewood C, May S. An update of stabilisation exercises for low back pain: a systematic review with meta-analysis. BMC Musculoskelet Disord. 2014;15:416.
36. Wewege MA, Booth J, Parmenter BJ. Aerobic vs. resistance exercise for chronic non-specific low back pain: A systematic review and meta-analysis. Journal of Back & Musculoskeletal Rehabilitation. 2018;31(5):889-99.
37. Yue YS, Wang XD, Xie B, Li ZH, Chen BL, Wang XQ, et al. Sling exercise for chronic low back pain: a systematic review and meta-analysis. PLoS One. 2014;9(6):e99307.
38. Zhang Y, Loprinzi PD, Yang L, Liu J, Liu S, Zou L. The Beneficial Effects of Traditional Chinese Exercises for Adults with Low Back Pain: A Meta-Analysis of Randomized Controlled Trials. Medicina. 2019;55(5):29.
39. Byrnes K, Wu PJ, Whillier S. Is Pilates an effective rehabilitation tool? A systematic review. Journal of Bodywork & Movement Therapies. 2018;22(1):192-202.
40. Bystrom MG, Rasmussen-Barr E, Grooten WJ. Motor control exercises reduces pain and disability in chronic and recurrent low back pain: a meta-analysis. Spine. 2013;38(6):E350-8.
41. Cramer H, Lauche R, Haller H, Dobos G. A systematic review and meta-analysis of yoga for low back pain. Clinical Journal of Pain. 2013;29(5):450-60.
42. Gomes-Neto M, Lopes JM, Conceicao CS, Araujo A, Brasileiro A, Sousa C, et al. Stabilization exercise compared to general exercises or manual therapy for the management of low back pain: A systematic review and meta-analysis. Physical Therapy in Sport. 2017;23:136-42.
43. Lawford BJ, Walters J, Ferrar K. Does walking improve disability status, function, or quality of life in adults with chronic low back pain? A systematic review. Clinical Rehabilitation. 2016;30(6):523-36.
44. Lim EC, Poh RL, Low AY, Wong WP. Effects of Pilates-based exercises on pain and disability in individuals with persistent nonspecific low back pain: a systematic review with meta-analysis. Journal of Orthopaedic & Sports Physical Therapy. 2011;41(2):70-80.
45. Luomajoki HA, Bonet Beltran MB, Careddu S, Bauer CM. Effectiveness of movement control exercise on patients with non-specific low back pain and movement control impairment: A systematic review and meta-analysis. Musculoskeletal Science & Practice. 2018;36:1-11.
46. Macedo LG, Maher CG, Latimer J, McAuley JH. Motor control exercise for persistent, nonspecific low back pain: a systematic review. Physical Therapy. 2009;89(1):9-25.
47. Miyamoto GC, Costa LO, Cabral CM. Efficacy of the Pilates method for pain and disability in patients with chronic nonspecific low back pain: a systematic review with meta-analysis. Brazilian Journal of Physical Therapy. 2013;17(6):517-32.
48. Niederer D, Engel T, Vogt L, Arampatzis A, Banzer W, Beck H, et al. Motor Control Stabilisation Exercise for Patients with Non-Specific Low Back Pain: A Prospective Meta-Analysis with Multilevel Meta-Regressions on Intervention Effects. J Clin Med. 2020;9(9).
49. Qin J, Zhang Y, Wu L, He Z, Huang J, Tao J, et al. Effect of Tai Chi alone or as additional therapy on low back pain: Systematic review and meta-analysis of randomized controlled trials. Medicine. 2019;98(37):e17099.
50. Shi Z, Zhou H, Lu L, Pan B, Wei Z, Yao X, et al. Aquatic Exercises in the Treatment of Low Back Pain: A Systematic Review of the Literature and Meta-Analysis of Eight Studies. American Journal of Physical Medicine & Rehabilitation. 2018;97(2):116-22.
51. Vanti C, Andreatta S, Borghi S, Guccione AA, Pillastrini P, Bertozzi L. The effectiveness of walking versus exercise on pain and function in chronic low back pain: a systematic review and meta-analysis of randomized trials. Disability & Rehabilitation. 2019;41(6):622-32.

52. Wells C, Kolt GS, Marshall P, Hill B, Bialocerkowski A. The effectiveness of Pilates exercise in people with chronic low back pain: a systematic review. PLoS ONE [Electronic Resource]. 2014;9(7):e100402.
53. Zou L, Zhang Y, Yang L, Loprinzi PD, Yeung AS, Kong J, et al. Are Mindful Exercises Safe and Beneficial for Treating Chronic Lower Back Pain? A Systematic Review and Meta-Analysis of Randomized Controlled Trials. Journal of Clinical Medicine. 2019;8(5):08.
54. Crow EM, Jeannot E, Trewhela A. Effectiveness of Iyengar yoga in treating spinal (back and neck) pain: A systematic review. International Journal of Yoga. 2015;8(1):3-14.
55. Elbayomy MA, Zaki LA, Koura G. Core strengthening for chronic nonspecific low back pain: systematic review. Bioscience Research. 2018;15(4):4506-19.
56. Ferreira PH, Ferreira ML, Maher CG, Herbert RD, Refshauge K. Specific stabilisation exercise for spinal and pelvic pain: a systematic review. Australian Journal of Physiotherapy. 2006;52(2):79-88.
57. Henao VOM, Bedoya EAP. Effect of CORE strength training compared to general exercise in adults with low back pain for 3 months: a systematic review. Viref-Revista De Educacion Fisica. 2016;5(2):41-67.
58. Hill C. Is yoga an effective treatment in the management of patients with chronic low back pain compared with other care modalities - a systematic review. Journal of Complementary & Integrative Medicine. 2013;10:07.
59. Holtzman S, Beggs RT. Yoga for chronic low back pain: a meta-analysis of randomized controlled trials. Pain Research & Management. 2013;18(5):267-72.
60. Lee JS, Yang SH, Koog YH, Jun HJ, Kim SH, Kim KJ. Effectiveness of sling exercise for chronic low back pain: a systematic review. Journal of Physical Therapy Science. 2014;26(8):1301-6.
61. Lin HT, Hung WC, Hung JL, Wu PS, Liaw LJ, Chang JH. Effects of pilates on patients with chronic non-specific low back pain: a systematic review. Journal of Physical Therapy Science. 2016;28(10):2961-9.
62. Pereira LM, Obara K, Dias JM, Menacho MO, Guariglia DA, Schiavoni D, et al. Comparing the Pilates method with no exercise or lumbar stabilization for pain and functionality in patients with chronic low back pain: systematic review and meta-analysis. Clinical Rehabilitation. 2012;26(1):10-20.
63. Posadzki P, Ernst E. Yoga for low back pain: a systematic review of randomized clinical trials. Clinical Rheumatology. 2011;30(9):1257-62.
64. Posadzki P, Lizis P, Hagner-Derengowska M. Pilates for low back pain: a systematic review. Complement Ther Clin Pract. 2011;17(2):85-9.
65. Wang XQ, Zheng JJ, Yu ZW, Bi X, Lou SJ, Liu J, et al. A meta-analysis of core stability exercise versus general exercise for chronic low back pain. PLoS One. 2012;7(12):e52082.
66. Weinhardt C, Heller KD, Weh L. Non-operative treatment of chronic low back pain: specific back muscular strength training versus improvement of physical fitness. Zeitschrift fur Orthopadie und Ihre Grenzgebiete. 2001;139(6):490-5.
67. Scharrer M, Ebenbichler G, Pieber K, Crevenna R, Gruther W, Zorn C, et al. A systematic review on the effectiveness of medical training therapy for subacute and chronic low back pain. European journal of physical & rehabilitation medicine. 2012;48(3):361-70.
68. Chang DG, Holt JA, Sklar M, Groessl EJ. Yoga as a treatment for chronic low back pain: A systematic review of the literature. Journal of Orthopedics & Rheumatology. 2016;3(1):1-8.
69. Kristensen J, Franklyn-Miller A. Resistance training in musculoskeletal rehabilitation: a systematic review. British Journal of Sports Medicine. 2012;46(10):719-26.
70. Powell KE, Paluch AE, Blair SN. Physical activity for health: What kind? How much? How intense? On top of what? Annu Rev Public Health. 2011;32:349-65.
71. Richardson C, Jull G, Hodges P. Therapeutic Exercise for Lumbopelvic Stabilisation: a Motor Control Approach for the Treatment and Prevention of Low Back Pain. Edinburgh.: Churchill Livingstone; 204.
72. Niederer D, Mueller J. Sustainability effects of motor control stabilisation exercises on pain and function in chronic nonspecific low back pain patients: A systematic review with meta-analysis and meta-regression. PLoS ONE [Electronic Resource]. 2020;15(1):e0227423.
73. Unsgaard-Tondel M, Fladmark AM, Salvesen O, Vasseljen O. Motor control exercises, sling exercises, and general exercises for patients with chronic low back pain: a randomized controlled trial with 1-year follow-up. Phys Ther. 2010;90(10):1426-40.
74. Hayden JA, van Tulder MW, Tomlinson G. Systematic review: strategies for using exercise therapy to improve outcomes in chronic low back pain. Annals of Internal Medicine. 2005;142(9):776-85.
75. Jakobsen MD, Sundstrup E, Brandt M, Andersen LL. Factors affecting pain relief in response to physical exercise interventions among healthcare workers. Scand J Med Sci Sports. 2017;27(12):1854-63.
76. Berglund L, Aasa B, Michaelson P, Aasa U. Effects of Low-Load Motor Control Exercises and a High-Load Lifting Exercise on Lumbar Multifidus Thickness: A Randomized Controlled Trial. Spine (Phila Pa 1976). 2017;42(15):E876-E82.
77. Michaelson P, Holmberg D, Aasa B, Aasa U. High load lifting exercise and low load motor control exercises as interventions for patients with mechanical low back pain: A randomized controlled trial with 24-month follow-up. J Rehabil Med. 2016;48(5):456-63.
78. Airaksinen O, Brox JI, Cedraschi C, Hildebrandt J, Klaber-Moffett J, Kovacs F, et al. Chapter 4. European guidelines for the management of chronic nonspecific low back pain. Eur Spine J. 2006;15 Suppl 2:S192-300.
79. Koes BW, van Tulder M, Lin CW, Macedo LG, McAuley J, Maher C. An updated overview of clinical guidelines for the management of non-specific low back pain in primary care. Eur Spine J. 2010;19(12):2075-94.
80. Stochkendahl MJ, Kjaer P, Hartvigsen J, Kongsted A, Aaboe 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(1):60-75.

81. Zadro J, O'Keeffe M, Maher C. Do physical therapists follow evidence-based guidelines when managing musculoskeletal conditions? Systematic review. BMJ Open. 2019;9(10):e032329.
82. Gardner T, Refshauge K, McAuley J, Goodall S, Hubscher M, Smith L. Patient led goal setting in chronic low back pain-What goals are important to the patient and are they aligned to what we measure? Patient Educ Couns. 2015;98(8):1035-8.
83. Williams K, Abildso C, Steinberg L, Doyle E, Epstein B, Smith D, et al. Evaluation of the effectiveness and efficacy of Iyengar yoga therapy on chronic low back pain. Spine (Phila Pa 1976). 2009;34(19):2066-76.
84. Gladwell V, Head S, Haggar M, Beneke R. Does a Program of Pilates Improve Chronic Non-Specific Low Back Pain? Journal of Sport Rehabilitation. 2006;15(4):338.
85. Gardner T, Refshauge K, McAuley J, Goodall S, Hubscher M, Smith L. Patient-led Goal Setting: A Pilot Study Investigating a Promising Approach for the Management of Chronic Low Back Pain. Spine (Phila Pa 1976). 2016;41(18):1405-13.

Tables

Table 1. Summary of methodological quality assessment of included studies using AMSTAR-2

Authors	1	2	3	4	5	6	7	8	8	10	11	12	13	14	15	16	#Y	#PY	#N	Tot	Qual
Aladro-Gonzalvo et al 2013 (32)	Y	PY	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	14	1	1	14.5	High
Bussing, et al 2012 (33)	N	PY	Y	Y	Y	Y	Y	Y	PY	N	Y	Y	Y	Y	Y	Y	12	2	2	13	High
Byrnes, et al. 2018 (39)	Y	PY	Y	Y	Y	Y	PY	Y	Y	Y	N	N	N	N	N	N	8	2	6	9	Mod
Bystrom, et al 2013 (40)	Y	PY	Y	PY	Y	N	PY	Y	Y	N	Y	N	Y	Y	N	Y	9	3	4	10.5	Mod
Chang, et al 2016 (68)	Y	PY	Y	N	N	N	N	PY	N	N	N	N	N	N	N	N	2	2	12	3	Crit. Low
Cramer, et al 2013 (41)	Y	PY	Y	Y	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y	Y	12	1	3	12.5	Mod
Crow, et al 2015 (54)	Y	PY	Y	Y	N	N	Y	Y	Y	N	N	N	N	N	N	N	6	1	9	6.5	Low
Elbayomy, et al 2018 (55)	Y	PY	Y	Y	N	N	PY	PY	Y	N	N	N	N	N	N	N	4	3	9	5.5	Low
Ferreira, et al 2006 (56)	Y	PY	Y	Y	Y	Y	N	N	Y	N	Y	N	N	N	N	N	7	1	8	7.5	Low
Gomes-Neto, et al 2017 (42)	Y	PY	Y	Y	Y	Y	N	Y	Y	N	Y	Y	Y	Y	N	N	11	1	4	11.5	Mod
Henao & Bedoya, 2016 (57)	Y	PY	Y	PY	Y	Y	Y	PY	Y	N	N	N	N	N	N	N	6	3	7	7.5	Low
Hill, 2013 (58)	N	PY	Y	PY	N	N	Y	PY	Y	N	Y	Y	Y	Y	N	N	7	3	6	8.5	Low
Holtzman & Begs, 2013 (59)	Y	PY	Y	Y	N	N	Y	PY	Y	N	N	N	Y	N	N	N	6	2	8	6.5	Low
Kristensen & Franklyn-Miller, 2011 (69)	N	N	N	PY	N	N	N	N	N	N	N	N	N	N	N	Y	1	1	14	1.5	Crit. Low
Lawford, et al 2016 (43)	Y	Y	Y	Y	Y	Y	N	PY	Y	N	N	N	Y	Y	N	Y	10	1	5	10.5	Mod
Lee, et al 2014 (60)	Y	PY	Y	PY	Y	Y	N	PY	PY	N	N	N	Y	Y	N	N	6	4	6	8	Low
Lim, et al 2011 (44)	Y	PY	Y	Y	Y	Y	N	PY	Y	N	Y	N	Y	Y	Y	Y	11	2	3	12	Mod
Lin, et al 2016 (61)	Y	N	Y	PY	Y	Y	N	PY	PY	N	N	N	Y	Y	N	N	6	3	7	7.5	Low
Luomajoki, et al 2018 (45)	Y	PY	N	Y	Y	Y	N	Y	Y	N	Y	Y	Y	Y	Y	Y	12	1	3	12.5	Mod
Macedo, et al 2009 (46)	Y	PY	Y	Y	Y	Y	N	Y	PY	N	Y	Y	Y	N	N	Y	10	2	4	11	Mod
Miyamoto, et al 2013 (47)	Y	PY	Y	PY	Y	N	PY	PY	PY	N	Y	Y	Y	Y	Y	N	8	5	3	10.5	Mod
Niederer & Mueller, 2020 (72)	Y	PY	N	PY	Y	Y	N	PY	Y	N	Y	Y	Y	Y	Y	Y	10	3	3	11.5	Mod
Pereira, et al 2012 (62)	Y	Y	Y	Y	N	N	N	PY	Y	N	N	Y	Y	N	N	N	7	1	8	7.5	Low
Posadzki & Ernst, et al 2011 (63)	Y	PY	N	Y	Y	Y	N	PY	PY	N	N	N	Y	Y	N	Y	7	3	6	8.5	Low
Posadzki, Lizis, et al 2011 (64)	Y	N	N	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	7	0	9	7	Low
Qin, et al 2019 (49)	Y	Y	N	PY	Y	Y	N	PY	PY	N	Y	Y	Y	Y	Y	Y	10	3	3	11.5	Mod
Saragiotto, 2016 (18)	Y	PY	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	14	1	1	14.5	High
Scharrer, et al 2012 (67)	Y	PY	N	PY	Y	Y	N	PY	PY	N	N	N	N	N	N	N	3	4	9	5	Low
Shi, et al 2018 (50)	Y	Y	N	PY	Y	Y	N	PY	Y	N	Y	N	N	Y	N	Y	8	2	6	9	Mod
Sitthipornvorakul, et al 2018 (34)	Y	PY	Y	PY	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	14	2	0	15	High
Smith, et al 2014 (35)	Y	Y	N	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	N	Y	13	0	3	13	High
Wang, et al 2012 (65)	Y	PY	N	PY	Y	Y	N	PY	Y	N	Y	N	N	N	N	Y	6	3	7	7.5	Low
Vanti, et al 2019 (51)	Y	PY	Y	Y	Y	Y	N	Y	Y	N	Y	N	N	N	Y	Y	10	1	5	10.5	Mod
Weinhardt, et al 2001 (66)	Y	PY	N	N	N	Y	N	N	PY	N	N	N	Y	N	N	N	3	2	11	4	Low
Wells, et al 2014 (52)	Y	N	Y	PY	Y	Y	Y	Y	N	Y	N	N	N	Y	N	Y	9	1	6	9.5	Mod

Wewege, et al 2018 (36)	**Y**	PY	N	PY	**Y**	**Y**	**Y**	**Y**	**Y**	N	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**12**	**2**	**2**	**13**	**High**
Wieland, et al 2017 (20)	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**16**	**0**	**0**	**16**	**High**
Yamato, et al 2015 (19)	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**16**	**0**	**0**	**16**	**High**
Yue, et al (2014) (37)	**Y**	PY	**Y**	**Y**	**Y**	**Y**	N	PY	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**13**	**2**	**1**	**14**	**High**
Zhang, et al 2019 (38)	**Y**	PY	N	PY	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	N	**Y**	**12**	**2**	**2**	**13**	**High**
Zou, et al 2019 (53)	**Y**	N	**Y**	**Y**	**Y**	**Y**	N	**Y**	**Y**	N	**Y**	N	**Y**	**Y**	**Y**	**Y**	**12**	**0**	**4**	**12**	**Mod**

The rating of overall confidence (OC) was categorized, depending on total number of fulfilled criteria, as follows: critically low (1-4), low (5-8), moderate (9-12), and high (13-16). Abbreviations: Y, criterion fulfilled; N, criterion not fulfilled; PY, criterion partially fulfilled; N/A, inapplicable; Crit. low, critically low, Mod, moderate. **AMSTAR Criteria:** 1. Did the research questions and inclusion criteria for the review include the components of PICO? 2. Did the report of the review contain an explicit statement that the review methods were established prior to the conduct of the review and did the report justify any significant deviations from the protocol? 3. Did the review authors explain their selection of the study designs for inclusion in the review? 4. Did the review authors use a comprehensive literature search strategy? 5. Did the review authors perform study selection in duplicate? 6. Did the review authors perform data extraction in duplicate? 7. Did the review authors provide a list of excluded studies and justify the exclusions? 8. Did the review authors describe the included studies in adequate detail? 9. Did the review authors use a satisfactory technique for assessing the risk of bias (RoB) in individual studies that were included in the review? 10. Did the review authors report on the sources of funding for the studies included in the review? 11. If meta-analysis was performed, did the review authors use appropriate methods for statistical combination of results? 12. If meta-analysis was performed, did the review authors assess the potential impact of RoB in individual studies on the results of the meta-analysis or other evidence synthesis? 13. Did the review authors account for RoB in primary studies when interpreting/discussing the results of the review? 14. Did the review authors provide a satisfactory explanation for, and discussion of, any heterogeneity observed in the results of the review? 15. If they performed quantitative synthesis did the review authors carry out an adequate investigation of publication bias (small study bias) and discuss its likely impact on the results of the review? 16. Did the review authors report any potential sources of conflict of interest, including any funding they received for conducting the review

Table 2. Main results in a glance

				Pain		Disability		Evidence [d]	
Type	**Number of reviews**	**Number of studies[a]**	**CCA [b]**	**Versus MI**	**Versus other intervention [c]**	**Versus MI**	**Versus other intervention [c]**	**Pain**	**Disability**
Aerobic	**1**	**6**	**N.A.**	**N.A.**	**= Resistance exercise**	**N.A.**	**= Resistance**	+++	+++
Aquatic	**1**	**8**	**N.A.**	**N.A.**	**+ Land exercise**	**N.A.**	**+ Land exercise**	++	++
MCE	**11**	**71**	**14%**	**+**	**= General exercise**	**+**	**= General exercise**	+++	++
Resistance	**3**	**20**	**4%**	**+**	**= Fitness exercise**	**+**	**= Fitness**	+	+
Pilates	**9**	**25**	**32%**	**+**	**= Other exercise**	**+**	**= General exercise**	+++	++
Sling	**2**	**13**	**23%**	**+**	**+ Thermo-electro = other exercise**	**+**	**+ Thermo-electro = other exercise**	+++	++
TCE	**3**	**18**	**13%**	**+**	**+ Usual care**	**+**	**+**	+++	++
Walking	**3**	**12**	**38%**	**N.A.**	**= Other intervention**	**N.A.**	**= Other intervention**	++	++
Yoga	**9**	**24**	**28%**	**+**	**= usual care = other exercise**	**+**	**= usual care = other exercise**	++	++

a. Without double counting

b. Corrected covered area

c. **=** Equally effective, **+** More effective

d. Level of evidence according to GRADE: "high" (++++), "moderate" (+++), "low" (++) or "very low (+)

Table 3-A. Results of aerobic exercises to various control interventions

Author (year) Study quality	Studies (N) Population (n)	Outcome measures	Results pain	Results disability	Original review authors conclusions
Wewege et al (2018) Amstar High	SR(MA) N=6 (6) n=333	**Pain** VAS Low Back Pain Rating scale (0-60) **Disability** ODI (0-100) RM (0-50)	**Aerobic exercise or resistance exercise > MI** SMD=-0.42 (95%CI -0.80; -0.03). **Aerobic exercise = MI** No sign difference.	**Aerobic exercise or resistance exercise = MI** SMD=-0.59 (95%CI -1.30;0;12). **Aerobic exercise = MI** No sign difference	Aerobic exercise and resistance exercise decreased pain intensity although neither mode was superior. High-quality RCTs comparing aerobic exercise, resistance exercise, and Aerobic exercise + resistance exercise, are required.
Abbreviations: MA=Meta-analysis; MI=Minimal intervention; ODI=Oswestry Disability Index; RCT=Randomized Clinical Trial; RM=Roland Morris Disability Questionnaire, SR=Systematic review; SMD=Standardized mean difference; VAS=Visual Analogue Scale (0-100).					

Table 3-B. Results of aquatic exercises to various control interventions

Author (year) Study quality	Studies (N) Population (n)	Outcome measures	Results pain	Results disability	Original review authors conclusions
Shi et al (2018) Amstar Moderate	SR (MA) N=8 (8) n=311	**Pain** VAS **Disability** Physical component of SF-36 and SF-12	**Aquatic exercise > land-based therapy, general practice or MI** SMD=-0.65 (95%CI -1.16; -0.14).	**Aquatic exercise > land-based therapy, general practice or MI** SMD=0.63 (95%CI 0.17-1.09).	Aquatic exercise could statistically significantly reduce pain and increase physical function in patients with LBP, but further investigations on a larger scale are needed to verify the findings.
Abbreviations: MA=Meta-analysis; SF=Short Form; SMD=Standardized Mean Difference; SR=Systematic review; VAS=Visual Analog Scale (0-100).					

Table 3-C: Results on Motor Control Exercises compared to various control interventions

Author (year) Study quality	Studies (N) Population (n)	Outcome measures	Results pain	Results disability	Original review authors conclusions
Byström et al (2013) Amstar Moderate	SR (MA) N=16 (16) n=1768	**Pain** NRS, VAS **Disability** ODI, RM Short-term Intermediate term Long-term	**MCE > GE** *short-term (7 trials)* WMD=-7.89 (95%CI -10.95;-4.65). *Intermediate (7 trials)* WMD=-6.06 (95%CI -10.94; -1.18). **MCE =MT** *All time periods* (3 *trials*) **MCE > MI** *Short-term (2 trials)* WMD=-12.48 (95%CI -19.04; -5.93). *Intermediate (2 trials)* WMD=-10.18 (95%CI 16.64; -3.72). *Long-term (2 trials)* WMD=-13.32 (95%CI 19.75; -6.90). **MCE > MM-PT** *Intermediate (4 trial)s* WMD=-14.20 (95%CI -21.23; -7.16).	**MCE > GE** *Short-term (7 trials)* WMD=-4.65 (95%CI - 6.20; -3.11). *Intermediate (7 trials)* WMD=-4.86 (95%CI -8.59; -1.13). *Long-term (7 trials)* WMD=-4.72 (95%CI -8.81; - 0.63). **MCE > MT** *Short-term (3 trials)* WMD=-6.12 (95%CI -11.94; -0.30). *Intermediate (3 trials)* WMD=-5.27 (95%CI -9.52; -1.01). *Long-term (3 trials)* WMD=-5.76 (95%CI -9.21; -2.32). **MCE > MI** *Short-term (3 trials)* WMD=-9.00 (95%CI 15.28; - 2.73). *Intermediate (3 trials)* WMD=-5.62 (95%CI -10.46; -0.77). *Long-term (3 trials)* WMD=-6.64 (95%CI -11.72; -1.57). **MCE > MM-PT** *Intermediate (4 trials)* WMD=-12.98 (95%CI -19.49; -6.47).	MCE seem to be superior to several other treatments. More studies are needed to investigate subgroups.

Elbayomy et al (2018) Amstar Low	SR N=34 n=2514	**Pain** VAS **Disability** RM Short-term Intermediate term Long-term	**CE > GE** *short-term (15 trials)* MD=-1.18 (95%CI 1.68; -0.67). *Intermediate (8 trials)* *MD=*-0.92 (95%CI -1.5; -0.35). *Long-term (5 trials)* MD=-0.11 (95%CI -0.52; 0.31). **CE = MT** *short-term (2 trials)* MD=0.39 (95%CI -0.98; 0.20). *Intermediate (3 trials)* MD=-0.55 (95%CI -1.39; 0.29). *Long-term (2 trials)* MD=-0.26 (95%CI -0.87; 0.35). **CE > MI** *Short-term (2 trials)* MD=-1.26 (95%CI -1.85; -0.67). *Intermediate (4 trials)* MD=-1.25 (95%CI -2.01; -0.49). *Long-term (3 trials)* MD=-1.3 (95%CI -1.85; -0.74). **CE > MM-PT** *Short-term (6 trials)* MD=-0.35 (95%CI -0.99; 0.29).	**CE > GE** *short-term (14 trials)* SMD=0.98 (95%CI -1.46; -0.50). *intermediate (8 trials)* SMD=-0.59 (95%CI -1.03; -0.15). *long-term (4 trials)* SMD=-0.04(95%CI -0.21; 0.12). **CE = MT** *short-term (2 trials)* SMD=-0.12 (95%CI -0.40; 0.16). *Intermediate (3 trials)* SMD=-0.09 (95%CI -0.31; 0.12). *Long-term (3 trials)* SMD=-0.07 (95%CI -0.27; 0.13). **CE > MI** *Short-term (3 trials)* SMD=-0.66 (95%CI -1.08; -0.24*).* *Intermediate (4 trials)* SMD=-0.37 (95%CI -0.75; 0.02). *Long-term (3 trials)* SMD=-0.29 (95%CI -0.73; 0.14). **CE > MM-PT** *Short-term (3 trials*) SMD=-0.5 (95%CI -0.87; -0.13).	CE reduced pain and disability at short and intermediate term more than GE, level of evidence from low to moderate. Low evidence support that CE reduce disability more than MT. No clinically important difference between CE and MT. Low to moderate evidence suggest CE has significant effect on pain more than MI at all follow-up periods and on disability at short-term.
Ferreira et al (2006) Amstar Low	SR/MA. N=12 (12) n=965	**Pain** VAS **Disability** RM	**MCE > UC** *short-term (2 trials)* ES=-21 (95%CI -32; -9).	**MCE = MT** *Short-term (2 trials)* ES=-5 (95%CI -12; 1).	The authors suggest that specific stabilization exercise is an effective treatment option for many forms of spinal pain. It is not clear if the improvements in pain & disability are associated with changes in the pattern of muscle activation.

			Intermediate (2 trials) ES=-24 (95%CI -38; -1). **MCE = MT** *Short-term / Long-term (2 trials)* NR in text **MCE+Educ > MM** *Short-term (2 trials)* ES=-11 (95%CI -13; -9). *Intermediate (2 trials)* ES=-11 (95%CI -18; -5). *Long-term (1 trial)* ES=-9 (95%CI -15; -3). **MCE+UC=UC** *short-term (3 trials)* NR in text	*Intermediate term (2 trials)* ES=-9 (95%CI -16; -2). **MCE = MT** *Short/ long-term (2 trials)* NR in text **MCE+Educ > MM** *Short-term (2 trials)* ES=-20 (95%CI -27; -13). *Intermediate (2 trials)* ES=-4 (95%CI -7; -1). **MCE+Educ = MM** *Long-term (1 trial)* ES=-3 (95%CI -6; 0). **MCE+UC = UC** *short-term (3 trials)* NR in text	
Gomes-Neto et al (2017) Amstar Moderate	SR/MA N=11 n=1014	**Pain** VAS **Disability** RM Estimates from baseline to study end	**MCE > GE** *Baseline to study end (8 trials)* WMD=-1.03 (95%CI -1.79; 0.27). **MCE = MT** *Baseline to study end (3 trials)* WMD=-0.38 (95%CI -0.98; 0.22).	**MCE > GE** *Baseline to study end (4 trials)* WMD=-5.41 (95%CI -8.34; -2.49). **MCE = MT** *Baseline to study end (3 trials)* WMD=-0.17 (95%CI -0.38; 0.03).	Based on relatively low-quality data that led to a high risk of bias. Additional research is required to ascertain the positive effects of MCE over time
Henao & Bedoya (2016) Amstar low	SR N=6 n=663	**Pain** NR **Disability** NR Short-term Long-term	**MCE = GE** No difference between MCE and GE in short or long-term.	**MCE = GE** No difference between MCE and GE in short or long-term	Although there are no differences between MCE and GE concerning pain and disability in people in chronic LBP there is uncertainty as to whether there is consensus in defined exercise protocols of MCE and GE. It is necessary to develop an exercise protocol that demonstrates evidence that favors optimal lumbo-pelvic stability.
Luomajoki et al (2018	SR/MA N=11	**Pain** VAS / NRS	**MvCE > control**	**MvCE >control**	MvCE may be more effective in disability in the short & long-term compared to other interventions. Pain was reduced through MVCE treatment in short but not in long-term.

Amstar Moderate	n=781	**Disability** ODI, RM Short long Long-term	*Short-term (9 trials)* SMD=-0.39 (95%CI -0.69; -0.04). *Long-term (5 trials)* SMD=-0.27 (95%CI -0.62; -0.09)..	*Short-term (11 trials)* SMD=-0.38 (95%CI -0.68; -0.09). *Long-term (6 trials)* SMD=0.37 (95%CI -0.61; 0.04)	
Macedo et al (2009) Amstar Moderate	SR/MA N=14 n=1696	**Pain** VAS **Disability** ODI	**MCE = GE** *All time intervals* **MCE > MT** *Intermediate (4 trials)* WMD=-5.7 (95%CI -10.7; -0.8). **MCE > MI** *Short-term (7 trials)* WMD=-14.3 (95%CI -20.4; -8.1). *Intermediate (7 trials)* WMD=-13.6 (95%CI -22.4; -4.1). *Long-term (7 trials)* WMD=-14.4 (95%CI -23.1; -5.7).	**MCE > GE** *Short-term (5 trials)* WMD=- 5.1 (95%CI -8.7; -1.4). **MCE > MT** *Intermediate (4 trials)* WMD=-4.0 (95%CI -7.6; -0.4). **MCE > MI** *Long-term (7 trials)* WMD=-10.8 95%CI (-18.7; -2.8).	MCE is more effective than MI and add benefit to another form of intervention in reducing pain and disability in LBP. The optimal implementation of MCE is unclear. Future trials need to study dosage parameters, feedback and subgroups.
Niederer & Mueller (2020) Amstar Moderate	SR/MA N=10 8 RCT 2 CT n = 1081	**Pain** NRS VAS **Disability** ODI RM	**MCE > Inactive, passive or other exercise** *Overall (13 trials)* SMD= -0.46 (95%CI -0.78; -0.14). **MCE > GE** *Short-term (3 trials)* SMD=-0.53 (95%CI -1.20; -0.14). *Intermediate (6 trials)* SMD=-0.23 (95%CI -0.46; 0.01). *Long-term (3 trials)* SMD=0.29 (95%CI -0.56; -0.01).	**MCE >Inactive, passive or other exercise** *Overall (12 trials)* SMD=-0.44 (95%CI -0.88; -0.09). **MCE = GE** *Short-term (4 trials)* SMD=0.45 (95%CI -1.51; 0.60). *Intermediate (5 trials)* SMD=-0.16 (95%CI -0.37; -0.04). *Long-term (3 studies)* SMD=-0.25 (95%CI -0.59; 0.10).	MCE lead, with low to moderate quality evidence, to a sustainable improvement in pain intensity and disability in chronic non-specific LBP compared to an inactive or passive control group or compared to other exercises.

			MCE = Inactive, passive *Short-term (3 trials)* SMD=-0.03 (95%CI -1.88; 0.03). *Intermediate and long-term* *No difference*	**MCE = Inactive, passive** *Short-term (4 trials)* SMD=-0.82 (95%CI -1.59; 0.04). *Intermediate and Long-term No difference*	
Saragiotto et al (2016) Amstar High	Cochrane SR/MA. N=29 n=2431	**Pain intensity** VAS **Disability** RM	**MCE > GE** *Short-term (13 trials)* MD=-7.53 (95%CI -10.54; -4.52). **MCE = GE** *Intermediate and Long-term* No difference **MCE = MT** No difference at any time point **MCE > MI** *Short-term* MD=-10.01 (95%CI -15.67; -4.35). *intermediate* MD=-12.61 (95%CI -20.53; -4.69). *Long-term* MD=-12.97 (95%CI -18.51; -7.42). **MCE > GE + EPA** *Short-term* MD=-30.18 (95%CI -35.32; -25.05). *Intermediate* MD=-19.39 (-36.83; -1.96).	**MCE > GE** *Short-term (11 trials)* MD=-4.82 (95%CI -6.95; -2.68). **MCE = GE** *Intermediate* and *Long-term* No difference **MCE = MT** No difference at any time point **MCE > MI** *Short-term* MD=-8.63(95%CI -14.78; -2.47). *Intermediate* MD=-5.47, (95%CI -9.17; -1.77). *Long-term* MD=-5.96 (95%CI -9.81; -2.11). **MCE > GE and EPA** *Short-term* MD=-20.83 (95%CI -28.07; -13.59). *Intermediate* MD=-11.5 (95%CI -20.69; -2.31)	MCE probably provides better improvements in pain, function and global impression of recovery than MI at all follow-up periods. MCE may provide slightly better improvements than exercise and EPA for pain, disability, global impression of recovery and the physical component of QoL in the short/intermediate term. There is probably little or no difference between MCE and MT for all outcomes and follow-up periods.
Smith et al (2014) Amstar High	SR/ MA N=29 n=2258	**Pain** VAS **Disability** RM	**MCE > Any treatment/control** *Short-term (22 studies)* MD=-7.93 (95%CI -11.74; -4.12). *Intermediate (22 trials)* MD=-6.10 (95%CI -10.54; -1.65).	**MCE > Any treatment/control** *Short-term (24 studies)* MD=-3.61 (95%CI -6.53 to -0.70). *Long-term (24 trials)* MD=-3.92 (95%CI -7.25 to -0.59).	MCE improve LBP symptoms, but no better than any other form of active exercise in the long-term.

			Long-term (22 studies) MD=-6.39 (95%CI -10.14; -2.65). **MCE > GE** *Short-term* MD=-7.75 (95%CI -12.23; -3.27). *Intermediate* MD=-4.24 (95%CI -8.27; -0.21). **MCE = GE** *Long-term* MD=-3.06 (95%CI -6.74; 0.63).	**MCE = Any treatment/control** *Intermediate no difference* MD=-2.31 (95%CI -5.85; 1.23). **MCE > GE** *Short-term* MD=-3.63 (95%CI -6.69; -0.58). *Intermediate* MD=-3.56 (95%CI -6.47; -0.66). **MCE = GE** *Long-term* No difference	
Wang et al (2012) Amstar Low	SR/ MA N=5 n=494	**Pain** VAS, NRS **Disability** RM, ODI	**MCE > GE** *Short-term* MD=-1.29 (95%CI -2.47; -0.11). **MCE = GE** No difference at intermediate or long-term.	**MCE > GE** *Short-term* MD=-7.14 (95%CI -11.64; -2.65). **MCE = GE** No difference at intermediate or long-term.	Compared to GE, MCE is more effective in decreasing pain and may improve physical function in patients with chronic LBP in the short-term but not in long-term.
Abbreviations: CE=Core Exercises; EPA=Electrophysical agents; ES = Effect Size; GE=General Exercise; MA= Meta-Analysis; MI=Minimal intervention; MT=Manual Therapy; MvCE=Movement Control Exercises; MCID=minimal clinical important difference; NR=not reported; NRS=Numeric rating scale (0-10); ODI=Oswestry Disability Index (0-100); RM=Roland Morris Disability Questionnaire (0-100), SR= systematic review; VAS=Visual Analogue Scale (0-100); WMD=Weighted Mean Difference.					

Table 3-D. Results of resistance exercises to various control interventions

Author (year)	Studies (N) Population (n)	Outcome measures	Results pain	Results disability	Original review authors conclusions
Kristensen et al (2012) Amstar Critically low	SR N=12 n=549	**Pain** NR **Disability** NR	Pain scores decreased in 8 trials	Functional ability increased in 7 trials	Evidence suggests that RT can increase muscle strength, reduce pain and improve functional ability in patients suffering from CLBP, RT can be used successfully as a therapeutic modality in several musculoskeletal conditions, especially those of a chronic variety. Although the exact application of training intensity and volume for maximal therapeutic effects is still unclear, it appears that RT guidelines, which have proven effective in a healthy population, can also be successfully applied in a rehabilitation context.
Scharrer et al (2012) Amstar Moderate	SR N=2 n=62	**Pain** NR **Disability** NR	**Resistance training > control** **Resistance training = CBI** Both trials, one was of high quality, found MTT to decrease pain better that therapy of uncertain effectiveness, but equal to a cognitive behavioral intervention.	**Resistance training > control** **Resistance training = CBI** Both trials, one was of high quality, found MTT to improve function significantly better that therapy of uncertain effectiveness, but equal to a cognitive behavioral intervention.	There is moderate evidence that a combination of endurance training and progressive resistance training of the back muscles is more effective than no intervention, but equal effective as a cognitive behavioral intervention. Future high quality RCT's will have to clarify whether MTT is effective and would be superior to other forms of therapeutic exercise.
Weinhardt et al (2001) Amstar low	SR N=7 n=NR	**Pain** NR **Disability** NR	**Resistance training > passive treatment** **Resistance training = fitness** Compared to passive treatment or no treatment, significant improvement in pain. No difference in effects between fitness and strength training.	**Resistance training > passive treatment** **Resistance training = fitness** Compared to passive treatment or no treatment, significant increase in function. No difference in effects between fitness and strength training.	In comparison with passive treatment or no treatment, there is strong evidence for the benefit of resistance training, but non-specific fitness training is comparable effective in rehabilitation.
Abbreviations: CBI=Cognitive Behaviour Intervention; CLBP=Chronic Low Back Pain; MA=Meta-analysis; NR=Not Reported; MTT=Minimal intervention; RCT=Randomized Clinical Trial; RT= Resistance training; SR=Systematic review.					

Table 3-E. Results on Pilates compared to various treatments.

Author (year)	Studies (N) Population (n)	Outcome measures	Results pain	Results disability	Original review authors conclusions
Aladro-Gonzalvo et al (2013) Amstar High	SR(MA) N=9(9) n=245	**Pain** VAS, NRS, MBI-pain **Disability** RM, RMDQ-HK, ODQ	**Pilates = Other physiotherapy treatment** ES=-0.14 (95%CI 0.27; -0.56). **Pilates > minimal intervention:** ES=-0.44 (95%CI -0.09; -0.80).	**Pilates > Other physiotherapy treatment** ES=-0.55, (95%CI -0.08; -1.03). **Pilates = minimal intervention:** ES=-0.28 (95%CI 0.07; -0.62).	Pilates based therapeutic exercise was found to be moderately superior to minimal intervention for pain relief and confers similar benefits when compared with pooled scores to another physiotherapeutic treatment but should be interpreted with caution. Pilates is moderately better than another physiotherapeutic treatment in reducing disability and provides comparable benefits to minimal intervention. Future studies should incorporate placebo-controlled trial, larger sample sizes, intervention protocols that are comparable, assessment of the several features not coded in this review and longer-term follow-up.
Byrnes et al (2018) Amstar Moderate	N=14 n=708 according to Byrnes (2018), but 676 according to our calculations	**Pain (10 studies)** VAS, NRS, Scheffe and Fischer, RMVAS. **Disability** ODI, Functional tests, RM. **Function** Balance and Sports performance Patient-specific functional tests.	The Pilates group showed a statistically significant decrease in pain. (8 *trials*).	The Pilates group showed a statistically significant decrease in disability after treatment. (5 *trials*). **Pilates = control** Mainly positive results on function in the Pilates group, but only a few studies found differences with the comparator group.	The Pilates group performed better in 10 out of 14 papers compared to the control or comparator group in their outcome measures by the end of the study. In 5 studies the improvement reached clinical significance.
Lim (2011) et al Amstar Moderate	N=7 n=194	**Pain** MBI-pain, NRS **Disability** ODI/ODQ, RMVAS, RM.	**Pilates > MI** SMD=-2.72 (95%CI -5.33; -0.11). **Pilates = other exercise** SMD=0.03 (95%CI -0.52; 0.58).	**Pilates = MI** SMD=-0.74 (95%CI -1.81; 0.33). **Pilates = other exercise** SMD=-0.41 (95%CI -0.96; 0.14).	Pilates is superior to minimal intervention for reduction of pain. Pilates is not more effective than other forms of exercise to reduce pain. Pilates is no more effective than minimal intervention or other exercise interventions to reduce disability. There is a need for well-designed randomized controlled trials with adequate follow-up.
Lin et al (2016) Amstar Low	N=8 n=500	**Pain** VAS, RMVAS, NRS. **Disability** ODI, RM.	**Pilates > usual or routine health care.** **Pilates= other exercise**	**Pilates > usual or routine health care.** **Pilates= other exercise**	In patients with chronic low back pain, Pilates showed significant improvement in pain relief and functional enhancement. Other exercises showed effects like those of Pilates, if waist or torso movement was included and the exercises were performed for 20 cumulative hours.
Miyamoto et al (2013)	N=8 n=363	**Pain**	**Pilates > MI**	**Pilates > MI**	Pilates was better than a minimal intervention for reducing pain and disability in patients with chronic low back pain. Pilates was not better than other types of exercise for short-term pain reduction.

Amstar Moderate		VAS, NRS, RMVAS 0-100. **Disability** ODI, RM.	*Short-term (Four trials).* (difference between means=1.6 points (95%CI 1.4;1.8). **Pilates=other exercise** *Short-term (two trials)* (difference between means=0.1 points (95% CI -0.3 to 0.6).	*Short-term (Four trials).* (difference between means=5.2 points (95% CI 4.3 to 6.1).	
Pereira et al (2012) Amstar Low	N=5 n=134	**Pain** NRS, VAS, RMVAS, SF-36 pain subscale. **Disability** RM, ODI Miami Back Index.	**Pilates = control group** SMD=-1.99 (95%CI -4.35; 0.37) *(Four trials).* **Pilates= lumbar stabilization exercises:** SMD=-0.11 (95%CI -0.74; 0.52) *(Two trials).*	**Pilates = control group** SMD=-1.34 (95%CI -2.80, 0.11). *(Four trials).* **Pilates = lumbar stabilization exercises:** SMD=-0.31 (95%CI -1.02; 0.40). *(Two trials).*	The Pilates method did not improve functionality and pain in patients who have low back pain when compared with control and lumbar stabilization exercise groups. Further research is needed with larger samples and using clearer definitions of the standard care and comparable outcome measures.
Posadzki et al (2011) Amstar Low	N=4 n=228	***Pain*** VAS, NRS. **Disability** ODI, RM.	**Pilates > back school programs, normal activities, or usual care**.	**Pilates > back school programs, normal activities, or usual care** in two studies but not in 1 study.	Although some of the authors of the reviewed studies conclude that Pilates yielded better therapeutic results than usual or standard care, the findings of this review suggest that the evidence available for its clinical effectiveness is inconclusive. This systematic review shows that the evidence base for Pilates method remains scarce and therefore larger and better-designed clinical trials are needed.
Wells et al (2014) Amstar Moderate	N=14 n=521	**Pain** VAS, NRS. **Disability** ODI, RM. **Pain and Disability:** Miami Back Index, Quebec Scale	**Pilates > usual care and physical activity** At 4 and 15 weeks, but not at 24 weeks. **Pilates = massage therapy, or other forms of exercise** At any time period.	**Pilates > usual care and physical activity** At 4 and 15 weeks, but not at 24 weeks. **Pilates = massage therapy, or other forms of exercise** At any time period.	Pilates offers greater improvements in pain and functional ability compared to usual care and physical activity in the short-term. Changes in pain are more likely to be clinically significant than improvements in functional ability. Pilates offers equivalent improvements to massage therapy and other forms of exercise. Future research should explore optimal Pilates designs, and whether some people with CLBP may benefit from Pilates more than others.
Yamato et al (2015) Amstar High	N =10 n=535	**Pain** VAS, NRS RMVAS, 0-100. **Disability:**	**Pilates > MI** *short-term* MD=-14.05 (95%CI -18.91; -9.19). *(Six trials).*	**Pilates > MI** *Short-term (Five trials).* MD=-7.95 (95%CI -13.23; -2.67).	No high-quality evidence for any of the treatment comparisons, outcomes or follow-up periods investigated. Low to moderate quality evidence that Pilates is more effective than minimal intervention for pain and disability. When Pilates was compared with other exercise we found a small effect for function at intermediate-term follow-up. Thus, while there is some evidence for the effectiveness of Pilates for low back pain, there is no conclusive evidence that it is superior to other forms of exercises. The decision to use Pilates for low back pain may be based on the patient's or care provider's preferences, and costs.

	RMQ, ODI 0-100 Quebec Disability scale	*intermediate-term* MD=-10.54 (95%CI -18.46; -2.62). *(Two trials).*	*intermediate-term (Two trials).* MD=-11.17 (95%CI -18.41; -3.92).
		Pilates > other exercises *Short-term* *(Two out of three trials)* *Intermediate-term* (one trial reported a significant effect in favor of Pilates, but one trial reported a non-significant difference for this comparison).	**Pilates = other exercises** *Short-term (Two trials).* MD=-3.29 (95%CI -6.82; 0.24). *intermediate term (Two trials).* MD=-0.91 (95%CI -5.02; 3.20)
Abbreviations: MA=Meta-analysis; MBI-Pain=Miami Back Index Pain Sub-Scale; MD=Mean difference; NRS=Numerical Rating Scale (0-10), ODI/ODQ=Oswestry Disability Questionnaire/Index/ Oswestry Low Back Pain Disability Questionnaire (0-100); RM=Roland-Morris Disability Questionnaire; RMDQ-HK=Roland Morris Questionnaire Chinese version (0-100); RMVAS=Roland Morris Visual Analogue Scale (0-100); SMD=Standardized Mean Difference; SR=Systematic review; VAS=visual analog scale (0-100).			

Table 3-F. Results of sling exercises to various control interventions

Author (year)	Studies (N) Population (n)	Outcome measures	Results pain	Results disability	Original review authors conclusions
Lee et al (2014) Amstar Low	SR N=7 n=483	**Pain** VAS NRS Pain domain of Qualeffo-41 **Disability** ODI Physical domain of Qualeffo-41	**Sling = other exercise** SE is no more effective/efficacious in reducing pain compared with other forms of exercise	**Sling = other exercise** SE is no more effective/efficacious in improving disability compared with other forms of exercise	As sling therapy studies are based on a small number of trials, we cannot draw conclusions about the therapeutic effects of sling exercise. When segmental stabilizing exercise and individually designed programs are added to sling exercise, it increases the effectiveness of sling exercise at improving low back pain. This should be the focus of future studies.
Yue et al (2014) Amstar High	SR (MA) N=9 (9) n=706	**Pain** VAS NRS **Disability** ODI M-ODI JOA	**SE > other exercise** *Short-term:* MD=-7.30 (95% CI -14.86; 0.25). No sign diff other time points **SE = traditional Chinese medical therapy** No sign diff short-term **SE > thermomagnetic therapy** *Short-term:* MD= -13.90 (95% CI -22.19; -5.62) *Long-term:* MD= -26.20 (95% CI-31.32; -21.08). **SE and acupuncture = acupuncture** *Short-term:* MD= -6.30 (95% CI 16.85; 4.25).	**SE > other exercise** *Intermediate term:* MD= -8.81 (95% CI -13.82;-3.80). No sign diff short-term **SE > thermomagnetic therapy** *Short-term:* MD= -10.54 (95% CI -14.32;-6.75). *Long-term:* MD= -25.75 (95% CI -30.79;-20.71).	Based on limited evidence from two trials, SE was more effective for LBP than thermomagnetic therapy. Clinically relevant differences in effects between SE and other forms of exercise, physical agents combined with drug therapy, traditional Chinese medical therapy, or in addition to acupuncture could not be found. More high-quality randomized trials on the topic are warranted
Abbreviations: JOA=Japanese Orthopedic Association; MA=Meta-Analysis; MD= Mean Difference; M-ODI=Modified Oswestry Disability Index; NRS=Numeric rating scale (0-10); ODI=Oswestry Disability Index(0-100); SE=Sling Exercise; SR=Systematic review; VAS=Visual Analogue Scale (0-100).					

Table 3-G: Results on Traditional Chinese Exercise (TCE) compared to various control interventions.

Author (year)	Studies (N) Population (n)	Outcome measures	Results pain	Results disability	Original review authors conclusions
Qin et al (2019) Amstar Moderate	SR (MA) n=10 (10) N=959	**Pain** VAS, NRS **Disability** ODI, RMDQ, JOA, SF-36 PF Short-term	**Tai Chi alone or combined > Control** WMD=-1.27 (95%CI -1.50; -1.04). *(8 trials).* Subgroup analyses: **Tai Chi combined with routine therapy (physiotherapy, massage, and health education) > Control (=routine therapy)** WMD=1.07 (95%CI 1.27; 0.86).	**Tai Chi alone or combined > Control** ODI (3 trials), pooled on subitem level (score 0-5): **Pain intensity** WMD=-1.70 (95%CI -2.63; -0.76). **Personal care** WMD= -1.93 (95%CI -2.86; -1.00). **Lifting** WMD=-1.69 (95%CI -2.22; -1.15). **Walking** WMD=-2.05 (95%CI -3.05; -1.06). **Standing** WMD=-1.70, (95%CI -2.51; -0.89). **Sleeping** WMD=-2.98 (95%CI -3.73; -2.22). **Social life** WMD=-2.06 (95%CI -2.77; -1.35). **Traveling** WMD=-2.20 (95%CI -3.21; -1.19). and remaining items with no significant improvement: **Sitting** WMD= -1.79 (95%CI -3.79; 0.21). **Sex life** WMD= -1.44 (95%CI -3.12; 0.23). **RMDQ** (*1 trial*) WMD=2.19 (95%CI -2.56; -1.82). **JOA** (*2 trials*)	A cautious conclusion that Tai Chi alone or as additional therapy with routine therapy may decrease pain intensity and improve function disability for patients with LBP. Tai Chi might be recommended for LBP patients, individually or integration with other conventional treatments.

				WMD=7.22 (95%CI 5.59; 8.86). **SF-36** (*1 trial*) WMD=3.30 (95%CI 1.92; 4.68).	
Zhang et al (2019) Amstar High	SR (MA) n=11 (11) N=886	**Pain** VAS **Disability** ODI, RMDQ Short-term?	**TCE (Tai Chi, Qigong) > Control** *(10 trials).* Hedges' g =-0.64 (95%CI -0.90; -0.37).	**TCE (Tai Chi, Qigong) > Control** ODI *(5 trials.)* Hedges' g=-0.96 (95%CI -1.42 -0.50). RMBQ (4 trials) Hedges' g=-0.41 (95%CI -0.79 to -0.03).	TCE may have a positive effect modulating pain intensity, RMDQ, and ODI for people with LBP.
Abbreviations: VAS=Visual Analogue Scale; MA=Meta-Analysis; NRS=Numeric rating scale (0-10); ODI=Oswestry Disability Index (0-100); RMDQ=Roland Morris Disability Questionnaire (0-100), JOA=Japanese Orthopedic Association; SF-36=Medical Outcomes Study Questionnaire Short Form 36 Health Survey; SR= systematic review; TCE=Traditional Chinese Exercises; VAS=Visual Analogue Scale (0-100); WMD=Weighted mean differences.					

Table 3-H: Results on Walking compared to various control interventions.

Author (year)	Studies (N) Population (n)	Outcome measures	Results pain	Results disability	Original review authors conclusions
Lawford et al (2016) Amstar Moderate	N=7 n=869	**Disability** ODI, RMDQ	NA	**Walking > control group** *(1 trial).* **Walking = control group** *(2 trials).* **Walking < control group** *(2 trials).*	Low quality evidence that walking is as effective as other non-pharmacological interventions for disability improvement.
Sitthipornvorakul et al (2018) AmsSMD=tar High	SR (MA) N=9 (4 MA walking alone; 5 MA walking + exercise). n=863	**Pain** Not reported **Disability** Not reported	**Walking alone vs other non-pharmacological interventions:** *Short-term*: SMD=0.07 (95%CI -0.31; 0.46). *Mid-term:* SMD=0.06 (95%CI -0.43; 0.56). **Walking + Exercise vs other non-pharmacological intervention** *Short-term:* SMD=0.04 (95%CI -0.26; 0.34). *Mid-term:* SMD=0.00 (95%CI -0.39; 0.39).	**Walking alone vs other non-pharmacological interventions** *Short-term:* SMD=0.03 (95%CI -0.36; 0.42). *Mid-term:* SMD=0.15 (95%CI -0.52; 0.82). **Walking + Exercise vs other non-pharmacological interventions** *Short-term:* SMD=-0.08 95%CI (-0.38; 0.21). *Mid-term:* SMD=0.19 95%CI (-0.58; 0.20).	Low- to moderate-quality evidence that walking is as effective as other non-pharmacological interventions for pain and disability improvement.
Vanti et al (2019) Amstar Moderate	SR (MA) N=5 (5) n=329	**Pain** NRS, VAS, LBPRS **Disability** ODI, LBPFS Short-term Mid term Long-term Walking alone Walking + Exercise	**Walking alone vs exercise** *Short-term:* SMD= -0.17 (95%CI -0.45; 0.10). *Mid-term:* SMD=-0.18 (95%CI -0.46; 0.10). *Long-term:* SMD=-0.22 (95%CI -0.51; 0.06). **Walking + Exercise vs exercise alone** *Short-term:* SMD=-0.09 (95%CI -0.56; 0.38).	**Walking alone vs exercise** *Short-term:* SMD=-0.11 (95%CI -0.36; 0.13). *Mid-term:* SMD=-0.08 (95%CI -0.36; 0.20). *Long-term:* SMD=-0.17 (95%CI -0.46; 0.11). **Walking + Exercise vs exercise alone** *Short-term:* SMD=-0.28 (95%CI -0.75; 0.19).	Pain and disability were similarly improved by walking or exercise, no additional improvement when walking is added to exercise. The low clinical relevance of the outcome was not sufficient to make recommendations.

Abbreviations: MD=Mean difference; LBPFS=Low back Pain Functional Score (0-100); LBPFS=Low back Pain Rating Score; MA=Meta-analysis; NRS=Numerical Rating Scale (0-10), ODI=Oswestry Disability Index (0-100); RMDQ=Roland-Morris Disability Questionnaire (0-100); SR=Systematic review; VAS=Visual Analogue Scale (0-100).

Table 3-I: Results on Yoga compared to various control interventions.

Author (year)	Studies (N) Population (n)	Outcome measures	Results pain	Results disability	*Original review authors conclusions*
Büssing et al (2012) Amstar High	SR (MA) N=16 (12) n=1007	Pain. VAS, PPI Disability ODI, RMDQ	**Yoga > control** SMD=-0.74 (95%CI -0.97; -0.52).	**Yoga > control** SMD=-0.79 (95%CI -1.02;-.56).	This meta-analysis suggests that yoga is a useful supplementary approach with moderate effect sizes on pain and associated disability. It is an important issue whether some yoga styles might be more effective than others... Due to the heterogeneity of the studies with their different yoga traditions, we cannot draw any valid conclusions on this topic. This and also the impact of the qualification of yoga trainers has to be addressed in future studies.
Cramer et al (2012) Amstar Moderate	SR (MA) N=9 (8) n= 967	**Pain:** ABPS, MPQ, PPI, NRS, VAS **Disability** RMDQ, ODI PDI	**Yoga > control** *Short-term:* SMD=-0.48 (95%CI -0.65; -0.31). *Long-term:* SMD=-0.33 (95% CI -0.59; -0.07). Yoga was not associated with serious adverse events.	**Yoga > control** *short-term*: SMD=-.59 (95%CI -.87; -0.30). *Long-term:* SMD=-0.35 (95% CI, -0.55; -0.15).	Strong evidence for short-term effectiveness and moderate evidence for long- term effectiveness of yoga for chronic LBP. Low number of adverse events. Yoga can be recommended as an additional therapy to patients who do not improve with education on self-care options.
Crow et al (2015) Amstar Low	SR N=4 n=441	**Pain** VAS, PPI, ABS **Disability** PSEQ, RMDQ	**Yoga > control** *Short-term* 56-69% decrease **Yoga = control** *Long-term:* NR	**Yoga > control** *Short-term* Lower RMDQ points **Yoga = control** *Long-term:* NR	This systematic review found strong evidence for short-term effectiveness, but little evidence for long-term effectiveness of yoga for chronic spine pain in the patient-centered outcomes.
Chang et al (2016) Amstar Low	SR N=14 n=1277	**Pain** MPQ, VAS **Disability** SF-12, SF-36, PDI, ODI, RMDQ.	**Yoga > MI/usual care**	**Yoga = non-pharmacologic treatment**	Yoga appears as effective as other non-pharmacologic treatments in reducing the functional disability of back pain. It appears to be more effective in reducing pain severity or “bothersomeness” of CLBP when compared to usual care or no care. Yoga may have a positive effect on depression and other psychological co-morbidities, with maintenance of serum BDNF and serotonin levels. Yoga appears to be an effective and safe intervention for chronic low back pain.
Hill et al (2013) Amstar Low	SR N=4 n=711	**Pain** NR **Disability** ODI, RMDQ	**NR**	**NR**	Three out of the four papers conclude that yoga is an effective management tool for cLBP, with all four concluding that it is effective in improving back function.
Holzman et al (2013)	SR (MA) N=8 (8)	**Pain** **Disability:**	**Yoga = Exercise**	**Yoga = Exercise**	Yoga may represent an efficacious adjunctive treatment for CLBP; the effect size for yoga in reducing pain and functional disability appears to be similar to, if not higher than, effects sizes for more traditional exercise therapy, cognitive behavioural therapy and acupuncture). Overall, the findings provide the strongest support for the effects of yoga on short-term improvements in functional disability among patients with CLBP; a range of different yoga interventions yielded statistically similar effect sizes.

Amstar Low	n=743		**Post-Treatment after Yoga** d=0.623 (95%CI 0.377; 0.868). (5 *trials*). **Follow-up after Yoga** d=0.397 (95%CI 0.053; 0.848). (5 *trials*).	**Post treatment after Yoga:** d=0.645 (95%CI 0.496; 0.795). (8 *trials*). **Follow up after Yoga**: d=0.486 (95%CI 0.226; 0.746). (6 *trials*).	
Posadzki & Ernst (2011) Amstar Low	SR N=7 n= 403	**Pain:** VAS, NRS, Pain medication usage and pain-related attitudes/ behaviors. **Disability:** ODI, RMDQ	**Yoga > Self-care** MD=-2.2 (95%CI -3.2; -1.2, **Yoga > conventional therapeutic exercise** MD=-1.8 (95%CI -3.5; -0.1). No significant differences between Iyengar yoga and standard exercise.	**Yoga > Self-care** MD=-3.4 (95%CI, -5.1;-1.6). No significant difference in RMDQ between Iyengar yoga and standard exercise.	Five RCTs suggested that yoga leads to a significantly greater reduction in low back pain than usual care, education or conventional therapeutic exercises. Two RCTs showed no between-group differences. It is concluded that yoga has the potential to alleviate low back pain. However, any definitive claims should be treated with caution.
Wieland et al (2017) Amstar High	SR(MA) N=12(9) n=1080	**Pain intensity** VAS **Disability** RMDQ	**Yoga > non-exercise controls** *Intermediate term:3mo* MD -4.55 (95% CI -7.04; -2.06). *Long-term:* 6mo MD -7.81 (95% CI -13.37; -2.25). *Long-term: 12*mo: MD -5.40 (95% CI -14.50; -3.70). **Yoga > non-yoga exercise controls** *Long-term: 7*mo	**Yoga > non-exercise controls** *Short-term:* SMD -0.45 (95%CI -0.71; -0.19). (5 *trials*) *Intermediate term:* SMD -0.40 (95%CI -0.66; -0.14). (7 *trials*) *Long-term:* 6mo: SMD -0.44 (95% CI -0.66; -0.22). (6 *trials*) *Long-term: 12*mo: SMD -0.26 (95%CI -0.46; -0.05). (*2 trials*).	Yoga was found to be more effective for pain at three and six months; uncertain whether there is any difference between yoga and other exercise for back-related function or pain, or whether yoga added to exercise is more effective than exercise alone. There is a need for additional high-quality research to improve confidence in estimates of effect, to evaluate long-term outcomes, and to provide additional information on comparisons between yoga and other exercise for chronic non-specific low back pain.

			MD -20.40 (95% CI -25.48;-15.32). (4 *trials*). **Yoga + exercise > exercise alone** *Short-term: 10wks* MD -3.20 (95% CI -13.76; 7.36). (*2 trials*)		
Zou et al (2019) Moderate	SR (MA) N=17 (11) n=1444	**Pain intensity:** NRS, VAS, ABPS **Disability:** RMDQ, ODI	**Yoga > control group** SMD= -0.33 (95%CI -0.47; -0.19).	**Yoga > control group** SMD=-0.39 (95%CI -0.49; -0.28).	Yoga, may be beneficial for CLBP symptomatic management, irrespective of non-control comparison or active control comparison (conventional exercises, core training, and physical therapy programs). There were also few Tai Chi and Qigong studies included as mindful exercises in analyses. Moderator analyses revealed no significant effect, except for pain in favor of 2 tai chi studies
Abbreviations: ABPS=Aberdeen Back Pain Scale (0-100); d=Cohen's d (Effect Size); GE=General Exercise; MA=Meta-analysis; MI=Minimal intervention; MT=Manual Therapy; NR=not reported; NRS=Numeric rating scale (0-10); MD=Mean difference, MPQ=McGill Pain Questionnaire (0-100); ODI=Oswestry Disability Index (0-100); PDI=Pain Disability Index (0-100); PPI= Present Pain Index (0-100), RMDQ=Roland Morris Disability Questionnaire (0-100); SR=Systematic Review; SMD=Standardized Mean Differences, SMC=Standard Medical Care; VAS=Visual Analog scale (0-100).					

Table 4: Summary of findings and overall quality as assessed with GRADE.

Outcome	Type of exercise (Intervention)	Phase	GRADE FACTORS							Overall quality (level of evidence)
			Study limitations	Inconsistency	Indirectness	Imprecision	Publication bias	Moderate/large effect size	Dose effect	
PAIN	Aerobic exercise	++++	0	0	0	0	-	0	0	Moderate quality (+++)
	Aquatic exercise	++++	-	0	0	0	-	0	0	Low quality (++)
	Motor control Exercises	++++	-	-	0	0	0	0	0	Moderate quality (+++)
	Pilates	++++	-	0	0	0	0	0	0	Moderate quality (+++)
	Resistance training	++++	-	-	0	-	-	0	0	Very low quality (+)
	Sling exercise	++++	-	0	0	0	0	0	0	Moderate quality (+++)
	TCE (Tai Chi, Qigong)	++++	0	-	0	0	0	0	0	Moderate quality (+++)
	Walking	++++	-	0	0	-	0	0	0	Low quality (++)
	Yoga	++++	0	-	0	-	0	0	0	Low quality (++)
DISABILITY	Aerobic exercise	++++	0	0	0	0	-	0	0	Moderate quality (+++)
	Aquatic exercise	++++	-	0	0	0	-	0	0	Low quality (++)
	Motor control Exercises	++++	-	-	0	-	0	0	0	Very low quality (+)
	Pilates	++++	-	-	0	0	0	0	0	Low quality (++)
	Resistance training	++++	-	-	0	-	-	0	0	Very low quality (+)
	Sling exercise	++++	0	-	0	-	0	0	0	Low quality (++)
	TCE (Tai Chi, Qigong)	++++	0	-	0	-	0	0	0	Low quality (++)
	Walking	++++	-	0	0	-	0	0	0	Low quality (++)
	Yoga	++++	0	-	0	-	0	0	0	Low quality (++)

Figures

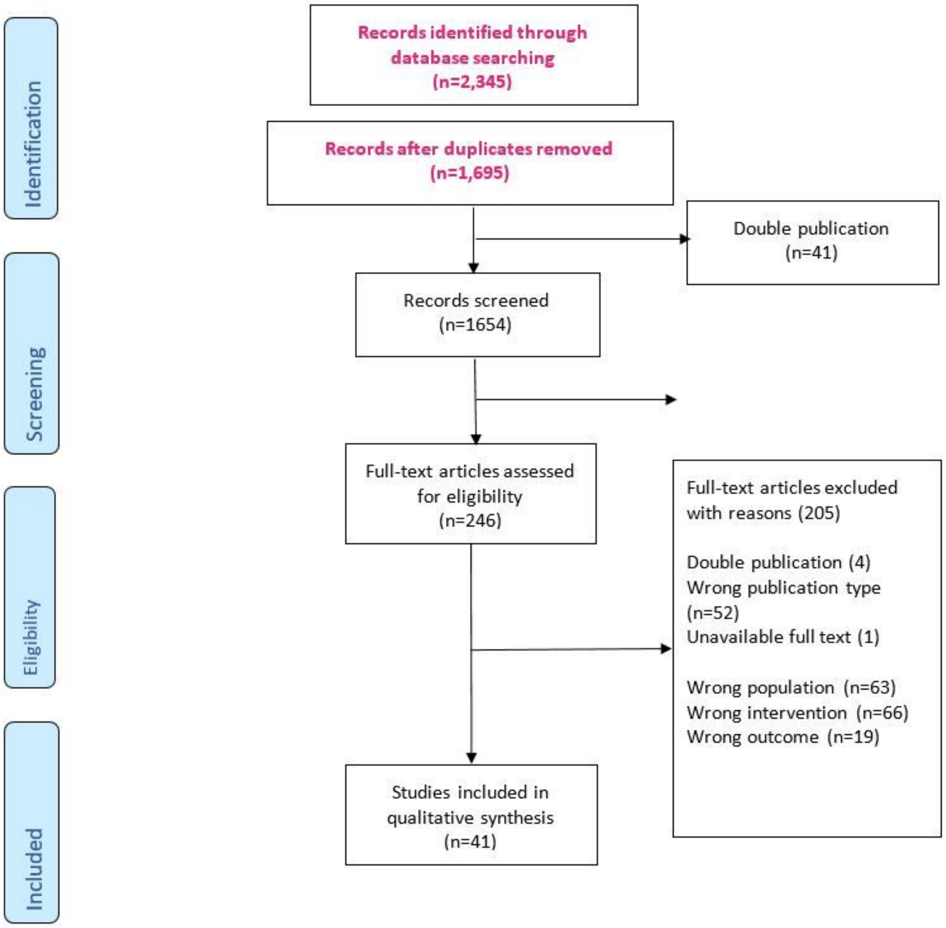

Figure 1

PRISMA chart for eligible study selection process

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Appendix1PRISMACHECKLIST.docx
- Appendix2Searchstrategy.docx
- APPENDIX3Listofexcludedstudies.docx
- APPENDIX4DESCRIPTIONOFTHEINCLUDEDSTUDIES.docx