Published in final edited form as:
Arch Phys Med Rehabil. 2023 May ; 104(5): 776–789. doi:10.1016/j.apmr.2022.10.004.

Mind-Body Exercise Performed by Physical Therapists for Reducing Pain and Disability in Low Back Pain: A Systematic Review with Meta-Analysis

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Abstract

Objective: *To a*ssess the effectiveness of mind-body (MB) exercise interventions provided by physical therapists for reducing pain and disability in people with low back pain (LBP).

Data Sources: MEDLINE, Embase, CINAHL, and the Cochrane Library were searched for articles published in English between Dec. 2010 and June 2020.

Study Selection: Randomized controlled trials evaluating the effects of Pilates, yoga, and Tai Chi interventions performed by physical therapists on pain or disability outcomes in adults with musculoskeletal LBP were included.

Data Extraction: Data were extracted by 2 independent reviewers. Quality of evidence and risk of bias were assessed using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) framework and Cochrane risk of bias tools, respectively.

Data Synthesis: 21,230 exercise trials were identified; 161 progressed to full-text review. Eight trials, 7 reporting on Pilates and one reporting on yoga, were included. Short-term outcomes for pain (SMD: −0.93; 95%CI: −1.65 to −0.021) and disability (SMD: −0.74 95%CI: −1.36 to −0.012) indicated MB exercise was more effective than control intervention. Tests for subgroup differences between studies with exercise vs non-exercise control groups revealed a moderating effect on short-term outcomes where larger effects were observed in studies with non-exercise comparators. Long-term outcomes for pain (SMD: −0.60; 95% CI:−1.43 to 0.23) and disability (SMD: −1.05; 95% CI:−3.51 to 1.41) suggested that MB exercise is not more effective than control interventions for pain or disability. Quality of the evidence ranged from very low to low.

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Competing Interests: Authors declare no conflict/competing interests

Registration and Protocol: The protocol for this review was not pre-registered.

Conclusion: Physical therapist-delivered MB exercise interventions, which overwhelmingly consisted of Pilates, were more effective than control in the short and long-term for pain and in the short-term for disability, with differences in the short-term effects lessened when compared to an active intervention. Pilates interventions delivered by physical therapists represent a viable tool for the clinical management of chronic LBP.

Keywords

Low back pain; mind-body exercise; Pilates; Meta-Analysis

Low back pain (LBP) is the most prevalent chronic pain in the United States (US)[1] and accounts for more years lived with disability than any other condition.[2, 3] Estimates of annual US healthcare spending related to LBP are greater than $100 billion.[4] This cost not only includes health care expenditures and disability payments, but also indirect costs such as lost school days, productivity, and employment, and reduced incomes, and quality of life.[1]

Despite the prevalence and cost, there is no consensus of "best practice" for treating LBP.[5] Exercise is recommended ubiquitously in practice guidelines;[6–10] however, associated effect sizes for pain and disability outcomes are small to moderate.[11–14] Direct comparisons of exercise interventions often fail to demonstrate superiority of one intervention over another.[15] The state of evidence makes clinical decision making regarding specific exercise approaches for individuals with LBP challenging. Additionally, exercise adherence is necessary for effective management of LBP[16, 17], and lack of adherence to exercise may limit long-term effects. Evidence-based strategies to support long-term exercise adherence include prescribing exercises patients perceive as effective, and encouraging self-initiated participation in structured and organized training.[18] These strategies are critical to transitioning patients with LBP from managed care in physical therapy to sustainable self-care that reduces the likelihood of persistent or recurrent symptoms. The challenges of prescribing specific and sustainable exercise for individuals with LBP are compounded by significant heterogeneity within the diagnosis, the limited utility of current subclassification systems[15, 19], and the fact that LBP is the most common diagnosis in outpatient physical therapy.[20]

Recent network meta-analyses indicate that mind-body (MB) exercise interventions are effective interventions for treating LBP.[11, 12] Systematic reviews assessing the treatment effects of Pilates[21, 22], yoga[23–25], and tai chi[26] interventions compared to non-exercise control interventions for LBP report these treatments reduce either pain, disability, or both in the short and long-term.[21–26] The non-exercise controls from these reviews include usual care, waitlist intervention, and educational booklets. When MB exercise interventions are compared to exercise controls, such as back-focused exercise, stabilization exercise, and multi-modal exercise training programs, little to no differences are reported for reducing short or long-term pain or disability.[21–23, 25]

As evidence for effectiveness of MB exercise interventions accumulates, these treatment approaches are being integrated into physical therapy plans of care in the clinical management of LBP.[27–36] The "mind-body" connection is of particular interest in the treatment and management of chronic pain.[37] In the majority of studies on MB exercise, the treatment of LBP is not performed in a clinical setting and is not provided by physical therapists.[25, 26, 38–44] For these reasons, the preponderance of literature regarding MB exercise interventions lacks information regarding effectiveness as a component of a treatment plan and generalizability to physical therapy practice. [25, 26, 38–44] It is also essential to consider if there are differences in effect sizes based on method of delivery, provider, and comparator intervention. Currently, no summary of evidence regarding MB exercise interventions with inclusion criteria that require interventions be performed by physical therapists exists. MB exercise may represent a powerful and underutilized clinical tool to combat the societal burden of LBP. Therefore, the aim of this study was to determine the effectiveness of MB exercise interventions when provided by physical therapists for reducing short and long-term pain and disability in people with LBP.

Methods

This review is a supplement to the recent Academy of Orthopedic Physical Therapy's Clinical Practice Guideline (AOPT CPG) *Interventions for the Management of Acute and Chronic Low Back Pain: Revision 2021*.[15] This study protocol was not preregistered because it is an analysis of the systematic search results produced for the AOPT CPG. The study was written in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[45] For the purpose of this review, we operationally defined MB exercise interventions as Pilates, yoga, and tai chi. This definition is in line with Cochrane Complementary Medicine's operational definition which excludes most exercise therapies, with an exception for MB exercise, such as tai chi/tai ji, Yoga therapy, and Pilates as MB exercise.[46] These exercises are the most common MB exercises used in trials for LBP treatment, and were included in the AOPT CPG search strategy, with relevant studies extracted; however, not included in the recent AOPT CPG, therefore, a separate review of this evidence was warranted.

Data Sources and Searches

The search strategy for the AOPT CPG included sub-searches based on intervention categories and is detailed elsewhere.[15] This review utilizes the results from the exercise sub-searches (Appendix A). These sub-searches included specific search terms for yoga, tai chi and Pilates. We searched Medline via PubMed, Embase (via Elsevier), CINAHL Complete (via EbscoHost), and Cochrane Library. On June 25, 2020, the final searches were completed with no language limitations. Searches were limited to articles published after December 1, 2010 as literature predating this was described in a previous CPG.[6] We included only randomized clinical trials (RCT). Search results were compiled in Endnote libraries before being added to Covidence (Veritas Health Innovation Ltd, Melbourne, Australia) to undergo screening and selection.

Study Selection

The evidence selection criteria were identical to that of the AOPT CPG.[15] Briefly, 2 reviewers screened titles and abstracts independently. Titles and abstracts were labeled "Yes" if they met inclusion criteria, "Maybe" if unsure, and "No" if irrelevant. Titles and abstracts labeled "Yes" or "Maybe" by 2 reviewers progressed to full-text review. Full-text review was independently performed by 2 reviewers who voted to “Include” or “Exclude” articles. A third reviewer resolved disagreements between reviewers at all stages. Only high-quality RCTs (Physiotherapy Evidence Database (PEDro) score ≥ 6) were included in the final analysis.

Population/Participants

We included trials that recruited adults (≥18 years old) with primary complaints of musculoskeletal LBP defined with search terms as: “non-specific low back pain”, “mechanical low back pain”, “lumbosacral segmental/spinal instability” (including spondylolisthesis) “lumbosacral sprain”, “intervertebral disc degeneration” and/or “herniation”, “lumbar radiculopathy”, “sciatica”, “lumbosacral strain flatback syndrome”, “Lumbosacral somatic dysfunction”. Trials were excluded when conditions were not considered musculoskeletal LBP (e.g., fractures, infectious disease, tumors, ankylosing spondylitis, and visceral dysfunction).

Intervention

Included trials assessed the effect of MB exercise interventions performed by physical therapists. If the authors did not explicitly state that the intervention was performed by physical or physiotherapists, trials were excluded.

Comparators

Comparison groups included any non-exercise or exercise control. Non-exercise control was defined as any intervention that did not include any directed active component. Examples included no intervention, waitlist, education, minimal intervention, electrophysical agents, and manual therapy. Exercise control was defined as any intervention that included a directed active component but did not include components of MB exercise. Examples included specific trunk exercise, exercise of the upper or lower limbs, general conditioning exercise, aerobic exercise training, or some combination of these.

Outcome

Trials were included if they reported the effects of the interventions on pain, function, and/or disability as a primary or secondary outcome. Collectively, these were the primary outcomes of interest for this review.

Data Extraction

Following full-text review, 2 independent reviewers extracted data on study design, characteristics of participants, description of interventions, outcome measures, and treatment effects using a standardized extraction sheet. Data were extracted for every intervention and control group at all available time points.

Quality Assessment

The Cochrane Collaboration risk of bias tool (Version 2) was used to assess bias risk for included studies.[47] Each trial was rated high, low, or unclear risk in 7 domains by 2 independent reviewers with input from a third reviewer to resolve disagreements. Trials were categorized as high risk of bias if they had 5 or more high or unclear ratings, moderate risk of bias if 3–4 high or unclear ratings, and low risk of bias if they had 0–2 high or unclear ratings.[48]

Evaluation of Quality of Evidence

The Grading of Recommendations Assessment, Development and Evaluation (GRADE) framework was used to evaluate the quality of evidence.[49] Evidence from RCTs began as high-quality evidence, but confidence decreased due to inconsistency of results, indirectness of evidence, study limitations, imprecision, and reporting bias. Factors that increased certainty of evidence include large magnitude of effect, dose-response gradient, and the impact of unmeasured confounding factors.[49] Quality of evidence was rated by 2 independent reviewers with input from a third reviewer to resolve disagreements.

Data Synthesis and Analysis

When 2 or more studies reported the same outcome at the same time point (short or long-term follow-up), meta-analysis was performed and results were reported using a random-effects model (fixed effect model results are included in Appendix 1).[50,51] Short-term effects were defined as those measured between 0 and 6 weeks following the completion of the intervention. Long-term effects were defined as ≥ 12 weeks following the completion of the intervention. If multiple time points ≥ 12 weeks were reported, the longest follow-up time point data was used. Post-treatment means, standard deviations, and sample sizes were used to calculate effect sizes for meta-analyses. Medians, interquartile range, and 95% confidence intervals (CIs) were converted to means and standard deviations using Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0.[52] If authors only reported outcomes of interest data graphically, the Grabit tool[53] (version 1.0.0.1) in MATLAB was used to extract data needed for analysis. Effect sizes were calculated as standardized mean differences (SMD) with 95% CIs. Statistical heterogeneity of reported treatment effects was tested using I^2 and τ^2 tests. Analyses were conducted using Comprehensive Meta-Analysis (v 3.3.07) and RStudio (v2021.09.2). To determine if there was a moderating effect of the comparator intervention on pain and disability outcomes, studies were also subgrouped as either "non-exercise controls" or "exercise controls" and differences were analyzed with Q-test based on analysis of variance; alpha was set p=.05.[51] Guidelines were used for interpreting the magnitude of the SMDs where: small, SMD = 0.2; medium, SMD = 0.5; and large, SMD = 0.8.[54]

Results

Search

A total of 21,230 exercise intervention trials were identified in the full AOPT CPG search. Following title and abstract screening 161 MB exercise articles progressed to full-text review. Of these, 8 articles met inclusion criteria and were included in the systematic review and meta-analysis.[28–30, 32–36] Reasons for exclusion are provided in Figure 1. Seven of 8 MB exercise interventions were Pilates;[28–30, 33–36] a single study included yoga.[32] Zero studies for tai chi interventions met the inclusion criteria. All studies included participants with chronic LBP; no studies included acute or subacute LBP. Chronic LBP was defined as symptoms >3 months in duration.[55] All studies reported at least one outcome measure for pain. [28–30, 32–36] Six trials also reported outcome measures for disability.[29, 30, 32, 34–36] Four studies had non-exercise control groups for comparators,[28–30, 34] 3 of which were completed by the same research group but appeared to represent different samples. Four studies compared MB exercise interventions to other exercise interventions.[32, 33, 35, 36] Table 1 describes study characteristics and key findings from each trial.

Quality Assessment

Figure 2 presents the results of the Cochrane risk of bias tool for each of the 8 studies. None of the studies blinded participants due to the nature of the interventions. Four studies had high or unclear risk of bias in the selective reporting domain.[28, 30, 33, 35] Three studies had either high or unclear risk of bias in the blinding of outcome assessment domain.[32, 33, 36] Three studies had unclear or high risk of bias in the incomplete outcome data domain.[32, 33, 35] Overall, 1 study had a high risk of bias[33], 5 studies had a moderate risk of bias[28, 30, 32, 35, 36], and 2 studies had a low risk of bias.[29, 34]

MB Exercise Interventions for Pain in the Short and Long-Term

Eight trials (n=558) indicate that MB exercise is more effective than control interventions for pain in the *short term* (random effects model - pooled SMD: −0.93; 95% CI:−1.65; −0.21) with high heterogeneity (I^2=88%, τ^2=.6283, p<.01) (Figure 3A).

Four trials (n=296) suggest that Pilates is not more effective than control interventions for pain at *long-term* follow-up (random effects model - pooled SMD: −0.60; 95% CI:−1.43; 0.23) with high heterogeneity (I^2=81%, τ^2=.2279, p<.01) (Figure 3B). Quality of evidence was very low; quality was downgraded due to study limitations, inconsistency, indirectness, imprecision, and reporting bias (see Table 2).

Moderating Effect of Type of Control Intervention on Pain

Tests for subgroup differences indicate that the type of control intervention (exercise vs non-exercise) is a moderator of the effect on pain in the *short term* (random effects: χ_1^2 = 12.78, df = 1, $p < 0.01$) but not in the *long term* (random effects: χ_1^2 = 1.34, df = 1, p =.25). The weighted average pain score at baseline across studies was 6.3/10 in studies with non-exercise comparators and 5.0/10 in studies with exercise comparators. Subgroup analysis of the 4 non-exercise control trials (n=348) suggests Pilates is more effective for pain in the *short term* (random effects model - pooled SMD: −1.56; 95% CI:−2.69; −0.42) (Figure 3A). Heterogeneity was high (I^2=83%, τ^2=.6283, p<.01) and quality of evidence was low. Quality was downgraded due to inconsistency, indirectness, and reporting bias, and upgraded due to a large effect (see Table 2). Subgroup analysis of the 4 exercise control trials (n= 210) indicates MB exercise is more effective than alternative exercise interventions (random effects model SMD: −0.26; 95%CI: −0.46; −0.07) for pain at *short-term* follow-up (Figure 3A). Heterogeneity was low (I^2=0%, τ^2=0, p=0.90; results from fixed-effect model are included in Appendix 1) and quality of evidence was very low. Quality was downgraded due to study limitations, imprecision, and reporting bias (see Table 2).

MB Exercise Intervention for Disability in the Short and Long-Term

Six trials (n=437) reveal MB exercise is more effective than control interventions for disability in the *short term* (random effects model - pooled SMD: −0.74; 95% CI:−1.36; −0.12) with high heterogeneity (I^2=80%, τ^2=.2737, p<.01) (Figure 3C).

Four trials (n=296) suggest that Pilates is not more effective than control interventions for disability at *long-term* follow-up (random effects model - pooled SMD: −1.05; 95% CI:−3.51; 1.41) with high heterogeneity (I^2=96%, τ^2=2.2930, p<.01) (Figure 3D). Quality of evidence was very low. Quality was downgraded due to due to study limitations, inconsistency, indirectness, imprecision, and reporting bias and upgraded due to a large effect estimate (see Table 2).

Moderating Effect of Type of Control Intervention on Disability

The type of control intervention (exercise vs non-exercise) is also a moderator of the effect on disability in the *short term* (random effects: χ_1^2 = 7.68, df = 1 p < 0.01) but not in the *long term* (random effects: χ_1^2 = 1.42, df = 1, p =.23). However, when pooled effects for *short-term* disability are calculated for each subgroup independently, both CIs contain the null value 0. Subgroup analysis from 3 non-exercise control trials (n= 251) indicates MB exercise is not more effective (random effects model SMD: −1.15 95% CI: −2.49; 0.18) for chronic LBP related disability in the *short term* (Figure 3C). There was high heterogeneity (I^2=75%, τ^2=.2141, p<.02) and quality of evidence was low. Quality was downgraded due to inconsistency, indirectness, and reporting bias and upgraded due to large effect (see Table 2). Subgroup analysis from 3 exercise control trials (n= 186) indicates MB exercise is not more effective than alternative exercise (pooled SMD: −0.27; 95%CI: −0.59; 0.05) for disability at *short-term* follow-up (Figure 3C). Heterogeneity was low (I^2=0%, τ^2=0, p<.78; results from fixed-effect model are included in Appendix 1). Quality of evidence was very low; quality was downgraded due to study limitations, imprecision, and reporting bias (see Table 2).

Discussion

Search Results

Our search resulted in 8 articles that were eligible for analysis. Seven of these articles investigated Pilates interventions, which make it impossible to generalize these findings to other MB exercise interventions. This is especially true for the analysis of subgroups with non-exercise comparators and long-term outcomes, where all studies included Pilates interventions. No studies were found for Tai Chi performed by physical therapists and only one for yoga. Assuming there is a relationship between interventions that demonstrate positive findings in randomized clinical trials and interventions that are implemented in practice, our results suggest that Pilates is more commonly used by physical therapist treating LBP than other MB exercise interventions. Pilates exercise focuses on activation of specific lumbopelvic muscles and the maintenance of trunk-hip postures while over time adding progressively more challenging movement patterns and postures. This is remarkably similar to the motor control exercises and trunk muscle strengthening/endurance exercises that are considered standard of care in physical therapy practice guidelines for LBP.[6, 15]

MB Exercise Interventions for Pain

We found a large effect favoring MB exercise for pain in the short term. Additionally, we found subgroup differences between studies with non-exercise and exercise control groups with larger effects observed in studies with non-exercise comparators. Prior meta-analyses comparing MB exercise to non-exercise controls have reported small effect estimates for pain at short-term follow-up with mean differences (MD) ranging from 0.83 to 1.62 on a 0–10 scale[22, 56] and between 10.83 to 14.05 on a 0–100 scale.[25, 57] Some authors of these reviews question the clinical significance of an effect of this magnitude.[34] Meta-analyses reporting SMDs for pain outcomes in the short term have varied. Anheyer et al[23] reported a small effect with narrow CIs from a relatively large pooled sample size when comparing yoga to non-exercise controls, whereas Lim et al[21] reported a large effect with wide Cis from a smaller pooled sample comparing Pilates to similar controls. The SMD estimate from the present review of MB exercise performed by physical therapists is large, and the upper bound of the CI approaches a moderate effect. Our estimate was calculated using studies of Pilates interventions only and should be interpreted accordingly.

Meta-analyses comparing MB exercise to exercise controls for pain in the short- term have uniformly reported null findings[21–23, 56] and have generated small MDs (0.12 to −0.37 on a scale from 0/10)[22, 56] and small SMDs (0.03 to −0.39).[21, 23] The results from the present review including both Pilates and yoga interventions performed by physical therapists are of similar magnitude to previous studies, but our random effects model returned CIs that did not contain zero. Alternatively, using a fixed effect model the SMD estimate is exactly the same (−0.26) but CIs widen to include zero (−0.54 to 0.01) (see Appendix 1). Given the low heterogeneity in the exercise control subgroup (I^2=0%, τ^2=0, p=0.90), a fixed effect model may produce a more accurate estimate.

Our results indicate that Pilates is not more effective than control interventions for pain at long-term follow-up and no subgroup differences between studies with non-exercise vs exercise control groups were detected (p=.25). Yamato et al[57] reported an effect (MD: −10.54 (scale 0–100) 95%CI:−18.46; −2.62) that favored Pilates over minimal intervention at long-term follow-up, but did not report effects compared to other exercises due to high heterogeneity.[57] The estimate from our analysis represents a moderate effect, but with a 95% CI that contains zero. This could be due to few studies and small pooled sample sizes limiting the power to detect a true effect. It is possible that with this small number of studies, the influence of a single study with a large effect[29] results in a pooled effect of this magnitude. See Table 3 for a summary of effect estimates for pain reduction from previous meta-analyses of MB exercise interventions for the treatment of LBP that were not limited to the intervention being performed by physical therapists.

MB Exercise Interventions for Disability

We found a moderate effect indicating MB exercise is more effective than control interventions for disability in the short term. Like our results for pain in the short term, we detected differences in effects between studies with non-exercise vs exercise control groups with larger effects seen in studies with non-exercise controls. Interestingly, both estimates from our subgroup analysis had 95% CIs that contained 0. This is true despite observing a large point estimate in the subgroup with non-exercise controls. This finding may be due to the small number of studies (n=3) in these subgroups limiting statistical power to detect a true effect.

Meta-analyses comparing MB exercise interventions to non-exercise controls for disability outcomes at short-term follow-up have reported mostly small effects favoring MB exercise.[23, 25, 34, 56, 57] In reviews of Pilates exercise, MDs for disability outcomes were reported between 5.2 to 7.95 on a 0–100 scale, which were statistically significant, but again authors have questioned their clinical relevance.[34, 57] Meta-analyses of yoga interventions have reported SMDs for disability ranging from −0.30 to −0.45.[23, 25, 56] In both the review of Pilates interventions by Lim and colleagues[21] and the present review, we see a moderate effect size but CIs were wide and contained zero. A large effect could be seen as promising, but the imprecision in this estimate is substantial, making interpreting this finding difficult.

Previous meta-analyses of MB interventions compared to exercise controls for disability outcomes at short-term follow-up have reported small effects[23] or null results[21, 25, 56, 57] with SMD estimates ranging from −0.02 to −0.41.[21, 23, 25, 56] The current review comparing Pilates and yoga interventions delivered by physical therapists to alternative forms of exercise agrees with the preponderance of literature demonstrating small effect estimates and CIs that contain zero (see Table 3).

Our results indicate Pilates is not more effective than control interventions for disability at long-term follow-up and no detectable subgroup differences between studies with non-exercise vs exercise control groups (p=.23). Yamato et al[57] reported a moderate effect (MD: −11.17 (scale 0–100) 95%CI: −18.41; −3.92) for disability compared to non-exercise control and no effect (MD: −0.91 (scale 0–100) 95%CI: −5.02; 3.20) compared to exercise control in the long term. The point estimate from the present analysis represents a large effect, but with a 95% CI that contains 0. Like our analysis for pain at long-term follow-up, this could be due to relatively few studies and small pooled sample sizes limiting the power to detect a true effect. Our point estimate for disability is strongly influenced by a single study[29] that also influenced our point estimate for pain at long-term follow-up. This study by Cruz-Diaz et al.[29] included an all-female sample between 45–75 years of age, whereas other studies with long-term follow-up did not restrict age and sex to this extent. This likely influenced the magnitude of their effect estimate and the width of the CIs.

Clinical Implications

A novel aspect of this review is that previous work did not require explicit reporting that interventions were performed by physical therapists. Additionally, this review includes higher-quality trials with updated evidence. The findings of large and moderate effects for pain and disability, respectively, favoring MB exercise over control interventions indicate that MB exercise represents a viable clinical tool in managing LBP.

The finding of small effects or no difference between MB exercise and other forms of exercise for pain and disability appears robust in the literature and does not vary when inclusion criteria necessitate interventions are performed by physical therapists.[21, 22, 25] This work corroborates existing evidence that suggests there may be no “best” exercise treatment for chronic LBP when studied as one heterogeneous group. Current evidence-based exercise prescription for treating chronic LBP may be *exercise-agnostic.* Instead of searching for a single superior exercise intervention therapists should consider a philosophy of exercise prescription that is focused on: 1) relevant factors identified during the history and examination, 2) patient preference and beliefs, 3) therapist training and experience, and 4) the feasibility and sustainability of exercise in the patient's specific context. Patients who value exercise utilizing a "mind-body" approach may find this form of exercise more enjoyable and sustainable than traditional interventions.

Clinicians utilizing these interventions should consider developing relationships with community partners (i.e., studios and gyms) to make appropriate referrals and recommendations to help clients realize the benefits of regular exercise to their health. Mind-body exercise interventions are widely offered and represent a pathway for patients with LBP to transition from individual supervised clinical exercise to more independent exercise in the community. Interventions like yoga, tai chi, and Pilates are offered at the YMCA and other local facilities, often at little or no cost at senior centers in communities across the US. This allows patients the potential to engage in self-initiated participation in structured and organized training to promote long-term adherence.

Future Directions

The current state of evidence provides some data regarding Pilates, much less information concerning yoga, and no evidence for tai chi interventions when performed by physical therapists. It would be of interest to determine if implementing these interventions clinically followed by transitioning patients to a similar exercise in a community setting leads to better long-term outcomes and exercise adherence. Facilitating transitions from managed to self-care is critical for effective, long-term management of chronic LBP.

Future research should also explore the potential of a dose-response relationship for Pilates interventions. In the subset of studies with non-exercise control groups, a much larger effect estimate was seen in the single trial that implemented a 12-week intervention[30] compared to 6-week interventions.[28, 29, 34] In a study excluded from this review because authors did not explicitly state interventions were performed by physical therapists, Marshall et al.[40] reported significant between-group differences for pain and disability that favored Pilates over a stationary cycling program (exercise control) in the short-term. Improvements in the Oswestry Disability Index following the 8-week intervention were in the range of established minimal clinically important differences. Differences in outcomes between Marshall et al. and the studies in this review may be attributable to a higher dose of Pilates (3x/week for 8 weeks) than any of the trials included in this review with exercise controls.[32, 33, 35, 36]

Finally, additional research is needed to identify patient characteristics or presentations that are most appropriate for MB exercise interventions or are associated with treatment response. The 2 largest studies in this review included only female participants >45 years of age.[28, 29] While this limits the generalizability of the findings, the large effect sizes in these studies for pain and disability scores suggest that this population may be particularly responsive to Pilates exercise interventions.

Limitations

This review is limited by the small number of studies included and the dearth of information on MB exercise interventions outside of Pilates. More comprehensive search terms that consider the full array of MB exercise interventions, such as including interventions like Qigong/ chi-kung and others, may have resulted in a larger study sample. The RCTs using exercise comparators in their control groups generally included participants (in both groups) with lower pain scores at baseline than those in the trials comparing MB exercise interventions to non-exercise control group interventions.[28–30, 32–36] This may contribute to smaller effect estimates in the studies with exercise comparators as these participants had less room to improve. Three of the 8 studies included in this review were produced by the same research group.[28–30] This raises concerns of repeatability and generalizability. Several studies included in this review recruited samples that had a disproportionate number of female subjects >45 years of age. While chronic LBP does affect females at a higher rate than males[1, 58], these samples limit the generalizability of findings outside this demographic. The literature search included publications from December 2010- June 2020, therefore, there is potentially both older and newer literature that could contribute to this body of knowledge that is not considered here. Lastly, because our inclusion criteria required authors to explicitly state interventions were performed by physical therapists, relevant studies may have been excluded for failure to report this information.

Conclusion

The existing MB exercise literature in which the intervention was delivered by physical therapists is dominated by Pilates studies, with a need for more trials focusing on yoga, tai chi, and other forms of MB exercise. MB exercise interventions performed by physical therapists are more effective in the short term than non-exercise treatments for low back related pain and disability and Pilates interventions are more effective in the long term for pain. MB exercise interventions were as effective in the short term, but not more effective than traditional exercise interventions for pain and disability.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements:

Contributors to the AOPT CPG exercise team who screened and reviewed articles and extracted data: Courtney Butowicz PhD, Travis Pollen PhD, Eric Folkins DPT, Michael Roberto DPT, Won Sung PhD, DPT, and Michael Steimling DPT.

Support:

This publication was made possible in part by Grant Number T32-GM081740 from NIH-NIGMS (JRG). Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the NIGMS or NIH. Dr. George disclosed financial relationships with Rehab Essentials and Med Risk Inc, outside the submitted work.

Availability of data, code, and other materials:

Data are available upon request. Data extraction sheets and data used to calculate effect sizes are available by emailing the corresponding author.

Abbreviations:

AOPT CPG	Academy of Orthopedic Physical Therapy's Clinical Practice Guideline
CIs	confidence intervals
GRADE	Grading of Recommendations Assessment, Development and Evaluation
LBP	low back pain
MB	mind-body
MD	mean difference
RCT	randomized controlled trials
SMD	standardized mean difference

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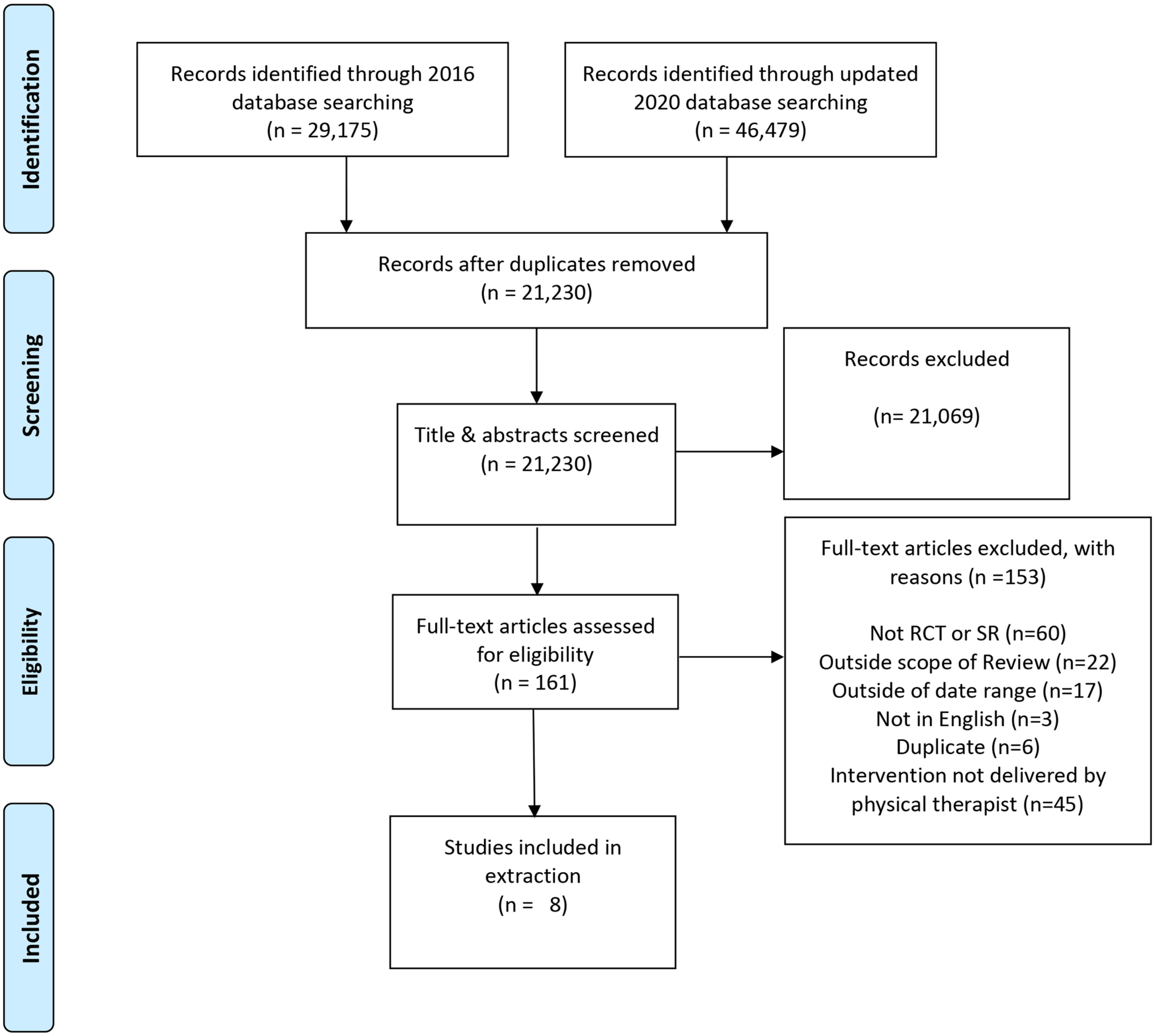


FIGURE 1. PRISMA Flow Diagram

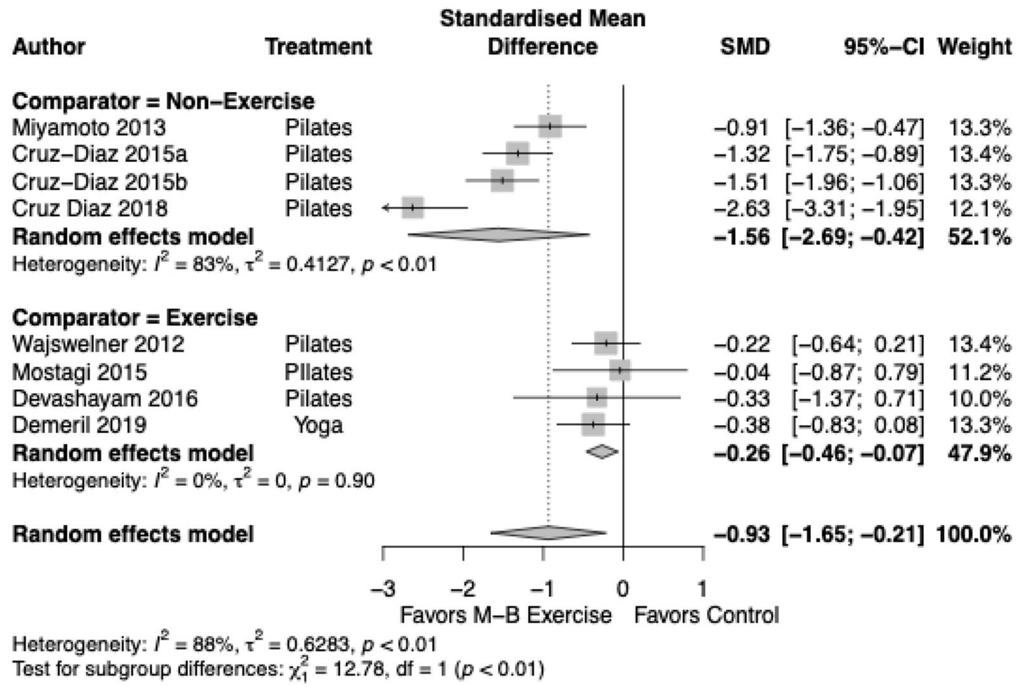
From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other Bias
Wajswelner 2012	+	+	-	?	+	+	?
Miyamoto 2013	+	+	-	+	+	+	+
Mostagi 2015	+	+	-	+	-	?	-
Cruz-Diaz 2015a	+	+	-	+	+	+	?
Cruz-Diaz 2015b	+	?	-	+	+	?	?
Devasahayam 2016	?	+	-	?	-	?	-
Cruz-Diaz 2018	+	+	-	+	+	?	?
Demirel 2019	+	+	-	-	?	+	?

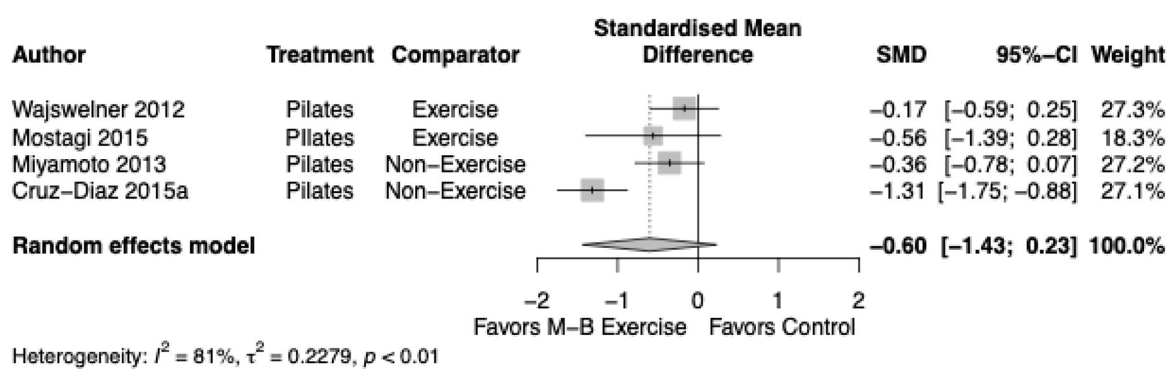
+ Low risk ? Unclear - High risk

FIGURE 2.
Risk of bias assessment results for included studies

A


Author
Treatment
Standardised Mean Difference
SMD
95%–CI
Weight
Comparator = Non–Exercise
Miyamoto 2013 Pilates −0.91 [−1.36; −0.47] 13.3%
Cruz–Diaz 2015a Pilates −1.32 [−1.75; −0.89] 13.4%
Cruz–Diaz 2015b Pilates −1.51 [−1.96; −1.06] 13.3%
Cruz Diaz 2018 Pilates −2.63 [−3.31; −1.95] 12.1%
Random effects model −1.56 [−2.69; −0.42] 52.1%
Heterogeneity: I2 = 83%, τ2 = 0.4127, p < 0.01
Comparator = Exercise
Wajswelner 2012 Pilates −0.22 [−0.64; 0.21] 13.4%
Mostagi 2015 PIlates −0.04 [−0.87; 0.79] 11.2%
Devashayam 2016 Pilates −0.33 [−1.37; 0.71] 10.0%
Demeril 2019 Yoga −0.38 [−0.83; 0.08] 13.3%
Random effects model −0.26 [−0.46; −0.07] 47.9%
Heterogeneity: I2 = 0%, τ2 = 0, p = 0.90
Random effects model −0.93 [−1.65; −0.21] 100.0%
−3 −2 −1 0 1
Favors M–B Exercise
Favors Control
Heterogeneity: I2 = 88%, τ2 = 0.6283, p < 0.01
Test for subgroup differences: χ21 = 12.78, df = 1 (p < 0.01)

B


Author
Treatment
Comparator
Standardised Mean Difference
SMD
95%–CI
Weight
Wajswelner 2012 Pilates Exercise −0.17 [−0.59; 0.25] 27.3%
Mostagi 2015 PIlates Exercise −0.56 [−1.39; 0.28] 18.3%
Miyamoto 2013 Pilates Non–Exercise −0.36 [−0.78; 0.07] 27.2%
Cruz–Diaz 2015a Pilates Non–Exercise −1.31 [−1.75; −0.88] 27.1%
Random effects model −0.60 [−1.43; 0.23] 100.0%
−2 −1 0 1 2
Favors M–B Exercise
Favors Control
Heterogeneity: I2 = 81%, τ2 = 0.2279, p < 0.01

C

D

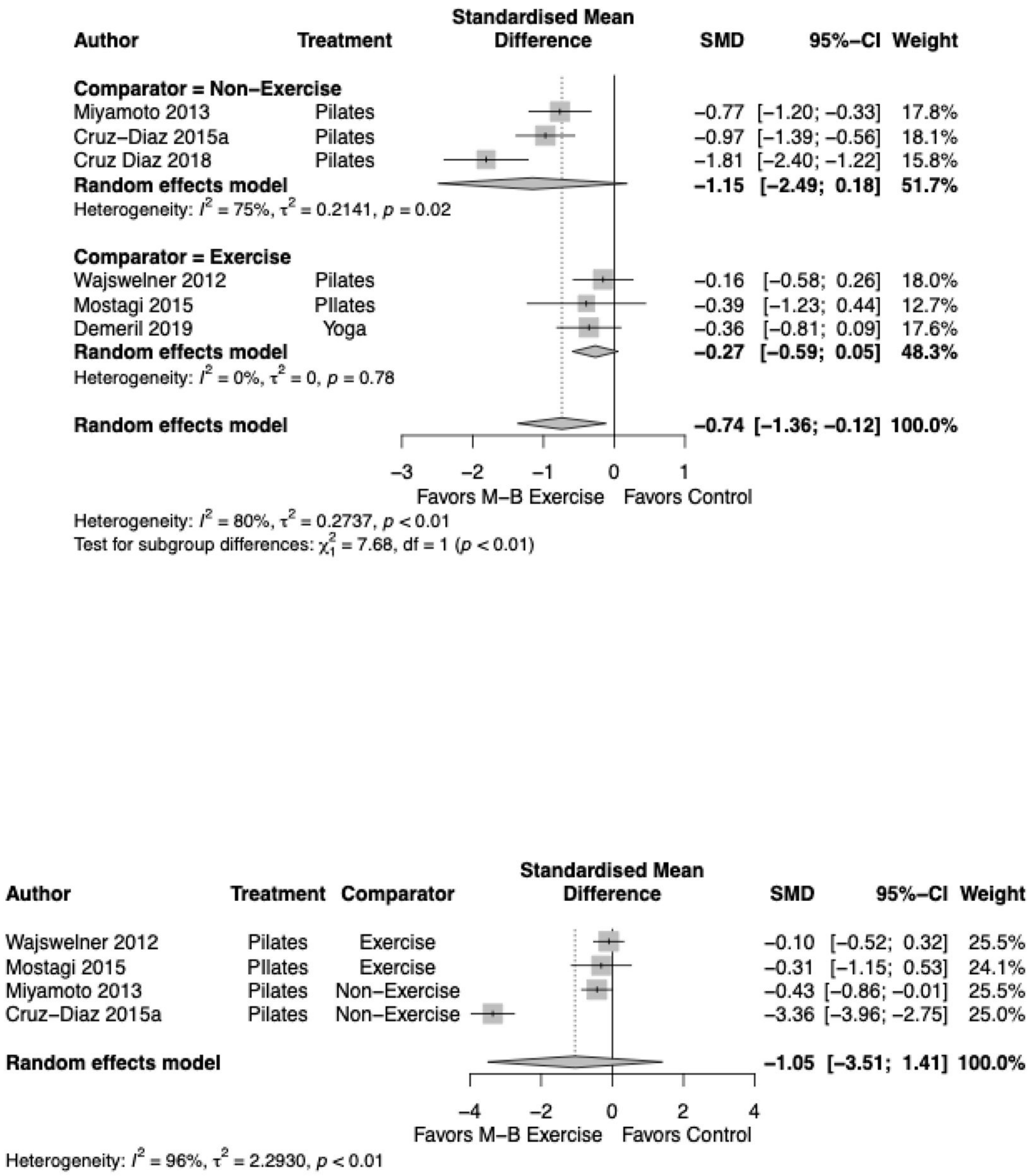


Fig 3 Forest plots of effect estimates. A: Outcome: pain at short-term follow-up. B: Outcome: pain at long-term follow-up. C: Outcome: disability at short-term follow-up D: Outcome: disability at long-term follow-up.

Fig 3.

Forest plots of effect estimates. A: Outcome: pain at short-term follow-up. B: Outcome: pain at long-term follow-up. C: Outcome: disability at short-term follow-up D: Outcome: disability at long-term follow-up.

TABLE 1.

STUDY CHARACTERISTICS & KEY FINDINGS

First Author/Year	n-Group	Intervention	Outcomes Measures & Follow-Up	Key findings
Mind-Body Exercise vs Non-Exercise Controls				
Miyamoto 2013 [34]	43-Pilates	8 exercises aimed at improving breathing associated with core stability, posture, strengthening of specific muscles, and flexibility of the lower limbs and spinal muscles in all planes of movement. Number of repetitions per exercise was individualized and ranged from 5 to 10 repetitions. Exercises were progressed in difficulty in 3 levels. <u>60 min 2x/wk for 6 wks.</u>	NRS; RMDQ Short & Long-term (6 mo.)	Pain: Between-group adjusted mean difference for NRS immediately following intervention was 2.2 (p<.01) favoring Pilates. No between-group differences on NRS were seen at 6 month follow-up. Disability: Between group adjusted mean difference for RMDQ was 2.7 (p<.01), but this statistical difference was not maintained at 6 month follow-up.
	43- Education	Educational booklet containing information about anatomy and recommendations regarding posture and movements involved in activities of daily living. Received <u>2x/wk</u> telephone calls for clarifications regarding instructions <u>for 6 wks.</u>		
Cruz-Diaz 2015 [29]	53-Pilates	Intervention provided to control group + Pilates based exercise using fitballs, magic rings and TheraBand; flexibility and joint mobility exercises; breathing exercises; and motor control and posture correction tasks. Difficulty progressed throughout intervention. Individualized exercise prescription based on limitations. <u>60 min 2x/wk for 6 wks.</u>	NRS; ODI Short & Long-term (12 mo.)	Pain: PT + Pilates group demonstrated statistically significant improvements [between or within] in NRS for short- and long-term follow-up. Disability: Within-group mean difference for ODI was statistically significant at both time points, but the MCID was only met at 1 year follow-up
	48-Standard PT	Electrotherapy (TENS) with a pulse frequency of 100 Hz, pulse duration of 200 ms and application time of 40 min and PA joint mobilization based on Maitland principles with an oscillation frequency of 1–2 Hz during 30 s in the hypomobile or painful lumbar segment for 10 min approximately. <u>2x/week for 6 wks.</u>		
Cruz-Diaz 2015 [28]	50-Pilates	Intervention provided to control group + Pilates exercise. <u>60 min 2x/wk for 6 wks.</u>	NRS Short-term	Pain: The intragroup effect size for the control group was small (d = .48), but very large for the Pilates group (d = 3.31). The between-group effect size was very large (d = 1.46).
	47-Standard PT	Electrotherapy (TENS) with a pulse frequency of 100 Hz for 40 min, and 20 min of massage and stretching of the "low-back zone." <u>2x/wk for 6 wks.</u>		
Cruz-Diaz 2018 [30]	32-Pilates	Pilates exercise including warm-up with breathing exercises, pelvis tilt centering, deep trunk and pelvic floor muscles activation and joint mobility. Followed by strength and flexibility exercises involving the trunk, upper and lower limbs. A cool down section with some stretching exercises was performed last. Exercises were adapted in difficulty to be suitable for participants and progressed. <u>50 min 2x/wk 12 wks.</u>	VAS; RMDQ Short-term	Pain: Between group mean differences favored the Pilates group. Between group mean difference for VAS was 2.8 and 2.4 following 6 and 12 weeks of intervention, respectively. Disability: Between group mean difference for RMDQ was 4.0 at both 6 and 12 weeks of intervention favoring the Pilates group.

First Author/Year	n-Group	Intervention	Outcomes Measures & Follow-Up	Key findings
	32-Control	Educational booklet and waitlist for future Pilates interventions.		
Mind-Body Exercise vs Exercise Control				
Wajswelner 2012 [36]	44-Pilates	Initial 1-hr individual session with physiotherapist. Up to 2 further 30-min individual sessions. Followed by group Pilates sessions (maximum of 4 people). Pilates program consisted of 6 to 12 equipment-based exercises plus 1–4 home-based exercises. 60 min 2x/wk for 6 wks	VAS; Quebec Scale Short-term & Long-term (18 wks)	Pain: Both groups showed significant improvements in pain following intervention. No statistically significant changes were observed between groups for VAS at any time point. Disability: Both groups showed significant improvements following intervention. Improvements on the Quebec Scale were maintained in both groups at 12 & 24 weeks. No differences between groups were observed
	43-Gen Ex.	Initial 1-hr individual session with physiotherapist. Up to 2 further 30-min individual sessions. Followed by group exercise sessions (max of 4 people). Exercises included stationary bike, leg stretches, upper body weights, TheraBand, Swiss ball, and floor exercises that were multidirectional and nonspecific in nature. Asked participants to perform daily home exercises. 60 min 2x/wk 6 wks		
Mostagi 2015 [35]	11-Pilates	Individual Pilates sessions included direction-specific exercise program based on examination. Body perception aspects included postural alignment (neutral spine, positioning of the scapula and cervical spine) and recruitment of "core muscles". All aspects were performed with controlled breathing. Exercises used bodyweight, Swiss ball, Cadillac, and Reformer; difficulty was progressed. 60 min 2x/wk for 8 wks	VAS; Quebec Scale Short-term & Long-term (3 mo.)	Pain: The Pilates group demonstrated greater reductions in pain immediately following intervention and at follow-up. These between group differences were not statistically significant. Disability: The General Exercise group demonstrated greater improvements in Quebec Scale score that were statistically significant at short- and long-term follow-up.
	11-Gen Ex.	Individual exercise sessions comprised of commonly used exercises for the management of CLBP. These exercises included stationary bicycling, trunk and lower limb stretching, spine mobilization and trunk muscle strengthening; difficulty was progressed. 60 min 2x/wk for 8 wks		
Devasahayam 2016 [33]	14-Pilates	Pilates group underwent individualized Pilates exercise that was prescribed based on Postural Stability Deficits observed during rebound hopping assessment. 30 min 1x/wk for 6 wks	NRS Short-term	Pain: Within group changes on NRS were similar between groups with mean control group scores decreasing 2.33 points and mean Pilates group decreasing 2.00 points.
	10-Control	Gym-based exercises by a physiotherapist "per their needs". A combination of strengthening, flexibility and balance training exercises was performed using gym equipment such as the leg press, foam roller, wobble board and stationary bicycle. Individualized 30-min sessions. 30 min 1x/wk for 6 wks		
Demirel 2019 [32]	40-Yoga	Yoga program included education on the philosophy of yoga, its purpose, and the exercises, in addition to diaphragmatic respiration. Authors describe specific poses and progression of exercise throughout program. 60 min 3x/wk for 6 wks	VAS; ODI Short-term	Pain: Mean resting VAS in the Yoga group decreased from 2.92 to 1.06. Mean resting VAS in the stabilization group decreased from 2.62 to 1.76. Mean activity VAS in the Yoga group decreased from 5.76 to 2.36. Mean activity VAS in the stabilization group decreased from 6.72 to 3.78. Between-group mean differences post treatment are not statistically significant or clinically meaningful based on MCID.
	37-Stabilization	Stabilization exercise program began with diaphragmatic respiration and co-contraction of TA and LM in supine,		

First Author/Year	n-Group	Intervention	Outcomes Measures & Follow-Up	Key findings
		prone, standing, sitting and crawling positions. Trunk and hip exercises progressed from sidelying exercise, to closed chain exercise, to open chain exercise and eventually use of resistive bands. 60 min 3x/wk for 6 wks		Disability: Mean ODI score in the yoga group decreased from 30.94 to 18.41. Mean ODI score in the stabilization group decreased from 39.67 to 23.66. Between-group mean differences post treatment are not statistically significant or clinically meaningful based on MCID.

NRS: Numeric Rating Scale; RMDQ: Roland Morris Disability Questionnaire; VAS: Visual Analog Scale; ODI: Oswestry Disability Index. Short-term: 0–6 weeks. Long-term: ≥ 12 weeks.

TABLE 2.

GRADE Evidence Profile of Mind-Body Exercise Interventions for the Treatment of Low Back Pain

	Quality Assessment					Participants n			
Measure Comparator Follow-Up (# of studies)	**Study Limitations**	**Inconsistency**	**Indirectness**	**Imprecision**	**Reporting Bias**	**Mind-Body**	**Ctrl**	**SMD* (95%CI)**	**Quality of Evidence**
Mind-Body Exercise Interventions for Pain									
Pain – ST NEC (n=4)	Not serious	Serious[b]	Serious[c]	Not Serious	Serious[e]	178	170	−1.56[f] (−2.69; −0.42)	Low
Pain – ST EC (n=4)	Serious[a]	Not Serious	Not serious	Serious[d]	Serious[e]	109	101	−0.26 (−0.46; −0.07)	Very Low
Pain – LT (n=4)	Serious[a]	Serious[b]	Serious[c]	Serious[d]	Serious[e]	151	145	−0.60 (−1.43; −0.23)	Very Low
Mind-Body Exercise Interventions for Disability									
Disability – ST NEC (n=3)	Not serious	Serious[b]	Serious[c]	Not Serious	Serious[e]	128	123	−1.15[f] (−2.49; 0.18)	Low
Disability – ST EC (n=3)	Serious[a]	Not Serious	Not serious	Serious[d]	Serious[e]	95	91	−0.27 (−0.59; 0.05)	Very Low
Disability – LT (n=4)	Serious[a]	Serious[b]	Serious[c]	Serious[d]	Serious[e]	151	145	−1.05[f] (−3.51; 1.41)	Very Low

SMD = Standardized mean difference; CI = Confidence interval *random effects model, negative values favor mind-body exercise interventions; ST = Short term; LT= Long term; NEC= Non-Exercise Control; EC = Exercise Control

Footnotes: Randomized trials begin with "High" quality of evidence.

[a] Downgraded 1 level due to studies with small sample sizes (n<25).

[b] Downgraded 1 level due to lack of similarity between point estimates

[c] Downgraded 1 level due to indirectness in patient population, studies included samples of only females > 45 yo.

[d] Downgraded 1 level due to large and varying confidence intervals.

[e] Downgraded 1 level due to selective outcome reporting.

[f] Increased 1 level due to large effects (SMD < −0.80).

Table 3.

Effect estimates from meta-analyses of mind-body interventions in people with LBP for the outcomes pain and disability

Meta-Analysis	Intervention	Effect Estimate	95% CI
Pain – Short Term – Comparator: Non-Exercise			
Zhu et al. 2020[56]	Yoga	MD: −0.83 (scale 0–10)	−1.19; −0.48
Miyamoto et al. 2013[22]	Pilates	MD: 1.61 (scale 0–10) *	1.43; 1.80 *
Wieland et al. 2017[25]	Yoga	MD: −10.83 (scale: 0–100)	−20.85; −0.81
Yamato et al. 2015[57]	Pilates	MD: −14.05 (scale: 0–100)	−18.9; −9.19
Anheyer et al. 2021[23]	Yoga	SMD: −0.37	−0.52; −0.22
Lim et al. 2011[21]	Pilates	SMD: −2.72	−5.33; −0.11
This Review	***Pilates***	***SMD: −1.56***	***−2.69; −0.42***
Pain – Short Term – Comparator: Exercise			
Miyamoto et al 2013[22]	Pilates	MD: 0.12 (scale 0–10) *	−0.31; 0.55 *
Zhu et al 2020[56]	Yoga	MD: −0.37 (scale 0–10)	−1.16; 0.42
Lim et al. 2011[21]	Pilates	SMD: 0.03	−0.52; 0.58
Anheyer et al. 2021[23]	Yoga	SMD: −0.39	−0.81; 0.03
This Review	***Pilates + Yoga***	***SMD: −0.26***	***−0.46; −0.07***
Pain – Long Term			
Yamato et al. 2015[57]	Pilates	MD: −10.54 (scale 0–100) †	−18.46; −2.62
This Review	***Pilates***	***SMD: −0.60***	***−1.43; 0.23***
Disability – Short Term – Comparator: Non-Exercise			
Miyamoto et al. 2013[22]	Pilates	MD: 5.21 (scale 0–100) *	4.33; 6.09 *
Yamato et al. 2015[57]	Pilates	MD: −7.95 (scale 0–100)	−13.23; −2.67
Zhu et al. 2020[56]	Yoga	SMD: −0.30	−0.51; −0.10
Anheyer et al. 2021[23]	Yoga	SMD: −0.38	−0.55; −0.21
Wieland et al. 2017[25]	Yoga	SMD: −0.45	−0.71; −0.19
Lim et al. 2011[21]	Pilates	SMD: −0.74	−1.81; 0.33
This Review	***Pilates***	***SMD: −1.15***	***−2.49; 0.18***
Disability – Short Term – Comparator: Exercise			
Yamato et al. 2015[57]	Pilates	MD: −3.29 (scale 0–100)	−6.82; 0.24
Wieland et al. 2017[25]	Yoga	SMD: −0.02	−0.41; 0.37
Zhu et al. 2020[56]	Yoga	SMD −0.33	−0.76; 0.09
Anheyer et al. 2021[23]	Yoga	SMD: −0.34	−0.67; −0.01
Lim et al. 2011[21]	Pilates	SMD: −0.41	−0.96, 0.14
This Review	***Pilates + Yoga***	***SMD: −0.27***	***−0.59; 0.05***

Meta-Analysis	Intervention	Effect Estimate	95% CI
Disability – Long Term			
Yamato et al 2015[57]	Pilates	MD: −11.17 (scale 0–100) † MD: −0.91 (scale 0–100) ‡	−18.41; −3.92 −5.02; 3.20
This Review	***Pilates***	***SMD: −1.05***	***−3.51; 1.41***

MD: mean difference; SMD: standardized mean difference; CI: confidence interval

*positive values indicates findings favoring mind-body intervention.

†effect size compared to non-exercise controls.

‡effect size compared to exercise controls.

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