Review article

The effects of hip-targeted physical therapy interventions on low back pain: A systematic review and meta-analysis

Brian A. Bernet, Erin T. Peskura, Samuel T. Meyer, Patrick C. Bauch, Megan B. Donaldson*

School of Behavioral and Health Sciences, Physical Therapy Program, Walsh University, 2020 E Maple St, North Canton, OH, 44720, United States

ABSTRACT

Purpose: To investigate the effects of physical therapy interventions of the hip on outcomes of pain and disability in patients with low back pain.

Data sources: PubMed, CINAHL, Scopus, Web of Science, and SPORTDiscus were searched from inception to 18 April 2018.

Study selection/eligibility criteria: The following inclusion criteria were required to be met: (1) randomized controlled trials; (2) populations with diagnosed low back pain; and (3) interventions that target the hip joint. Two researchers independently screened titles, abstracts, and full texts for inclusion.

Data extraction and synthesis: Data was extracted for information related to patient demographics, specific interventions, and outcomes assessed. When studies demonstrated homogeneity on outcome measures, the mean differences or standardized mean differences with 95% confidence interval were calculated and pooled in a meta-analysis.

Results: Six articles with a total of 387 participants were included in the review and meta-analysis. Specific intervention categories that were found in the search included: hydrotherapy (n = 1); exercise therapy (n = 4); and manual therapy (n = 2). Trivial effect size was found for the pain outcomes and small effect size was found for disability. All of these studies were found to have high risk of bias according the Cochrane Risk of Bias tool.

Conclusion: The meta-analyses from the pooled studies did not result in statistically significant reductions in either pain or disability with the addition of hip-targeted physical therapy interventions to patients with LBP.

1. Introduction

The human movement system has interconnectedness of the lumbopelvic structures and the hip through joints, ligaments, and surrounding musculature (American Physical Therapy Association: Guide to Physical Therapy Practice, 2014). This interconnectedness can result in one's primary musculoskeletal symptom(s) being influenced either directly or indirectly by impairments from an adjacent joint (Sueki et al., 2013). There has been a significant increase of lumbopelvic pain and lower extremity relationships published within the literature (Ben-Galim et al., 2007). Despite this recent rise in research, Offierski and MacNab first introduced this relationship appropriately named "Hip-Spine Syndrome" in a 1983 case study (Offierski and MacNab, 1983). Hip-spine syndrome explains the association of hip dysfunction resulting in low back pain (LBP) through altered biomechanics caused by degeneration of either lumbar spine or hip joints (Offierski and MacNab, 1983).

The relationship of LBP originating from or being worsened by dysfunctional hips is associated with their anatomical interrelationship, and past studies have found older adults with chronic LBP have a higher incidence of hip joint pain and pain with hip internal rotation (Wainner et al., 2007; Hicks et al., 2017). It is difficult to measure the prevalence of hip-spine syndrome due to lumbar pain referral patterns, and no study has been able to quantify how much of the estimated $100 billion of socioeconomic impact LBP can be attributed to patients with hip-spine syndrome (Katz, 2006). It is also possible that there are other mechanisms explaining the association of hip and LBP. The pain and dysfunction described in hip-spine syndrome may also be explained by congenital, psychosocial, and systemic influences.

Treatment methods incorporating the influence of the lumbopelvic region from outside the physical therapy scope of practice have been explored, with each having unique advantages and drawbacks. Total hip arthroplasty has been shown to benefit low back symptoms in patients with hip osteoarthritis and LBP which may be attributed to the interconnectedness between the lumbar spine and hip (Ben-Galim et al., 2007). Opioid use to manage non-cancer pain was increasing at the

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* Corresponding author.
E-mail address: mdonaldson@walsh.edu (M.B. Donaldson).

beginning of the century, (Sullivan et al., 2008), but recent guidelines have recommend against their use due to abuse and adverse effects (Dowell et al., 2016). These guidelines also follow recent studies that found insufficient evidence supporting the use of opioids for chronic LBP (Abdel Shaheed et al., 2016; Chou et al., 2015). The medical community needs to offer an effective conservative treatment to deliver better outcomes to patients who are not candidates for invasive surgeries or prescription opioids.

There has not yet been a published systematic review exploring the effectiveness of hip treatment on LBP despite the need for high quality evidence (Reiman et al., 2009). Recently published systematic reviews have found varying levels of evidence for LBP treatment, moderate for exercise therapy focused on the lumbar region, and little significant improvements found using muscle energy techniques (MET) and ultrasound (Saragiotto et al., 2016; Ebadi et al., 2014; Franke et al., 2015). Alternative treatments like yoga and behavioral training patients were found to have little to no clinical improvement of outcomes compared to other forms of therapy (Henschke et al., 2010; Wieland et al., 2017) and treatment with non-steroidal anti-inflammatory drugs (NSAIDs) provided only a small improvement over no treatment (Enthoven et al., 2016). Broadening the focus of exercise therapy for LBP beyond the local structures and considering adjacent joint in conservative treatment may be a way to improve clinical outcomes. The purpose of this review is to explore the effectiveness of adding physical therapy interventions performed at the hip to standard conservative treatment of LBP in improving outcomes of pain and disability.

2. Methods

2.1. Design

The protocol for this systematic review was registered with the International Prospective Register of Systematic Reviews (PROSPERO; registration number CRD42016050852). Searching and reporting of this systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta Analyses (PRISMA) statement (Liberati et al., 2009).

2.2. Search strategy

The PRISMA Guidelines (Liberati et al., 2009) were utilized as a review protocol to provide a methodical descriptive systematic review. A bibliographical search was conducted through electronic databases: PubMed, CINAHL, Scopus, Web of Science, and SPORTDiscus from inception to 18 April 2018. Searches were limited to peer-reviewed randomized controlled trials on adults (aged greater than 18 years) and published in English. Medical Subject Headings were used for the keywords: Low Back Pain, Physical Therapy Modalities, and Hip. The full search strategies for each database are provided in Appendix A. The Population, Intervention, Comparison, and Outcome (PICO) framework was used to define the search strategy. A hand literature search was performed from the reference lists of included titles and abstracts. The Scopus database was included as a tool for searching gray literature.

2.3. Study selection

Articles were screened by title and abstract, and then by full text for inclusion for this systematic review. Two independent researchers (BB, PB) completed each stage of the screen and discrepancies in eligibility assessment for inclusion were resolved through discussion. A third researcher (SM) was contacted if disagreement persisted. Kappa statistics were calculated for interrater agreement for inclusion screening between examiners. Kappa statistics was interpreted as following: less than 0.2 represents poor agreement; 0.2–0.4 represents fair agreement;

0.41–0.6 represents moderate agreement; 0.61–0.8 represents substantial agreement; greater than 0.8 represents great agreement (Landis and Koch, 1977).

2.4. Eligibility criteria

The present systematic review and meta-analysis targeted studies on adults diagnosed with LBP, with or without lower extremity symptoms, who have received hip interventions for treatment of their LBP. The interventions had to include the following: strengthening, stretching, manual therapy, hydrotherapy, and/or Pilates. Study designs eligible for inclusion were limited to randomized controlled trials. The control groups of the included studies were required to have administered non-hip interventions that targeted the low back specifically. Studies that included post-surgical participants or with complications from prior surgical procedures were excluded from this meta-analysis.

2.5. Risk of methodological bias assessment

In order to identify the level of bias within each study and across studies for this meta-analysis, the summary assessments approach detailed by the *Cochrane Handbook* was utilized (Higgins et al., 2011). Prior to the assessment, the researchers met to ensure consistency when evaluating the included studies. The Cochrane Risk of Bias Tool (Modified) for Quality Assessment of Randomized Control Trials was utilized to determine potential bias and the internal validity of the studies (Higgins et al., 2011). The Cochrane Collaboration Tool for Assessing Risk of Bias does not formulate a comprehensive quality score, only a judgment of "low," "unclear," or "high" risk based on 7 criteria: 1.) sequence generation; 2.) allocation concealment; 3.) participant and personnel blinding; 4.) blinding of outcome assessors; 5.) incomplete outcome data; 6, selective outcome reporting; and 7.) other sources of bias. (Higgins et al., 2011). A score of 6 or below is given the score of "high risk of bias". Two researchers (BB, PB) independently evaluated the studies according to the 7 criteria. Discordance in assessment was resolved by consensus or by opinion of a third researcher (SM). Kappa statistic was used to calculate the inter-rater agreement for the risk of bias tool.

2.6. Quality of the evidence

The GRADE approach was utilized to assess the quality of evidence related to our primary outcomes of pain and disability (Higgins et al., 2011). The GRADE approach addresses five reasons to decrease the quality of evidence and three to increase the quality of the study. The five reasons that are considered to reduce the quality of evidence include: limitations in study design or execution (risk of bias), inconsistency of results, indirectness of evidence, imprecision, and publication bias. The three factors that are considered to increase the quality of evidence are large magnitude of effect, all plausible residual confounding variables, and dose-response gradient. A summary of findings table was created for the main comparison.

2.7. Data extraction

Data and results from the included articles were extracted using a standardized form created by the researchers that documented characteristics of the participants, diagnosis, interventions, follow-up periods, outcome measures and reported results. Data extraction was first practiced then conducted independently by two researchers (EP, SM) and independently cross-checked by a third author (BB).

2.8. Outcome measures

Outcome assessments including both the assessment of self-report measures and performance measures were extracted. Constructs of pain and disability were synthesized at the reported follow-up periods. For inclusion in the meta-analysis, the studies must have reported outcome measures pain or disability within the study. The Oswestry Disability Index (ODI) is a patient-reported questionnaire for disability associated with the low back that analyzes 10 items (Fairbank and Pynsent, 2000). A higher total score correlates with higher disability. This outcome measure has been shown to have excellent test-retest reliability (ICC of 0.94–0.97; 95% CI) (Miekisiak et al., 2013). Pain was assessed using the Visual Analogue Scale (VAS) on the 11-point scale (0–10); higher scores correlate with an increased amount of pain.

2.9. Physical therapy intervention characteristics

The standardized definition of therapeutic exercise was utilized for this study (APTA). Therapeutic exercise is defined as the systematic, planned performance of body movements, postures, or physical activities intended to: improve or prevent impairments; restore or enhance physical function; and optimize health, fitness, and overall well-being (American Physical Therapy Association: Guide to Physical Therapy Practice, 2017). Specific intervention characteristics of included studies were identified *a priori* by the research team. Exercise therapy, manual therapy, and hydrotherapy approaches had to include the following elements: program approach (e.g. prescriptive or pragmatic style), method and type of exercise delivery, and dosage (i.e. intensity, repetitions, sets, and/or load/resistance of the exercise prescription).

2.10. Meta-analysis methodology

Results were synthesized quantitatively with analysis of effect size calculations when applicable. Effect size is a method of quantifying a difference between two groups, especially when differences between groups are not obvious (Cohen, 1998). Effect size interpretation will classify a value as trivial (< 0.2), small (> 0.2- < 0.5), moderate (> 0.5- < 0.8), or large (> 0.8) (Cohen, 1998). Effect sizes between hip interventions and the control group were compared between the articles.

Mean differences or standardized mean differences with 95% confidence interval (CI) were calculated using Comprehensive Meta-Analysis, version 2.0. The I^2 statistic was used to determine heterogeneity, which was expressed in percentages: 25% = low, 50% = medium, and 75% = high heterogeneity. Using this scale, if I^2 was $< 50\%$, a fixed effects model was used and if I^2 was $> 50\%$, a random effects model was used (Higgins and Thompson, 2002).

3. Results

3.1. Study selection

The electronic database search yielded 1518 articles. Duplicates were removed and 1216 articles remained. After the screening of titles and abstracts, 17 articles were selected for full-text eligibility. Six studies (Jeong et al., 2015; Bade et al., 2017; Dundar et al., 2009; Ju et al., 2015; Kendall et al., 2015; Lee and Kim, 2015) fulfilled the eligibility criteria and were included in the final review and 6 studies (Bade et al., 2017; Dundar et al., 2009; Ju et al., 2015; Kendall et al., 2015; Lee and Kim, 2015) were included in the meta-analysis (Fig. 1). The agreement between researchers was considered moderate for all stages of the screening process (κ = 0.54).

3.2. Study characteristics

A total of 387 participants were identified from the 6 included studies. The mean age of participants ranged from 33 to 55.55 years. The main study characteristics are presented in Table 1. Pain constructs were assessed using the VAS. Disability constructs were assessed using the ODI and the RMD (Table 1). Re-evaluation of symptoms and outcome measures for these studies ranged from 2 weeks to 12 weeks after baseline measurements were collected to determine the effects of these treatments on the patient's LBP.

3.3. Risk of bias

The risk of bias assessment was conducted with an agreement of 90.5% (38 of 42 criteria) using the Cochrane Risk of Bias Tool (Modified) for Quality Assessment of Randomized Control Trials. All six of the included studies were found to have high risk of bias (a score of 6 or lower out of 7). The risk of biases reported ranged from a 2/7 to 6/7, with lower scores correlating with a greater degree of bias associated with the study. A majority of the studies lacked appropriate blinding of the participants, personnel, or outcome assessors. The criteria assessment consensus for each study is reported in Table 2.

3.4. Quality of the evidence

The GRADE approach was utilized to determine the quality of evidence based on the primary outcomes of pain and disability. We found the quality of evidence for the primary outcomes of pain and disability to be low due to the high risk of bias (Table 3).

3.5. Program specifics

3.5.1. Hydrotherapy

There was one study that incorporated hydrotherapy interventions targeting the hip. The interventions provided in this study included aquatic-resisted hip extension, flexion, abduction, and adduction (Dundar et al., 2009). This study used a dosage of 5 sessions per week for a total of 4 weeks, with the hydrotherapy exercises lasting 40 min. The control group received a 60-minute home exercise program which included range of motion exercises, stretching, strengthening major muscle groups, and aerobic exercising to be performed each day for 4 weeks for 15–20 repetitions.

3.5.2. Exercise therapy

The study conducted by Kendall et al. involved a 6-week program consisting of 42 therapy sessions. The control group received a lumbar motor control program and the experimental group received the lumbar motor control program with additional hip strengthening exercises (Kendall et al., 2015). Dosage or length of session was not specified in this study. In the study by Lee et al., the control group received four closed chain lumbar stabilization exercises presented in a separate paper (Unsgaard-Tøndel et al., 2010). The experimental group performed open-chain hip joint exercises using slings. The patients performed the exercises for a total of 20 min, three times a week. The experimental group also received active resistance Theraband exercises to perform each hip motion (flexion, extension, internal rotation, external rotation, abduction, and adduction).

3.5.3. Manual therapy

There were two included studies that analyzed hip manual therapy interventions to treat LBP. The 6-week program study conducted by Ju. et al. included 40 min sessions at a frequency of 3 times per week (Ju et al., 2015). The experimental group received 30 s bouts of hip distraction and other mobilizations. The control group received modalities
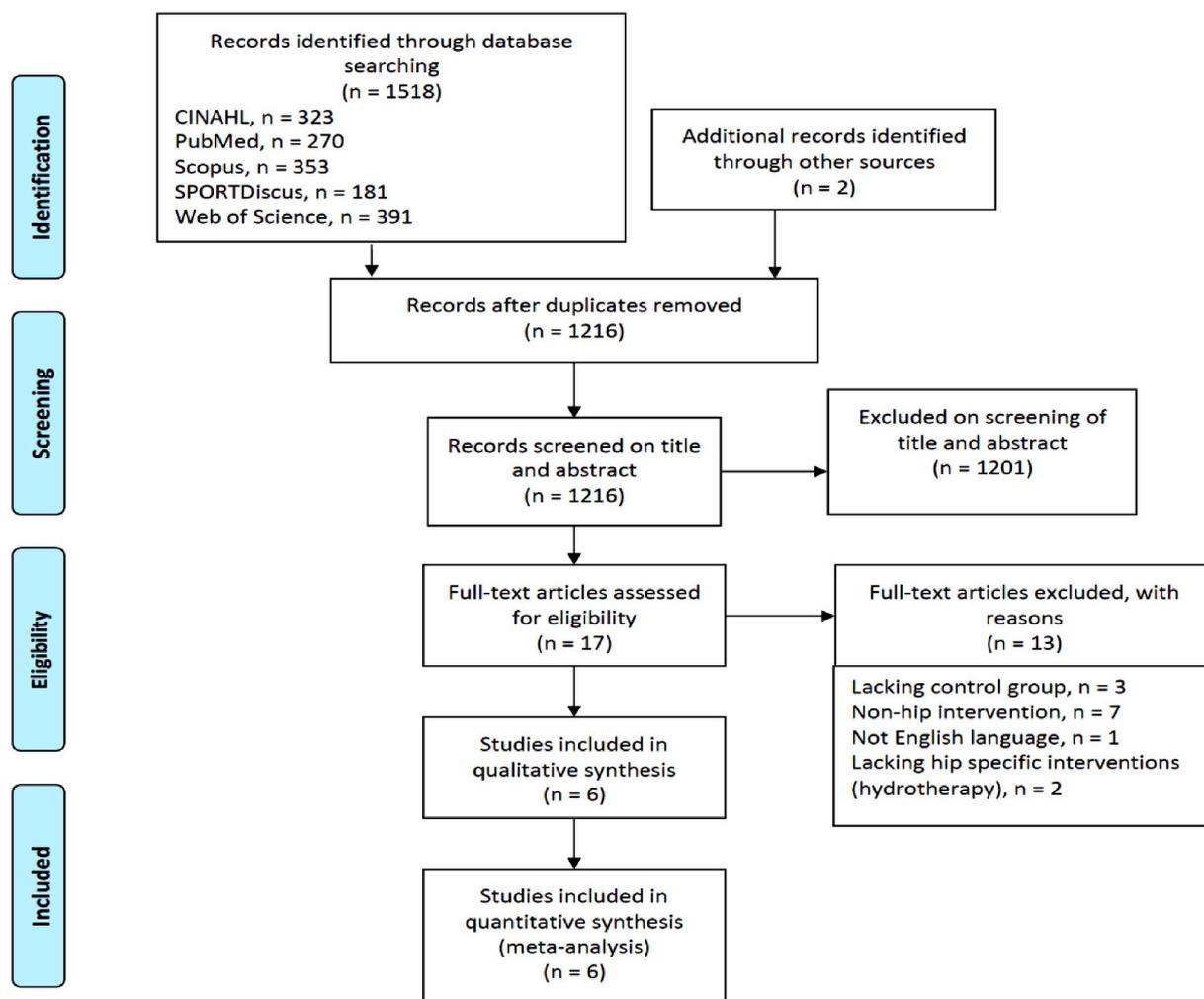
Fig. 1. Flow Chart of the Study.

as treatment which included a hot pack, ultrasound, and electrical therapy.

In the study conducted by Bade et al., the control group received pragmatic LBP interventions which were most appropriate for the patients' needs (Bade et al., 2017). The experimental group received both a pragmatic LBP treatment and prescriptive hip interventions based on a previous study (Selkowitz et al., 2013). Manual therapy was also designed to target the hip in several directions based from a protocol that demonstrated benefits for patients with hip osteoarthritis (Hando et al., 2012). The manual therapy interventions were dosed at one bout of 30 s for each technique with a grade III-IV mobilization. The techniques included an anterior to posterior mobilization of the hip, long axis distraction of the hip, and posterior to anterior mobilization of the hip. Both groups also received a lumbar spine targeted home exercise program, but the experimental group also received three exercises that targeted the hip.

3.6. Hip interventions and pain

Based on the meta-analysis and included studies that assessed pain outcome measures, the heterogeneity statistic was determined to be $I^2 = 83.21\%$. The random effects model was used to estimate the mean of a distribution of effects. Since each study provides information about an effect size in a different population, the objective was to have all populations captured by the various studies represented in the combined estimate.

Table 4 provides a summary of results for the 5 included studies that examined pain. The study by Jeong et al. did not report on a pain construct measure (outcome), therefore it could not be included in the meta-analysis for pain. The results from five of the included studies were pooled and quantitatively analyzed. A total of 347 participants demonstrated a Standard Differences in Means (SMD) of 0.317 with a 95% CI of −0.244, 0.879 (Fig. 2).

3.7. Hip interventions and disability

Based on the meta-analysis and included studies that assessed disability outcome measures, the heterogeneity statistic was determined to be $I^2 = 84.56$. Again, due to the high heterogeneity of the included studies, the random effects model was used to estimate the mean of a distribution of effects. Table 4 provides a summary of results for the 6 included studies that examined disability. The results from the six included studies were pooled and quantitatively analyzed based on the outcome of disability. Therefore, a total of 387 total participants demonstrated a Standard Differences in Means (SMD) of 0.064 with a 95% CI of −0.485, 0.614 (Fig. 3).

4. Discussion

The purpose of this systematic review and meta-analysis was to

Table 1
Characteristics of Included Studies.

Study, year	Sample Size	Control Group Characteristics and Interventions	Experimental Group Characteristics and Interventions	Outcomes
Bade et al. (2017)	84	Age (mean ± SD) – 48.1 ± 2.4 Participants (females) – 43 (16) BMI (% ± SD) - NR Guideline-oriented low back treatment	Age (mean ± SD) – 44.8 ± 2.3 Participants (females) – 47 (21) BMI (% ± SD) - NR Guideline-oriented low back treatment and prescriptive hip treatment	Pain Intensity (NPRS) Disability (ODI)
Dundar et al. (2009)	65	Age (mean ± SD) – 34.8 ± 8.3 Participants (female) – 33 (16) BMI – NR Land-based Exercises	Age (mean ± SD) – 35.3 ± 7.8 Participants (female) – 32 (56) BMI – NR Hydrotherapy Exercises	Pain Intensity (VAS) Disability (mODI)
Jeong et al. (2015)	40	Age (mean ± SD) – 41.2 ± 6.7 Participants (females) – 20 (NR) BMI (% ± SD) – NR Lumbar Stabilization Exercises	Age (mean ± SD) – 41.2 ± 5.5 Participants (females) – 20 (NR) BMI (% ± SD) – NR Lumbar Stabilization exercises and Strengthening of the gluteus	Disability (ODI)
Ju et al. (2015)	40	Age (mean ± SD) – 55.55 ± 9.70 Participants (females) – 20 (15) BMI (% ± SD) - NR Conventional Physical Therapy consisting of a thermal therapy, ultrasound, and electrical therapy	Age (mean ± SD) – 52.70 ± 6.40 Participants (females) – 20 (14) BMI (% ± SD) - NR Conventional Physical Therapy and hip joint mobilization	Pain Intensity (NPRS) Disability (ODI)
Kendall et al. (2015)	80	Age (mean, 95% CI) – 33 (33, 41) Participants (female) – 40 (18) BMI – NR Lumbopelvic motor control exercises	Age (mean, 95% CI) – 33 (33, 41) Participants (female) – 40 (24) BMI – NR Lumbopelvic motor control exercises and hip strengthening exercises	Pain Intensity (VAS) Disability (ODI)
Lee and Kim (2015)	78	Age (mean ± SD) – 50.0 ± 11.4, 59.4 ± 17.3 Participants (female) – 37 (NR) BMI (% ± SD) – 23.2 ± 2.8, 22.8 ± 2.9 Lumbar Stabilization Exercises	Age (mean ± SD) – 54.9 ± 10.6, 61.0 ± 13.2 Participants(female) – 25 (NR) BMI (% ± SD) – 23.8 ± 2.8, 23.3 ± 2.6 Lumbar Stabilization Exercises and hip joint exercises	Pain Intensity (VAS) Disability (ODI)

Abbreviations: CI – Confidence Interval, BMI – Body Mass Index, NR – Not Reported, VAS – Visual Analogue Scale, ODI – Oswestry Disability Index, SD – Standard Deviation, mODI – Modified Oswestry disability Index.

Table 2
Risk of Bias for Included Studies Based on The Cochrane Risk of Bias Tool (Modified) for Quality Assessment of Randomized Control Trials.

	Criteria[a]							
Study	1	2	3	4	5	6	7	Study Quality[b]
Bade et al.	Yes	No	No	Yes	No	Yes	Yes	High Risk of Bias
Dundar et al.	No	No	No	Yes	Yes	Yes	No	High Risk of Bias
Jeong et al.	Unclear	No	No	No	Yes	Yes	No	High Risk of Bias
Ju et al.	Yes	No	No	No	Yes	No	No	High Risk of Bias
Kendall et al.	Yes	Yes	Yes	Yes	No	Yes	Yes	High Risk of Bias
Lee and Kim	Unclear	No	No	No	No	Yes	Yes	High Risk of Bias

[a] 1, Sequence generation; 2, Allocation concealment; 3, Participant and personnel blinding; 4, Blinding of outcome assessors; 5, Incomplete outcome data; 6, Selective outcome reporting; 7, Other sources of bias.

[b] Low, unclear, high.

determine the effectiveness of a LBP treatment program that utilized hip treatments in addition to standard low back treatment. There were three main types of physical therapy intervention categories that were used in the included studies: hydrotherapy, manual therapy, and exercise therapy. The results of our meta-analysis were statistically insignificant and small effect sizes for the pooled intervention for both pain and disability included within the meta-analysis.

The GRADE approach was utilized to determine the quality of evidence based on the primary outcomes of pain and disability. We found the quality of evidence for the primary outcomes of pain and disability to be low due to the high risk of bias. The high risk of bias weakens the confidence in the results and lacking multiple criterion affects the applicability of the results to clinical practice. The quality of the evidence was downgraded by two levels due to these limitations in study design.

In regards to the heterogeneity for both outcomes, the study design can impact the results exhibited in the meta-analysis. Particularly for experimental groups, longer treatment times can have more of a

Table 3
Summary of Findings for the Main Comparison - Effectiveness of Hip treatments on Chronic Low Back Pain.

Outcomes	95% Confidence Interval	Relative Effect	Number of Participants	GRADE of Evidence
Pain Follow-up 2–12 weeks	− 0.485–0.614	0.622–2.816	347 (5 studies)	Low[a]
Disability Follow-up 2–12 weeks	− 0.244–0.879	0.564–1.896	387 (6 studies)	Low[b]

Grade Working Group Grades of Evidence.
High: We are very confident that the true effect is close to the estimate of the effect.
Moderate: We are moderately confidence in the effect estimate. The true effect is close to the estimate of the effect, but the result can be different.
Low: Confidence in the effect estimate is limited, the true effect can be substantially different from the estimate of the effect.
Very Low: There is little confidence in the effect estimate, the true effect is likely to be substantially different from the estimate effect.

[a] Lack of sequence generation, allocation concealment, participant and personnel blinding, blinding of outcome assessors, and other sources of bias throughout the 5 included studies, plausible explanation for heterogeneity provided, therefore the quality was downgraded from high to low.

[b] Lack of sequence generation, allocation concealment, participant and personnel blinding, blinding of outcome assessors, and other sources of bias throughout the 5 included studies, plausible explanation for heterogeneity provided, therefore the quality was downgraded from high to low.

Table 4

Primary Outcome Data Summary from Included Studies.

Authors	Pain Construct	Disability Construct
Bade et al. (2017)	Low Back Pain (LBP) Baseline: 5.4 ± 0.3. 2 Weeks: 2.9 ± 1.6 Discharge: 1.9 ± 1.6 LBP+ Hip Baseline: 5.1 ± 0.3. 2 Weeks: 2.7 ± 1.5 Discharge: 1.1 ± 1.1 Mean Difference (95% CI) 2 Weeks: 0.2 (−0.6, 0.5). Discharge: 0.8 (0.6, 1.0) Effect Size 2 Weeks: 0.13. Discharge: 0.58 P Value 2 Weeks: 0.27. Discharge: < 0.01	Low Back Pain (LBP) Baseline: 36.7 ± 2.1. 2 Weeks: 23.8 ± 10.5 Discharge: 11.9 ± 7.1 LBP+ Hip Baseline: 36.4 ± 1.5. 2 Weeks: 21.2 ± 11.4 Discharge: 9.1 ± 8.5 Mean Difference (95% CI) 2 Weeks: 2.6 (0.67, 4.43). Discharge: 2.9 (1.5,4.2) Effect Size 2 Weeks: 0.23. Discharge: 0.36 P Value 2 Weeks: 0.01. Discharge: < 0.01
Dundar et al. (2009)	Experimental Baseline: At Rest: 4.72 ± 2.05 4 wks: At Rest: 1.68 ± 1.12 P: < .001 12 wks: At Rest: 1.46 ± 1.21 P: < .001 Control Baseline: At Rest: 4.82 ± 2.4 4 wks: At Rest: 1.90 ± 1.33 P: < .001 12 wks: At Rest: 1.17 ± 1.52 P: < .001	Experimental Baseline: 38.5 ± 9.1 4 wks: 20.84 ± 7.6 12 wks: 18.42 ± 8.2 P: < .001 Control: Baseline: 37.9 ± 9.3 4 wks: 29.89 ± 8.5 12 wks: 27.65 ± 8.9 P: < .001
Jeong et al. (2015)		Strengthening muscles of the gluteus + Lumbar Stabilization exercise: 9.9 ± 3.2 P: < .05 Lumbar Stabilization exercise: 4.5 ± 2.4 P: < .05 Mean ± SD (Post-Pre)
Ju et al. (2015)	Experimental: Pre-test: 6.90 ± 1.74. Post-test: 2.55 ± 1.50. Changes: 4.35 ± .81 Control: Pre-test: 6.05 ± 1.54. Post-test: 4.95 ± 1.79. Changes: 1.10 ± .85	Experimental: Pre-test: 26.40 ± 7.20. Post-test: 18.00 ± 4.48. Changes: 8.40 ± 4.68 Control: Pre-test: 26.00 ± 7.99. Post-test: 26.00 ± 11.89. Changes: 0.00 ± 8.74
Kendall et al. (2015)	Lumbopelvic: Baseline: 57 (54, 61). 6 wks: 37 (31, 41) Change: −26 (−26, −16). Difference: −4 (12,4). P: .29 Lumbopelvic+ Hip Baseline: 55 (51, 58). 6 wks: 30 (24,36) Change: −25 (−31,-19)	Lumbopelvic: Baseline: 22 (19.24). 6 wks: 14 (11,17) Change: −8 (−10, −5). Difference: 0 (−4,3). P: .85 Lumbopelvic + Hip Baseline: 22(17,23). 6 wks: 12 (10,14) Change: −8 (−10, −5)
Lee and Kim (2015)	Before: LSEGI: 55. 7 ± 8.9. LSCGI: 55.3 ± 10.7 LICGII: 61.0 ± 10.0. LIEGII: 58.9 ± 8.6 3 wks: LSEGI: 46.1 ± 6.9. LSCGI: 47.5 ± 10.8 LICGII: 39.1 ± 10.7. LIEGII: 53.89 ± 9.6 6 wks: LSEGI: 39.6 ± 7.5. LSCGI: 45.6 ± 10.3 LICGII: 27.6 ± 9.8. LIEGII: 43.3 ± 12.0	Before: LSEGI: 23.8 ± 10.5. LSCGI: 25.6 ± 12.3 LICGII: 30.6 ± 18.8. LIEGII: 25.9 ± 15.8 3 wks: LSEGI: 20.2 ± 9.1. LSCGI: 23.2 ± 11.3 LICGII: 22.7 ± 14.5. LIEGII: 22.7 ± 13.1 6 wks: LSEGI: 17.5 ± 8.1. LSCGI: 21.7 ± 10.7 LICGII: 18.3 ± 11.1. LIEGII: 19.8 ± 12.1

Abbreviations: NPRS – Numeric Pain Rating Scale, mODI – Modified Oswestry disability Index, CI – Confidence Interval, VAS – Visual Analogue Scale, ODI – Oswestry Disability Index, LSEGI – Lumbar Stabilization Group 1, LICGI – Lumbar Instability Exercise Group 1, LSCGI – Lumbar Stabilization Control Group 1. LIEGI – Lumbar Instability Exercise Group 1.

positive influence on standard difference of the means. For these plausible explanations for differences in heterogeneity, the quality of evidence was not downgraded.

The results of our study varied from previous systematic reviews on the efficacy of treating joints outside of the symptomatic region (Aoyagi et al., 2015; Thomson et al., 2016; Sueki et al., 2013). These reviews (Aoyagi et al., 2015; Thomson et al., 2016; Sueki et al., 2013) conclude that targeting adjacent joints in addition to the pathological joint improves outcomes, which is different from this present study.

Hydrotherapy in practice cannot be limited to purely hip interventions given the systemic and whole body nature of the treatments. Specific discretion was taken during the decision of inclusion to ensure hydrotherapy studies administered hip-targeted treatment. While there are undoubtedly other benefits to hydrotherapy, such as the aerobic conditioning, decreased weight bearing and increased resistance, this study specifically incorporated hydrotherapy exercises targeting the hip such as underwater hip flexion, extension, abduction, and adduction (Dundar et al., 2009). The hydrotherapy study performed by Dundar et al. found that the experimental group had significant improvements with both pain and disability at the 4-week and
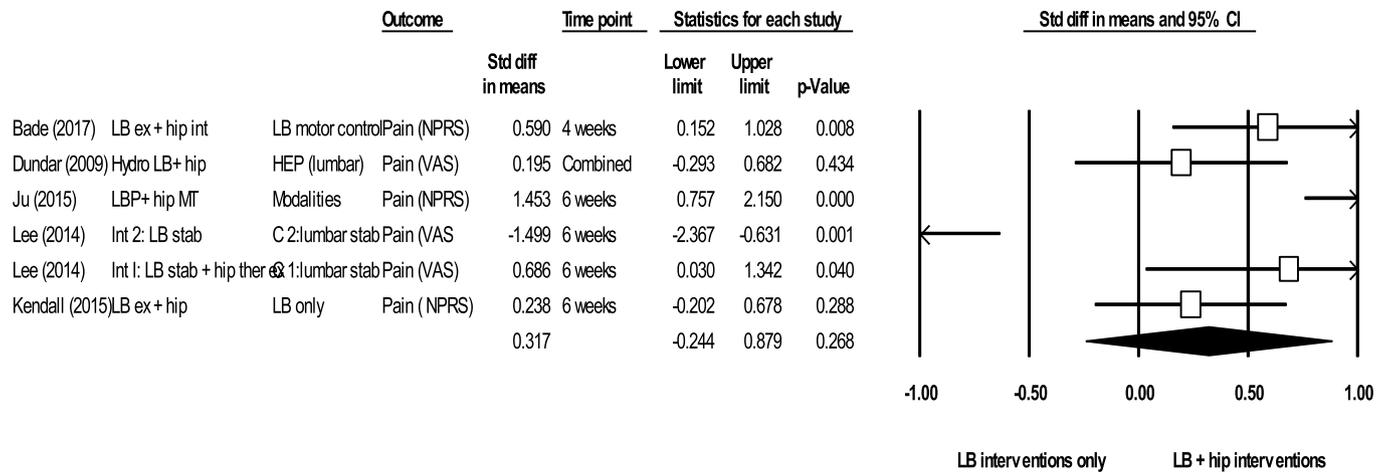
	Outcome		Time point	Statistics for each study				Std diff in means and 95% CI
				Std diff in means	Lower limit	Upper limit	p-Value	
Bade (2017)	LB ex + hip int	LB motor control	Pain (NPRS)	0.590	4 weeks	0.152	1.028	0.008
Dundar (2009)	Hydro LB+ hip	HEP (lumbar)	Pain (VAS)	0.195	Combined	-0.293	0.682	0.434
Ju (2015)	LBP+ hip MT	Modalities	Pain (NPRS)	1.453	6 weeks	0.757	2.150	0.000
Lee (2014)	Int 2: LB stab	C 2:lumbar stab	Pain (VAS	-1.499	6 weeks	-2.367	-0.631	0.001
Lee (2014)	Int I: LB stab + hip ther ex	C 1:lumbar stab	Pain (VAS	0.686	6 weeks	0.030	1.342	0.040
Kendall (2015)	LB ex + hip	LB only	Pain (NPRS)	0.238	6 weeks	-0.202	0.678	0.288
				0.317		-0.244	0.879	0.268

LB interventions only   LB + hip interventions

Fig. 2. Meta-analysis Pain Outcomes at 6 weeks Random Effects Model.

12-week follow up periods (Dundar et al., 2009). Despite the improvements, the control group that received land-based exercises also showed similar improvements.

Only two of the three studies that utilized exercise therapy as interventions within the experimental group reported pain as an outcome (Kendall et al., 2015; Lee and Kim, 2015). In both studies, each experimental and control groups demonstrated substantial changes in their pain scale rating means. However, the average total change in pain experienced in each group in the study by Kendall et al. were within 1 mm of each other (Kendall et al., 2015). The minimum detectable change for the VAS has been found to be 2 mm, indicating no significant difference between the test groups. In terms of disability, many of the same trends continued for the studies by Kendall et al. and Lee et al. While improvements were made in each study group, no significant differences could be noted between the control and experimental groups. In the study by Lee et al., the results mirrored those reported for the VAS measurements (Lee and Kim, 2015). The lumbar stability patients benefitted more from the addition of hip interventions while the lumbar instability patients benefitted most from just stabilization exercises. In the study performed by Jeong et al. (2015), the addition of gluteus muscle strengthening exercises resulted in almost twice the change in mean ODI score.

The study by Lee and Kim (2015) showed that while the patients classified in the "lumbar stability group" benefitted more from the additional hip interventions, the subjects with "lumbar instability"

benefitted most from solely lumbar stabilization exercises. The range of motion of the "lumbar instability" participants did improve however failed to have significant improvement in pain reduction or disability compared to the lumbar stabilization group. This study also highlights the impact of hip mobility deficits as it relates to exercises that target the hip and pelvic musculature as part of lumbar stabilization exercises.

In summary of our varied result and statistically insignificant findings, an investigation of the interventions, dosages, and length of program can also be used to interpret the significance of the standard difference of the means. Some of the changes in outcomes for the experimental groups may have been contributed to more time spent with the patients who also received hip interventions. Due to Lee and Kim (2015) dividing their sample into lumbar stability versus lumbar instability with corresponding control and experimental groups, the negative standard difference of the means favors the control interventions in regards to pain; in regards to disability the positive standard difference of means favors the experimental group in each study. The positive standard difference of the means favors the experimental group for both pain and disability in Kendall et al. (2015).

There were two studies included that utilized hip manual therapy interventions to treat LBP (Bade et al., 2017; Ju et al., 2015). The study by Ju et al. looked at a prescriptive hip exercise program in addition to the low back interventions. Bade et al. used a combination of therapeutic exercise and manual therapy for the hip. Both reported better outcomes with pain and disability for their experimental groups. Bade
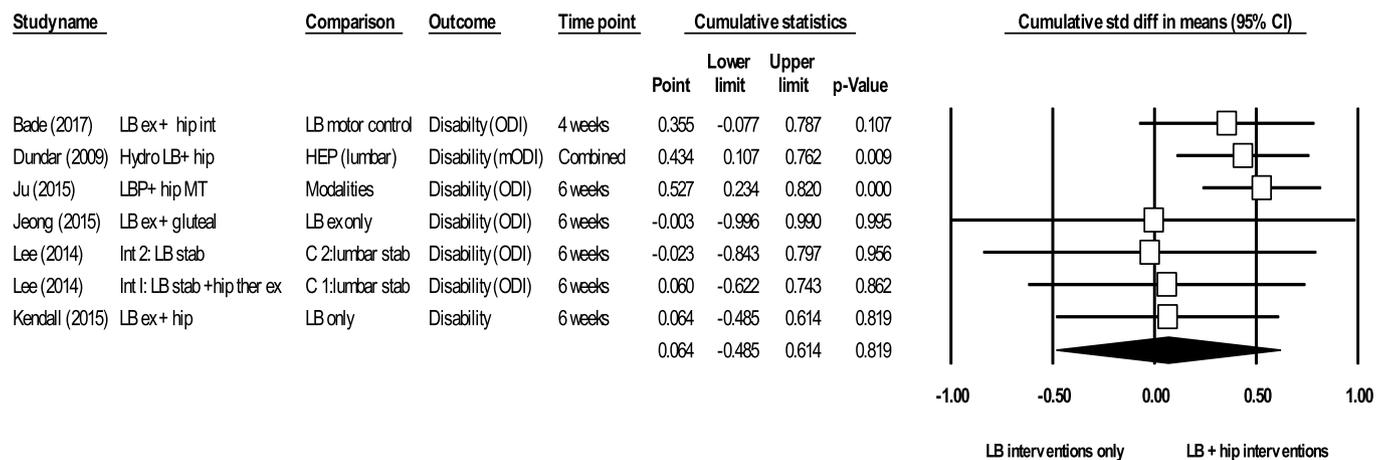
Study name		Comparison	Outcome	Time point	Cumulative statistics				Cumulative std diff in means (95% CI)
					Point	Lower limit	Upper limit	p-Value	
Bade (2017)	LB ex + hip int	LB motor control	Disabilty (ODI)	4 weeks	0.355	-0.077	0.787	0.107	
Dundar (2009)	Hydro LB+ hip	HEP (lumbar)	Disability (mODI)	Combined	0.434	0.107	0.762	0.009	
Ju (2015)	LBP+ hip MT	Modalities	Disability (ODI)	6 weeks	0.527	0.234	0.820	0.000	
Jeong (2015)	LB ex + gluteal	LB ex only	Disability (ODI)	6 weeks	-0.003	-0.996	0.990	0.995	
Lee (2014)	Int 2: LB stab	C 2:lumbar stab	Disability (ODI)	6 weeks	-0.023	-0.843	0.797	0.956	
Lee (2014)	Int I: LB stab + hip ther ex	C 1:lumbar stab	Disability (ODI)	6 weeks	0.060	-0.622	0.743	0.862	
Kendall (2015)	LB ex + hip	LB only	Disability	6 weeks	0.064	-0.485	0.614	0.819	
					0.064	-0.485	0.614	0.819	

LB interventions only   LB + hip interventions

Fig. 3. Meta-analysis Disability Outcomes at 6 weeks Random Effects Model.

et al. were able to specifically capture the effects of the hip interventions by merely adding them to the pragmatic approach utilized by the control group. Further, higher quality studies need to be conducted to display the multifaceted approach that encapsulates the human movement system view. Given the low number of studies including manual therapy treatment, more research is needed to further clarify these initial findings.

5. Conclusion

This was the first systematic review that looked specifically at how hip-targeted interventions affect LBP. All of the included studies were found to have high risk of bias. The findings from our review support the need for further, higher quality research on the connectedness of the hip and low back and the efficacy of hip treatments for different diagnoses. The meta-analyses from the pooled studies did not result in statistically significant reductions in either pain or disability with the addition of hip-targeted physical therapy interventions to patients with LBP. Further research into this topic will continue to clarify the relationship between the hip and lumbar spine.

6. Limitations

This review did not include studies that included patient who had invasive hip or back surgery, so patients who had already had surgery to treat their LBP were not taken into account. A small number of studies fit into our inclusion criteria, many with small sample sizes, so only 387 subjects were included in this review. We were unable to include any articles that were not published in English. Cautious interpretation should be used when considering these results due to the small sample size and the lack of quality of the included studies.

Conflict of interest

The authors declare that there is no conflict of interest.

Funding

Appendix A. Search strategy for systematic review

Database:	PubMed
Date	12/18/2017
Strategy:	#1 AND #2
#1	(((((((((((((((((low back pain [mesh]) OR "low back pain") OR "lumbago") OR "chronic low back pain") OR "acute low back pain") OR "LBP") OR "non-specific low back pain") OR "Lumbo-pelvic pain") OR "lumbosacral pain") OR "low back ache") OR "recurrent low back pain") OR "lumbar instability")))))
#2	(("hip strength*") OR "Therapeutic exercise*") OR "hip stretch*") OR "hip intervention") OR "hip mobilization") OR "gluteus") OR "hamstrings") OR "hip mobility") OR "hip treatment") OR "hip flexibility") OR "hip exercise*") OR "Aquatic therapy") OR "Aquatic exercise") OR "Hydrotherapy"))
Database:	CINAHL
Date	12/18/2017
Strategy:	#1 AND #2 AND #3
#1	(((MH low back pain) OR "low back pain") OR ("lumbago") OR ("chronic low back pain") OR ("acute low back pain") OR ("LBP") OR ("non-specific low back pain") OR ("Lumbo-pelvic pain") OR ("lumbosacral pain") OR ("low back ache") OR ("recurrent low back pain") OR ("lumbar instability"))
#2	AND MH ("hip" OR "physical therapy")
#3	AND (((("hip strength*") OR "Therapeutic exercise*") OR "hip stretch*") OR "hip intervention") OR "hip mobilization") OR "gluteus") OR "hamstrings") OR "hip mobility") OR "hip treatment") OR "hip flexibility") OR "hip exercise*") OR "Aquatic therapy") OR "Aquatic exercise") OR "Hydrotherapy"))))
Database:	Web of Science
Date	12/18/2017
Strategy:	#1 AND #2
#1	TS = ("hip strength*") OR TS = ("therapeutic exercise") OR TS = ("hip stretch*") OR TS = ("hip intervention") OR TS = ("hip mobilization") OR TS = ("gluteus") OR TS = ("hamstrings") OR TS = ("hip treatment") OR TS = ("hip mobility") OR TS = ("hip flexibility") OR TS = ("hip exercise*") OR TS = ("hydrotherapy") OR TS = ("Aquatic exercise") OR TS = ("aquatic therapy*")
#2	TS = ("Low back pain") OR TS = ("lumbago") OR TS = ("Chronic low back pain") OR TS = ("Acute low back pain") OR TS = ("LBP") OR TS = ("Non-specific low back pain") OR TS = ("Lumbo-pelvic pain") OR TS = ("lumbosacral pain") OR TS = ("Low back ache") OR TS = ("Recurrent low back pain") OR TS = ("lumbar instability")
Database:	SPORTDiscus
Date	12/18/2017
Strategy:	#1 AND #2
#1	("Low back pain" OR "low back pain" OR "lumbago" OR "chronic low back pain" OR "acute low back pain" OR "LBP" OR "non-specific low back pain" OR "Lumbo-pelvic pain" OR "lumbosacral pain" OR "low back ache" OR "recurrent low back pain" OR "lumbar instability")
#2	("hip strength*" OR "Therapeutic exercise*" OR "hip stretch*" OR "hip intervention" OR "hip mobilization" OR "gluteus" OR "hamstrings" OR "hip mobility" OR "hip treatment" OR "hip flexibility" OR "hip exercise*" OR "Aquatic therapy" OR "Aquatic exercise" OR "Hydrotherapy")
Database:	Scopus
Date	12/18/2017
Strategy:	#1 AND #2
#1	TITLE-ABS-KEY ({Low back pain}) OR TITLE-ABS-KEY ({lumbago}) OR TITLE-ABS-KEY ({acute low back pain}) OR TITLE-ABS-KEY ({chronic low back pain}) OR TITLE-ABS-KEY ({LBP}) OR TITLE-ABS-KEY ({Non-specific low back pain}) OR TITLE-ABS-KEY ({Lumbo-pelvic pain}) OR TITLE-ABS-KEY ({Lumbosacral pain}) OR TITLE-ABS-KEY ({Low back ache}) OR TITLE-ABS-KEY ({Recurrent Low Back Pain}) OR TITLE-ABS-KEY ({Lumbar instability})
#2	TITLE-ABS-KEY ({hip treatment}) OR TITLE-ABS-KEY ({Therapeutic exercise*}) OR TITLE-ABS-KEY ({Hip stretch*}) OR TITLE-ABS-KEY ({Hip intervention}) OR TITLE-ABS-KEY ({Hip mobilization}) OR TITLE-ABS-KEY ({Gluteus}) OR TITLE-ABS-KEY ({Hamstrings}) OR TITLE-ABS-KEY ({Hip Mobility}) OR TITLE-ABS-KEY ({hip exercise*}) OR TITLE-ABS-KEY ({Hip Flexibility}) OR TITLE-ABS-KEY ({Aquatic exercise}) OR TITLE-ABS-KEY ({Hydrotherapy}) OR TITLE-ABS-KEY ({aquatic therapy})

Appendix B. PRISMA checklist for systematic review

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	3-4
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	4
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	4
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	4-5
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	4
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	4-5
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	5
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	6
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	6-7
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	5-6
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	5-7
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	7-8

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PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	5-6
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	6-7
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	8
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	8
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	8-9
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	9-11
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	10-11
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	8
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	10-11
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	11-14
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	14
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	14
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	15

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(6): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit: www.prisma-statement.org

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