The Effectiveness of Exercise for the Management of Musculoskeletal Disorders and Injuries of the Elbow, Forearm, Wrist, and Hand: A Systematic Review by the Ontario Protocol for Traffic Injury Management (OPTIMa) Collaboration

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Abstract

Objective: The purpose of this systematic review was to evaluate the effectiveness of exercise compared to other interventions, placebo/sham intervention, or no intervention in improving self-rated recovery, functional recovery, clinical, and/or administrative outcomes in individuals with musculoskeletal disorders and injuries of the elbow, forearm, wrist, and hand.

Methods: We searched MEDLINE, EMBASE, CINAHL, PsycINFO, and the Cochrane Central Register of Controlled Trials from 1990 to 2015. Paired reviewers independently screened studies for relevance and assessed the risk of bias using the Scottish Intercollegiate Guidelines Network criteria. We synthesized the evidence using the best evidence synthesis methodology.

Results: We identified 5 studies with a low risk of bias. Our review suggests that, for patients with persistent lateral epicondylitis, (1) adding concentric or eccentric strengthening exercises to home stretching exercises provides no additional benefits; (2) a home program of either eccentric or concentric strengthening exercises leads to similar

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outcomes; (3) home wrist extensor strengthening exercises lead to greater short-term improvements in pain reduction compared to "wait and see"; and (4) clinic-based, supervised exercise may be more beneficial than home exercises with minimal improvements in pain and function. For hand pain of variable duration, supervised progressive strength training added to advice to continue normal physical activity provides no additional benefits.

Conclusion: The relative effectiveness of stretching vs strengthening for the wrist extensors remains unknown for the management of persistent lateral epicondylitis. The current evidence shows that the addition of supervised progressive strength training does not provide further benefits over advice to continue normal physical activity for hand pain of variable duration. (J Manipulative Physiol Ther 2015;38:507-520)

Key indexing terms: *Lateral Humeral Epicondylitis; Exercise Therapy; Upper Extremity; Review; Systematic; Elbow; Hand*

Musculoskeletal disorders and injuries of the upper limb are associated with significant disability in the population.[1] In 2013, arm, wrist, and hand injuries accounted for 12.1% of lost time claims in Canadian workers.[2] Musculoskeletal disorders and injuries of the elbow, forearm, wrist, and hand may occur in their supporting and related muscles, ligaments, and capsules. Injuries resulting in neuropathy may involve peripheral entrapment of the median, ulnar, or radial nerve near the elbow or wrist.

The most common conditions affecting the elbow, forearm, wrist, and hand include lateral epicondylitis, medial epicondylitis, and carpal tunnel syndrome. In the general population, the point prevalence of lateral epicondylitis varies from 1% to 3%.[3] Lateral epicondylitis affects as many as 15% of workers who perform tasks involving repetitive hand movements.[4,5] Medial epicondylitis is less common than lateral epicondylitis and accounts for 10% to 20% of all epicondylitis diagnoses.[6] In the United States, medical care and lost work time associated with epicondylitis are estimated to cost more than US $22 billion annually.[7] Carpal tunnel syndrome is also more common in the general population with a point prevalence ranging from 2.7% to 7.8%.[8,9] Furthermore, carpal tunnel syndrome is one of the most costly work-related upper extremity disorders, accounting for direct and indirect costs in excess of US $2 billion per year in the United States.[10]

Patient care is dependent on a clinician's training, beliefs, preferences, and understanding of the evidence. Clinicians often choose to combine various interventions when managing patients; this is also known as multimodal care. Exercise is frequently incorporated into multimodal programs of care; however, it is important to understand if exercise, in isolation, is effective in managing musculoskeletal disorders and injuries of the elbow, forearm, wrist, and hand, in addition to determining what types of exercises are effective for these conditions. This will inform which exercise offers benefits to patients when given alone and whether it likely contributes to the effectiveness of multimodal programs of care.

Previous systematic reviews have examined the effectiveness of exercise for the management of lateral epicondylitis[11-14] and carpal tunnel syndrome.[15,16] One systematic review found that an eccentric exercise program was effective for the management of lateral epicondylitis.[13] Furthermore, 2 other systematic reviews supported the use of stretching and strengthening for lateral epicondylitis.[11,12] The last review on lateral epicondylitis found inconclusive evidence to support the use of exercise.[14] In 2007, Piazzini et al[15] suggested that exercise therapy was not effective for carpal tunnel syndrome. However, Page et al[16] in 2012 suggested that neurodynamic mobilization (stretching/nerve flossing exercises) may be beneficial for the management of pain in those with carpal tunnel syndrome. The conclusions of these reviews may have been influenced by methodological limitations. Specifically, all reviews synthesized evidence from all eligible studies regardless of their scientific quality.[11-16] Second, all reviews included studies with small sample sizes.[11-16] Studies with small sample sizes may be underpowered and unable to detect differences between groups. Furthermore, small samples increase the likelihood that randomization will fail to equalize baseline characteristics across the intervention arms. Therefore, a systematic review of adequate methodological quality is needed to evaluate the effectiveness of exercise for musculoskeletal disorders and injuries of the elbow, wrist, and hand.

The purpose of this systematic review is to investigate the effectiveness of exercise compared to other interventions, placebo/sham interventions, or no intervention in improving self-rated recovery, functional recovery, or clinical outcomes in adults and children with musculoskeletal disorders and injuries of the elbow, forearm, wrist, or hand regions.

Methods

Registration

This review protocol was registered with the International Prospective Register of Systematic Reviews on March 12, 2014 (CRD42014008911).

Eligibility Criteria

Population. Our review targeted studies of adults or children with musculoskeletal disorders and injuries of the elbow, forearm, wrist, or hand region. Based on the

Table 1. *Case Definition of Sprains*[18]

Grade	Definition
I	Sprain occurs when ligamentous fibers are stretched but remain structurally intact.
II	Sprain occurs when ligamentous fibers become partially torn. Physical stress reveals increased laxity with a definite end point.
III [a]	Sprain occurs when a ligament is completely torn, leading to gross instability.

[a] Grade III sprains are excluded from this review.

Table 2. *Case Definition of Strains*[18]

Grade	Definition
I	Strain occurs when <5% of muscle/fibers are disrupted, with fascia remaining intact.
II	Strain occurs when muscle fibers/tendon discontinuity involves a moderate number of muscle fibers.
III [a]	Strain occurs when there is complete discontinuity in the muscle fibers.

[a] Grade III strains are excluded from this review.

Centers for Disease Control and Prevention, we defined musculoskeletal disorders and injuries as injuries or disorders of the muscles, nerves, tendons, joints, cartilages, and supporting structures of the elbow, forearm, wrist, and hand.[17] Musculoskeletal disorders and injuries include but are not limited to grade I and II sprain/strains, nonspecific pain, olecranon bursitis, lateral epicondylitis, medial epicondylitis, cubital tunnel syndrome, carpal tunnel syndrome, de Quervain tenosynovitis, and other musculoskeletal injuries of the elbow, forearm, wrist, or hand region as informed by available evidence (Tables 1 and 2). We excluded studies of patients with severe injuries, which include but are not limited to grade III sprains/strains, fractures, complete ruptures, dislocations, osteoarthritis, infections, malignancies, and systemic diseases.

Interventions. We restricted our review to studies that tested the effectiveness of exercise. We defined exercise as planned, structured, and repetitive bodily movements done to improve or maintain 1 or more components of physical fitness.[9] Studies applying exercise in either supervised or home-based settings to individuals or groups were included. Exercise may include but is not limited to strengthening, stretching, and proprioceptive retraining.

Comparison Groups. We included studies that compared one or more exercise interventions to one another or one exercise intervention to another intervention, placebo/sham intervention, wait list, or no intervention.

Outcomes. To be eligible, studies had to include one of the following outcomes: (1) self-rated recovery, (2) functional recovery (eg, disability, return to activities, work, or school), (3) clinical outcomes (eg, pain, health-related quality of life, or depression), (4) administrative data (eg, time on benefits), and (5) adverse events.

Study Characteristics. Eligible studies met the following criteria: (1) English language; (2) studies published between January 1, 1990, and April 13, 2015; (3) study designs including randomized controlled trials (RCTs), cohort studies, and case-control studies; and (4) an inception cohort of at least 30 subjects per treatment arm for RCTs or 100 subjects per exposed group for cohort studies with musculoskeletal disorders and injuries of the elbow, forearm, wrist, or hand region.

We excluded studies with the following characteristics: (1) guidelines, letters, editorials, commentaries, unpublished manuscripts, dissertations, government reports, books and book chapters, conference proceedings, meeting abstracts, lectures and addresses, consensus development statements, or guideline statements; (2) study designs including pilot studies, cross-sectional studies, case reports, case series, qualitative studies, narrative reviews, systematic reviews, clinical practice guidelines, biomechanical studies, or laboratory studies; (3) cadaveric or animal studies; and (4) studies on patients with severe injuries (eg, grade III sprains/strains or fractures and dislocations of the elbow, wrist, or hand).

Information Sources

We developed our search strategy with a health sciences librarian (Supplementary data). A second librarian reviewed the search strategy for completeness and accuracy using the Peer Review of Electronic Search Strategies Checklist.[19,20] We searched the following databases: MEDLINE, EMBASE, CINAHL, PsycINFO, and the Cochrane Central Register of Controlled Trials. We searched all bibliographic databases from January 1, 1990, to April 13, 2015.

The search strategy was first developed in MEDLINE and subsequently adapted to the other bibliographic databases. The search terms included subject headings (eg, MeSH) specific to each database and free text words relevant to exercise and musculoskeletal disorders and injuries of the elbow, forearm, wrist, or hand region.

Study Selection

We used a 2-phase screening process to select eligible studies. In phase 1, random pairs of independent reviewers screened citation titles and abstracts to determine the eligibility of studies. Phase 1 screening resulted in studies being classified as relevant, possibly relevant, or irrelevant. In phase 2, the same pairs of reviewers independently screened possibly relevant studies to determine eligibility. Reviewers met to resolve disagreements and reach consensus on the eligibility of studies. We involved a third reviewer if consensus could not be reached.

Assessment of Risk of Bias

Random pairs of trained independent reviewers critically appraised the internal validity of eligible studies using the

Scottish Intercollegiate Guidelines Network (SIGN) criteria.[21] This checklist was developed by SIGN to guide the development of evidence-based clinical practice guidelines for the National Health Service in Scotland. It has been used internationally in more than 140 clinical practice guidelines.[22] The SIGN criteria were used to qualitatively evaluate the presence and impact of selection bias, information bias, and confounding on the results of a study. We did not use a quantitative score or a cutoff point to determine the internal validity of studies when using the SIGN criteria.[23] Rather, the SIGN criteria were used to assist reviewers make an informed overall judgment on the internal validity of studies. This methodology has been previously described.[24-29] We focused on the presence or absence of important methodological issues. Studies were considered to have high risk of bias if the internal validity was markedly compromised due to biases and methodological flaws.

Specifically, we critically appraised the following methodological aspects of a study: (1) clarity of the research question, (2) randomization method, (3) concealment of treatment allocation, (4) blinding of treatment and outcomes, (5) similarity of baseline characteristics between/among treatment arms, (6) cointervention contamination, (7) validity and reliability of outcome measures, (8) follow-up rates, (9) analysis according to intention-to-treat principles, and (10) comparability of results across study sites (where applicable). Reviewers reached consensus through discussion. An independent third reviewer was used to resolve disagreements if consensus could not be reached. We contacted authors when additional information was needed to complete the critical appraisal. Furthermore, a senior epidemiologist reviewed the risk of bias of each appraised study by cross-checking consensus results with the original study. Studies with adequate internal validity had a low risk of bias and were included in our evidence synthesis.[30]

Data Extraction and Synthesis of Results

We computed agreement between reviewers for the screening of articles and reported the κ statistic and 95% confidence interval (CI).[31] We computed differences in mean changes between groups (with 95% CI) where data were available. The computation of CIs assumed an r = 0.80 between baseline and follow-up outcome values.[32,33]

The lead author extracted data from studies with a low risk of bias to build evidence tables. A second reviewer independently checked the extracted data. Moreover, a senior epidemiologist (PC) performed a final check of the extracted data by comparing the data to the original study. When meta-analysis was not appropriate, we performed a qualitative synthesis of findings from studies with a low risk of bias to develop evidence statements according to principles of best evidence synthesis.[30] We used standardized cutoff values to determine if clinically significant changes were reached in each trial for common outcome measures. These include a between-group 14/100 mm or 10% difference on the visual analog scale (VAS)[34]; a 10.83-point difference on the Disabilities of the Arm, Shoulder and Hand outcome measure (DASH)[35]; and a 7/100 or 22% difference for "a little better" or 11/100 or 37% difference for "much better" on the patient-rated lateral epicondylitis evaluation.[36] We stratified our results according to the musculoskeletal injury and duration: recent (symptoms lasting ≤3 months), persistent (symptoms lasting >3 months), or variable duration (included recent and persistent).

Reporting

The systematic review was organized and reported based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement.[37]

Results

Study Selection

We screened 9218 citations (Fig 1). Six articles were eligible for critical appraisal, and 5 studies (4 RCTs and 1 nonrandomized trial) had a low risk of bias and were included in our evidence synthesis. The interrater agreement for the article screening was κ = 0.71 (95% CI, 0.52-0.90). The percentage agreement for the critical appraisal of articles was 75% (5/6 studies) based on admissible/inadmissible results. For the 1 study where reviewers disagreed, consensus was reached through discussion.[38]

Study Characteristics

Four trials with a low risk of bias investigated the effectiveness of exercise for the management of persistent lateral epicondylitis in adults. One trial investigated the effectiveness of exercise for the management of persistent hand pain (excluding major pathology).[39] The following types of exercises were evaluated: concentric strengthening, eccentric strengthening, incremental loading, supervised exercise, and home exercise.

Risk of Bias Within Studies

All 5 studies with a low risk of bias clearly stated their research question and used valid and reliable outcome measures (Table 3). All studies had follow-up rates greater than 80% except 1 study that did not report dropouts stratified by condition.[39] However, the low risk of bias studies had minor limitations. One study provided limited details on randomization methods,[38] and another study performed sequential allocation.[42] Appropriate blinding was only sufficiently described in 1 study.[42] The method of

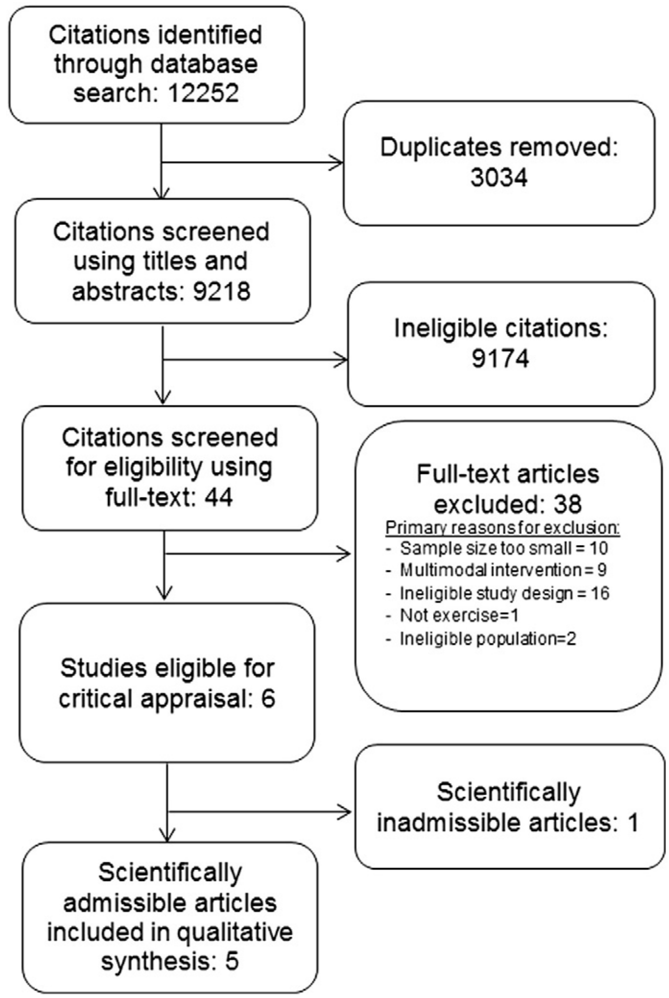

Fig 1. *Identification and selection of articles.*

allocation concealment was not adequately described in any studies.[38-42] Two studies reported differences in baseline characteristics; however, these differences were controlled for in the analyses.[40,41] Two of the 5 studies did not adequately describe whether there were cointerventions[39,41]

The study with a high risk of bias had important methodological limitations. Specifically, there were important differences in baseline characteristics between treatment groups that were not adjusted for in the analysis.[43] Furthermore, the outcome measures had unknown validity and reliability. Finally, there was no mention of whether an intention-to-treat analysis was carried out.[43]

Summary of Evidence

Persistent Lateral Epicondylitis (>3 Months). Evidence from 1 RCT suggests that adding home eccentric or concentric strengthening exercises to home stretching and advice provides no additional benefit to home stretching exercises and advice alone in patients with persistent lateral epicondylitis[38] (Table 4). Martinez-Silvestrini et al[38] randomized patients to 6 weeks of (1) stretching and advice plus eccentric strengthening exercises, (2) stretching and advice plus concentric exercises, or (3) stretching and advice alone. All exercises were performed at home. The stretching and advice group received instruction and advice on stretching exercises for wrist extensors, icing, use of counterforce straps, and how to avoid precipitating and exacerbating activities. Immediately after the 6-week intervention period, those who received eccentric exercises reported statistically significant improvements in pain scores compared to the concentric exercise group (mean difference, 8.0/100 [95% CI, 0.5-15.6]). Furthermore, individuals who received stretching and advice reported statistically significant improvements in pain scores compared to the concentric exercise group (mean difference, −9.0/100 [95% CI, −16.5 to −1.6]). However, neither of these differences were clinically important. No other differences between groups were found.

Table 3. *Risk of Bias for Randomized Controlled Trials With a Low Risk of Bias Based on Scottish Intercollegiate Guidelines Network Criteria*[21]

Author, Year	Research Question	Randomization	Concealment	Blinding	Similarity at Baseline	Similarity Between Arms	Outcome Measurement	Percent Dropout	Intention to Treat	Results Comparable Between Sites
Martinez-Silvestrini et al, 2005[38]	Y	CS	N	CS	Y	Y	Y	6 wk Concentric: 4/30, 13.3%; eccentric: 4/31, 12.9%; stretching: 5/33, 15.2%	Y	NA
Pedersen et al, 2013[39]	Y	Y	CS	CS	CS	CS	Y	No. of dropouts for hand pain cases unknown	Y	CS
Peterson et al, 2011[40]	Y	Y	CS	N	N	Y	Y	1 mo Exercise: 2/40, 5%; WS: 0/41, 0% 2 mo Exercise: 2/40, 5%; WS: 0/41, 0% 3 mo Exercise: 2/40, 5%; WS: 1/41, 2.45%	Y	NA
Peterson et al, 2014[41]	Y	Y	N	N	Y	CS	Y	3 mo Eccentric : 2/60, 3.3%; concentric : 3/60, 5% 6 mo Eccentric :3/60, 5%; concentric :3/60, 5% 12 mo Eccentric : 3/60, 5%; concentric : 3/60, 5%	Y	CS
Stasinopoulos et al,[a] 2010[42]	Y	N	N	Y	Y	Y	Y	Home exercise program: 0/35, 0% at both 12 and 24 wk Clinic-based exercise program: 0/35, 0% at both 12 and 24 wk	NA	NA

CS, cannot say; *N*, no; *NA*, not applicable; *WS*, wait and see; *Y*, yes.
[a] Non-randomized trial.

Table 4. *Evidence Table for Randomized Controlled Trials With a Low Risk of Bias Assessing the Effectiveness of Exercise for Musculoskeletal Injuries and Neuropathies of the Elbow, Forearm, Wrist, or Hand Region*

Author(s), Year	Subjects and Setting; Number (n) Enrolled	Interventions; No. (n) of Subjects	Comparisons; No. (n) of Subjects	Follow-Up	Outcomes	Key Findings
Martinez-Silvestrini et al, 2005[38]	Adult patients recruited from the Mayo Clinic and in local health clubs in Minnesota. Case definition: Pain and tenderness at lateral elbow >3 mo and pain with 2/3 tests (resisted wrist extension, resisted middle finger extension, and chair lift test); n = 94	CS: (1) Full wrist extension with resistance band (3 sets/ 10× daily/6 wk); (2) stretching and advice; n = 30 ES: (1) Full wrist flexion with resistance band (3 sets/ 10× daily/6 wk); (2) stretching and advice; n = 31	Stretching (S) Stretching and advice: stretches for wrist extensors (3× for 30 s twice daily/6 wk), avoid precipitating and exacerbating activities, use of counterforce strap as needed, information sheet on ice massage; n = 33	Postintervention	Primary outcomes: PFG strength (electronic dynamometer); PRFEQ, DASH, SF-36, pain intensity (100-mm VAS).	Difference in mean change (CS − S) at 6 wk: [a] PFG (N), −1.0 (95% CI, −5.5 to 3.5); VAS, −9.0 (95% CI, −16.5 to −1.6); total PRFEQ, 0.3 (95% CI, −0.2 to 0.8); DASH, −3.0 (95% CI, −7.4 to 1.4) Difference in mean change (ES − S) at 6 wk: [a] PFG (N), −3.0 (95% CI, −1.7 to 7.7); VAS, −1.0 (95% CI, −8.2 to 6.2); total PRFEQ, −0.1 (95% CI, −0.6 to 0.4); DASH, −3.0 (95% CI, −7.5 to 1.5) Difference in mean change (ES − CS) at 6 wk: [a] PFG (N), 4.0 (95% CI, −0.0 to 8.0); VAS, 8.0 (95% CI, 0.5-15.6); total PRFEQ, −0.4 (95% CI, −1.0 to 0.2); DASH, 0.0 (95% CI, −4.5 to 4.5)
Pedersen et al, 2013[39]	Industrial workers (18-67 years old) with repetitive work tasks from Copenhagen, Denmark. Case definition: right hand pain intensity ≥3/9 on the Nordic questionnaire on trouble; n = 95	Supervised progressive strength training (wrist extension with dumbbells) at the workplace provided by staff and students trained in physical education or physiotherapy (20 min/3 times per week for 20 wk). Advice to continue their normal physical activity as usual; n = 55	Advice to continue their normal physical activity as usual; n = 40	20 wk	Primary outcome: pain intensity during the last 7 d (Nordic questionnaire on trouble 0-9)	Between-group mean differences (strength training and advice-advice): [b] No statistically significant between-group differences in pain intensity and percentage of subjects with pain reductions ≥2
Peterson et al, 2011[40]	Patients (20-75 years old) recruited from general practitioners, physiotherapist, and newspaper advertisements in Uppsala, Sweden, from 2003 to 2006 Case definition: Diagnosis	SE: Progressive loading exercise for extensor muscles at home (3 sets/15 repetitions/daily/3 mo) and some information as comparison group; n = 40	WS with information that condition was painful but harmless and continue ordinary daily activities; n = 41	Immediately postintervention	Primary outcomes: pain on MVC and MME (100-mm VAS); secondary outcomes: muscle strength (hand-held dynamometer); tertiary outcomes: DASH, GQL (well-being score,	Difference in mean change (SE − WS) postintervention: [a] VAS for MVC (0-100 mm), 15.8 (95% CI, 8.3-23.4); VAS for MME (0-100 mm), 12.9 (95%

(continued on next page)

Table 4. (*continued*)

Author(s), Year	Subjects and Setting; Number (n) Enrolled	Interventions; No. (n) of Subjects	Comparisons; No. (n) of Subjects	Follow-Up	Outcomes	Key Findings
	of tennis elbow (>3 mo) on palpation, Mill's test loading and Maudley's middle finger test; n = 81				activity score, complaint score)	CI, 5.6-20.2); muscular strength (N), 7.5 (95% CI, −5.3 to 20.3); DASH score (0-100), 4.6 (95% CI, 0.6-8.6); well-being score (0-7), 1.0 (95% CI, −0.9 to 2.9); activity score (0-2), 0.2 (95% CI, −0.2 to 0.6); complaint score, 0.0 (95% CI, −1.4 to 1.4)
Peterson et al, 2014[41]	Patients (20-75 years old) recruited from general practitioners, physiotherapists, and newspaper advertisements in Uppsala, Sweden. Case definition: Diagnosis of tennis elbow (>3 mo) with pain on palpation, pain on stretching (Mill's test), pain on loading, and Maudley's middle finger test; n = 120	Home-based eccentric exercise group instructed to lower weight by flexing the wrist of the affected arm downwards and to lift back up with unaffected arm (15 repetitions/set and 3 sets daily for 3 mo). Load increased weekly by 1 hectogram; n = 60	Home-based concentric exercise group instructed to lift the weight by extending the wrist of the affected arm upwards and lower it with unaffected arm (15 repetitions/set and 3 sets daily for 3 mo). Load increased weekly by 1 hectogram; n = 60	3, 6, and 12 mo after baseline assessment	Primary outcomes: pain reduction (100-mm VAS) during forearm muscle contraction, pain reduction (100-mm VAS) during forearm muscle elongation; secondary outcomes: muscle strength (N) (hand-held dynamometer); tertiary outcomes: DASH, 0-100: GQL (well-being score, 0-2; activity score, 0-7; complaint score). Adverse events	Difference in mean change (eccentric exercise − concentric exercise): [a] 3 mo: VAS for MVC (0-100 mm), 4.3 (95% CI, −1.8 to 10.4); VAS for MME (0-100 mm), 4.8 (95% CI, −1.3 to 10.9); muscle strength (N), 5.9 (95% CI, −4.8 to 16.6); DASH score (0-100), 0.1 (95% CI, −4.0 to 4.2); activity score (0-2): −1.4 (95% CI, −3.0 to 0.2); well-being score (0-7), 0 (95% CI, −0.3 to 0.3); complaint score, 0.4 (95% CI, −0.9 to 1.7) 6 mo: VAS for MVC (0-100 mm), 5.2 (95% CI, −0.7 to 11.1); VAS for MME (0-100 mm), 4.2 (95% CI −1.8 to 10.2); muscle strength (N), 5.4 (95% CI, −5.4 to 16.2); DASH score (0-100), −0.3 (95% CI, −4.3 to 3.7); activity score (0-2), −0.6 (95% CI, −2.2 to 1.0); well-being score (0-7), −0.1 (95% CI, −0.4 to 0.2); complaint score, −0.2

						(95% CI −1.4 to 1.0) 12 mo: VAS for MVC (0-100 mm), 4.8 (95% CI −1.2 to 10.8); VAS for MME (0-100 mm), 3.7 (95% CI −2.9 to 10.3); muscle strength (N), 4.3 (95% CI, −6.8 to 15.4); DASH score (0-100), 1.3 (95% CI, −2.7 to 5.3); activity score (0-2), −0.9 (95% CI, −2.6 to 0.8); well-being score (0-7), 0.1 (95% CI, −0.2 to 0.4); complaint score, 1 (95% CI, −0.3 to 2.3) No adverse events reported.
Stasinopoulos et al, 2010[42]	Patients (18 years old) from Athens, Greece, referred by physicians and physiotherapists from 2005 to 2007. Case definition: Lateral epicondylitis (≥4 wk): (1) pain on palpation; pain with resisted elbow extension; (3) 2/4 positive tests (Tomsen, resisted middle finger, Mill's handgrip dynamometer); n = 70	CEP: slow progressive eccentric exercises of the wrist extensors and static stretching exercises of the extensor carpi radialis brevis tendon supervised by a physical therapist (5×/week/12 wk); n = 35	HEP: same exercise protocol as CEP group except performed at home (5×/week/12 wk). Visit with physical therapist 1×/week for further instructions; n = 35	12 wk postintervention, and 24 wk	Primary outcomes: pain (10-cm VAS); secondary outcomes: elbow function (10-cm VAS); tertiary outcomes: pain-free grip strength (Jamar hand-held dynamometer)	Difference in mean change (CEP − HEP): Postintervention (week 12): VAS for pain (0-10 cm), 1.54 (95% CI, 0.54-2.55); VAS for function (0-10 cm), 2.55 (95% CI, 1.72-3.38); pain-free grip strength (lb), 17.05 (95% CI, 16.03-18.07) 3 mo (week 24): VAS for pain (0-10 cm), 1.76 (95% CI, 1.03-2.50); VAS for function (0-10 cm), 2.81 (95% CI, 1.81-3.81); pain-free grip strength (lb), 17.08 (95% CI, 16.14-18.01)

CS, concentric strengthening; *CEP*, clinic-based exercise program; *ES*, eccentric strengthening; *GQL*, Gothenburg Quality of Life Instrument; *HEP*, home exercise program; *PFG*, pain-free grip; *PRFEQ*, Patient-rated Forearm Evaluation Questionnaire; *S*, stretching; *SE*, strengthening exercises; *SF-36*, Short Form 36; *WS*, wait and see.

[a] Recalculated data from study.

[b] Data were presented in graphs; differences in mean change and 95% CIs could not be calculated.

Similarly, evidence from another RCT suggests that home-based, graded eccentric and concentric exercise programs lead to similar outcomes in patients with persistent lateral epicondylitis. Peterson et al[41] randomized participants to 3 months of (1) home-based, graded eccentric exercises (15 repetitions/set and 3 sets daily), or (2) home-based, graded concentric exercises (15 repetitions/set and 3 sets daily) (Table 4). There were no statistically significant differences between groups in pain (VAS), muscle strength (dynamometer), disability (DASH), and quality of life (Gothenburg Quality of Life Instrument) at any follow-up. The between-group differences for pain and disability were not clinically important. The clinical importance of the muscle strength and quality-of-life outcomes is unknown because minimal clinically important differences have not been established.

Evidence from a third RCT suggests that a home strengthening exercise program is more effective than "wait and see" in reducing pain in patients with persistent lateral epicondylitis[40] (Table 4). In their trial, Peterson et al[40] randomized participants to (1) 3 months of daily home progressive incremental loading exercises for the forearm extensors or (2) "wait and see." All participants received advice that their condition was painful but harmless and to continue ordinary daily activities. Immediately after the 3 month intervention period, participants in the exercise group reported clinically important improvement in elbow pain (VAS) during maximum voluntary contraction (MVC) (mean difference, 15.8/100 [95% CI, 8.25-23.35]) compared to individuals in the "wait and see" group. Furthermore, participants in the exercise group reported statistically significant but not clinically important self-reported improvement in elbow pain (VAS) during maximum muscle elongation (MME) (mean difference, 12.9/100 [95% CI, 5.63-20.17]) compared to individuals in the "wait and see" group. Moreover, the exercise group had statistically significant improvement in disability (DASH) at 3 months when compared to the wait-list group; however, these differences were not clinically important (Table 4).

Evidence from 1 nonrandomized trial suggests that a clinic-based supervised exercise program is more effective than a therapist-monitored home exercise program in reducing self-reported pain, function, and pain-free grip strength in patients with lateral elbow tendinopathy with a mean duration of 5 months (we, therefore, classified this study under persistent duration)[42] (Table 4). Stasinopoulos et al[42] compared a clinic-based supervised exercise program to a similar home exercise program. Participants allocated to clinic-based exercise completed a 12-week protocol that included slow progressive eccentric exercises of the wrist extensors and static stretching of the extensor carpi radialis brevis tendon under supervision by a physical therapist 5 times per week. Participants allocated to a home exercise program followed an identical exercise program and received weekly visits from a physical therapist to provide further instructions. At 12 weeks (postintervention) and 24 weeks, participants in the clinic-based exercise program demonstrated statistically and clinically important improvements in self-reported pain (VAS) (mean difference at 12 weeks, 1.54/10 [95% CI, 0.54-2.55]; 24 weeks, 1.76/10 [95% CI, 1.03-2.50]). There were also statistically significant differences in function (VAS) (mean difference at 12 weeks, 2.55/10 [95% CI, 1.72-3.38]; 24 weeks, 2.81/10 [95% CI, 1.81-3.81]) and pain-free grip strength (mean difference at 12 weeks, 17.05/10 [95% CI, 16.03-18.07]; 24 weeks, 17.08/10 [95% CI, 16.14-18.01]). However, the clinical importance of these differences is unknown (Table 4).

Hand Pain of Variable Duration. Evidence from 1 RCT suggests that supervised strength training at the workplace does not provide additional benefits to advice to continue normal physical activity to individuals with hand pain (excluding major pathology). In their RCT, Pedersen et al[39] randomized industrial workers who perform repetitive work tasks and report hand pain to (1) supervised progressive strength training at the workplace (20 minutes/3 times per week/20 weeks) with advice to continue normal physical activity as usual or (2) advice to continue normal physical activity as usual. There were no statistically significant or clinically important between-group differences in pain.

Adverse Events. Two trials reported that no adverse events were associated with performing the investigated strengthening or stretching exercises.[41,42] The other 3 studies did not report on adverse events.[38-40]

Discussion

Summary of Evidence

Our systematic review provides an update of the evidence on the effectiveness of exercise for the management of lateral epicondylitis. The role of strengthening exercises for the management of persistent lateral epicondylitis remains unclear. Although a home strengthening exercise program is more effective than "wait and see" for persistent lateral epicondylitis, we found that adding eccentric or concentric strengthening exercises to stretching and advice alone does not improve outcomes of patients with this condition. We also found that clinic-based, supervised eccentric strengthening exercises combined with static stretching were more effective than the same exercises performed at home for patients with persistent lateral epicondylitis. We also found no differences between groups who performed home-based eccentric or concentric exercises for persistent lateral epicondylitis. Moreover, adding supervised progressive strength training does not provide additional benefits to advice to continue normal physical activity as usual for patients with hand pain. We found no studies with a low risk of bias to inform the use of exercise for the management of other musculoskeletal disorders and injuries of the hand, wrist, forearm, and elbow, which include but are not limited to medial epicondylitis, carpal tunnel syndrome, and de Quervain tenosynovitis.

Previous Systematic Reviews

Some of the findings of our review contradict findings from previous systematic reviews. A review by Cullinane et al[13] supported the inclusion of eccentric strengthening exercises as a part of a multimodal therapy program for patients with lateral epicondylitis.[13] In our review, we found that the addition of an eccentric exercise program to stretching and advice provides no further benefits for patients with persistent lateral epicondylitis. Our conclusions may differ because Cullinane et al included studies involving multimodal interventions (with exercise as a component of the multimodal program) and studies with a high risk of bias. Furthermore, our review partially agrees with 2 previous systematic reviews[11,12] suggesting that strengthening exercises are effective for lateral epicondylitis. However, we found 1 recent RCT, published after these reviews, that suggests that the addition of eccentric or concentric strengthening exercises to stretching and advice provides no further benefits for patients with persistent lateral epicondylitis.[38] We did not find any studies with a low risk of bias that evaluated the effectiveness of stretching alone for lateral epicondylitis. Finally, a review by Bisset et al[14] concluded that the evidence of exercise for lateral epicondylitis is inconclusive. Our review suggests that stretching or strengthening exercises may be beneficial for the management of persistent lateral epicondylitis. However, it is not clear which of stretching or strengthening provides more benefit.

We did not find studies with a low risk of bias to inform the discussion on the effectiveness of exercise for other musculoskeletal disorders and injuries of the elbow, forearm, wrist, and hand such as medial epicondylitis, cubital tunnel syndrome, carpal tunnel syndrome, and de Quervain tenosynovitis. Two previous systematic reviews that studied the effectiveness of exercise for carpal tunnel syndrome were found.[15,16] One review suggested that exercise therapy was not effective for carpal tunnel syndrome,[15] and 1 review suggested that neurodynamic mobilization (stretching/nerve flossing exercises) may be beneficial for the management of pain in those with carpal tunnel syndrome.[16] The studies from these reviews were not included in our review because their sample size did not meet our inclusion criteria. Our review found that adding supervised progressive strength training to advice to continue normal physical activity provided no additional benefits for hand pain. However, this study does not specify whether some patients may have carpal tunnel syndrome. As such, the evidence for the effectiveness of exercise for the management of carpal tunnel syndrome can be considered inconclusive.

The conclusions of these reviews may have been influenced by methodological limitations. Conclusions from previous reviews may differ from our results because they synthesized evidence from all eligible studies regardless of their scientific quality.[11-16] They also included studies with small sample sizes,[11-16] which reduces the precision of the effect sizes and increases the chance of residual confounding.

Implications of the Research

The findings from this review may help clinicians and health care providers in making evidence-based decisions regarding patient care for the management of musculoskeletal disorders and injuries. It is important to provide evidence-based interventions to limit the personal, financial, and societal burden of disability associated with these conditions.[7,10] This review suggests that specific exercise interventions may benefit patients; it is, therefore, important for clinicians to prescribe the right type of exercise at the right time during the course of the condition.

Strengths

We implemented a comprehensive and rigorous search strategy that was reviewed by a second librarian to help minimize errors. Second, we defined clear inclusion and exclusion criteria for the selection of relevant studies. Third, we used 2 trained independent reviewers to screen and critically appraise the literature to minimize error and bias. Fourth, the SIGN criteria were used to standardize the critical appraisal process and to inform our scientific judgment. Lastly, our conclusions were based on a best evidence synthesis, omitting studies of low quality to minimize the risk of bias.

Limitations

We limited our search to studies published in the English language, which may have excluded some relevant studies. However, this is an unlikely source of bias because most trials are published in English. The sole inclusion of trials published in English has not previously led to biased results.[44-47] Second, our search may have missed relevant studies despite our broad search strategy. Third, our review may have missed potentially relevant studies published before 1990. Finally, the critical appraisal process entails scientific judgment that may differ between reviewers. This potential bias was minimized by training reviewers to use a standardized critical appraisal tool and by using a consensus process.

Recommendations for Future Research

High-quality studies to establish the effectiveness of exercise programs are needed to inform for the management of lateral epicondylitis. Similarly, studies are needed to determine the role of exercise for the management of other common musculoskeletal injuries of the elbow, wrist, and hand (eg, medial epicondylitis, de Quervain tenosynovitis, and carpal tunnel syndrome).

Conclusion

This review helps clarify the effectiveness of exercise for the management of musculoskeletal disorders of the elbow, forearm, wrist, and hand. The results suggest that, for persistent lateral epicondylitis, home strengthening exercise is more effective than "wait and see" and that home-based concentric or eccentric exercises lead to similar outcomes. However, adding eccentric or concentric strengthening exercises to stretching and advice provides no additional benefits to stretching and advice alone. This review also found that clinic-based strengthening and static stretching exercises are more effective than monitored home-based strengthening and stretching exercises for persistent lateral epicondylitis. Therefore, the relative effectiveness of stretching vs strengthening the wrist extensors remains unknown for the management of persistent lateral epicondylitis. The review also suggests that supervised progressive strength training added to advice to continue normal physical activity provides no additional benefits for hand pain. No studies with a low risk of bias to inform the use of exercise for the management of other musculoskeletal disorders and injuries of the hand, wrist, forearm, and elbow were found.

Practical Applications

- This review suggests that eccentric or concentric strengthening exercises combined with advice and stretching alone are equivalent for the management of persistent epicondylitis.
- For patients with persistent lateral epicondylitis, home strengthening exercises are more beneficial than "wait and see" for short-term improvements in pain reduction.
- Clinic-based strengthening exercises and static stretching are more effective than monitored home strengthening and stretching exercises.
- The relative effectiveness of stretching vs strengthening the wrist extensors remains unknown for the management of persistent lateral epicondylitis.
- For hand pain of variable duration, supervised progressive strength training added to advice to continue normal physical activity provides no additional benefits.

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Contributorship Information

Concept development (provided idea for the research): P.C., H.S.
Design (planned the methods to generate the results): C.J., K.R., P.C., M.S., J.W., S.V., De.S., H.Y., Da.S., A.TV., H.S.
Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): P.C.
Data collection/processing (responsible for experiments, patient management, organization, or reporting data): R.M., K.R., S.D., J.W., C.B., K.D., S.V., J.D., De.S., H.Y., Da.S., A.TV.
Analysis/interpretation (responsible for statistical analysis, evaluation, and presentation of the results): R.M., K.R., P.C., M.S.
Writing (responsible for writing a substantive part of the manuscript): R.M., K.R., P.C.
Critical review (revised manuscript for intellectual content, this does not relate to spelling and grammar checking): C.J., R.M., K.R., S.D., J.W., P.C., M.S., C.B., K.D., S.V., J.D., De.S., H.Y., Da.S., S.M., H.S.

Appendix A. Supplementary data

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References

1. Buckle PW, Devereux JJ. The nature of work-related neck and upper limb musculoskeletal disorders. Appl Ergon 2002;33:207-17.
2. Workplace Safety & Insurance Board. By the Numbers: 2013 WSIB Statistical Report; 2014 [Toronto, ON].
3. Shiri R, Viikari-Juntura E, Varonen H, Heliovaara M. Prevalence and determinants of lateral and medial epicondylitis: a population study. Am J Epidemiol 2006;164:1065-74.
4. Ranney D, Wells R, Moore A. Upper limb musculoskeletal disorders in highly repetitive industries: precise anatomical physical findings. Ergonomics 1995;38:1408-23.
5. Kurppa K, Viikari-Juntura E, Kuosma E, Huuskonen M, Kivi P. Incidence of tenosynovitis or peritendinitis and epicondylitis in a meat-processing factory. Scand J Work Environ Health 1991;17:32-7.
6. Plancher KD, Halbrecht J, Lourie GM. Medial and lateral epicondylitis in the athlete. Clin Sports Med 1996;15:283-305.
7. Werner RA, Franzblau A, Gell N, Hartigan A, Ebersole M, Armstrong TJ. Predictors of persistent elbow tendonitis among auto assembly workers. J Occup Rehabil 2005;15:393-400.
8. Atroshi I, Gummesson C, Johnsson R, Ornstein E, Ranstam J, Rosen I. Prevalence of carpal tunnel syndrome in a general population. JAMA 1999;282:153-8.
9. Dale AM, Harris-Adamson C, Rempel D, et al. Prevalence and incidence of carpal tunnel syndrome in US working populations: pooled analysis of six prospective studies. Scand J Work Environ Health 2013;39:495-505.
10. Palmer DH, Hanrahan LP. Social and economic costs of carpal tunnel surgery. Instr Course Lect 1995;44:167-72.
11. Trudel D, Duley J, Zastrow I, Kerr EW, Davidson R, MacDermid JC. Rehabilitation for patients with lateral epicondylitis: a systematic review. J Hand Ther 2004;17:243-66.
12. Smidt N, Assendelft WJ, Arola H, et al. Effectiveness of physiotherapy for lateral epicondylitis: a systematic review. Ann Med 2003;35:51-62.
13. Cullinane FL, Boocock MG, Trevelyan FC. Is eccentric exercise an effective treatment for lateral epicondylitis? A systematic review. Clin Rehabil 2014;28:3-19.
14. Bisset L, Paungmali A, Vicenzino B, Beller E. A systematic review and meta-analysis of clinical trials on physical interventions for lateral epicondylalgia. Br J Sports Med 2005;39:411-22 [discussion −22].
15. Piazzini DB, Aprile I, Ferrara PE, et al. A systematic review of conservative treatment of carpal tunnel syndrome. Clin Rehabil 2007;21:299-314.
16. Page MJ, O'Connor D, Pitt V, Massy-Westropp N. Exercise and mobilisation interventions for carpal tunnel syndrome. Cochrane Database Syst Rev 2012;6:CD009899.
17. Prevention CfDCa. NIOSH Program Portfolio. Musculoskeletal Disorders; 2015 [[March 19, 2015]; Available from: http://www.cdc.gov/niosh/programs/msd/].
18. America Academy of Orthopaedic Surgeons. Homepage on the Internet. Combined knee ligament injuries. C. Available from: http://orthoinfo.aaos.org/topic.cfm?topic=A00551 2014.
19. McGowan J, Sampson M, Lefebvre C. An evidence based checklist for the Peer Review of Electronic Search Strategies (PRESS EBC). Evid Based Libr Inf Pract 2010;5:149-54.
20. Sampson M, McGowan J, Cogo E, Grimshaw J, Moher D, Lefebvre C. An evidence-based practice guideline for the peer review of electronic search strategies. J Clin Epidemiol 2009;62:944-52.
21. Harbour R, Miller J. A new system for grading recommendations in evidence based guidelines. BMJ 2001;323:334-6.
22. Than M, Flaws D, Sanders S, et al. Development and validation of the Emergency Department Assessment of Chest pain Score and 2 h accelerated diagnostic protocol. Emerg Med Australas 2014;26:34-44.
23. van der Velde G, van Tulder M, Côté P, et al. The sensitivity of review results to methods used to appraise and incorporate trial quality into data synthesis. Spine (Phila Pa 1976) 2007;32:796-806.
24. Carroll LJ, Cassidy JD, Peloso PM, Garritty C, Giles-Smith L. Systematic search and review procedures: results of the WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury. J Rehabil Med 2004(43 Suppl):11-4.
25. Carroll LJ, Cassidy JD, Peloso PM, et al. Methods for the best evidence synthesis on neck pain and its associated disorders: the Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders. J Manipulative Physiol Ther 2009;32(2 Suppl):S39-45.
26. Côté P, Cassidy JD, Carroll L, Frank JW, Bombardier C. A systematic review of the prognosis of acute whiplash and a new conceptual framework to synthesize the literature. Spine 2001;26:E445-58.
27. Hayden JA, Côté P, Bombardier C. Evaluation of the quality of prognosis studies in systematic reviews. Ann Intern Med 2006;144:427-37.
28. Hayden JA, van der Windt DA, Cartwright JL, Côté P, Bombardier C. Assessing bias in studies of prognostic factors. Ann Intern Med 2013;158:280-6.
29. Spitzer WO, Skovron ML, Salmi LR, et al. Scientific monograph of the Quebec Task Force on Whiplash-Associated Disorders: redefining "whiplash" and its management. Spine 1995;20(8 Suppl):1S-73S.
30. Slavin RE. Best evidence synthesis: an intelligent alternative to meta-analysis. J Clin Epidemiol 1995;48:9-18.
31. Cohen J. A coefficient of agreement for nominal scales. Educ Psychol Meas 1960;20:37-46.
32. Abrams KR, Gillies CL, Lambert PC. Meta-analysis of heterogeneously reported trials assessing change from baseline. Stat Med 2005;24:3823-44.
33. Follmann D, Elliott P, Suh I, Cutler J. Variance imputation for overviews of clinical trials with continuous response. J Clin Epidemiol 1992;45:769-73.
34. Tashjian RZ, Deloach J, Porucznik CA, Powell AP. Minimal clinically important differences (MCID) and patient acceptable symptomatic state (PASS) for visual analog scales (VAS) measuring pain in patients treated for rotator cuff disease. J Shoulder Elbow Surg 2009;18:927-32.
35. Franchignoni F, Vercelli S, Giordano A, Sartorio F, Bravini E, Ferriero G. Minimal clinically important difference of the disabilities of the arm, shoulder and hand outcome measure (DASH) and its shortened version (QuickDASH). J Orthop Sports Phys Ther 2014;44:30-9.
36. Watson T, Poltawski L. Measuring clinically important change with the Patient-rated Tennis Elbow Evaluation. J Hand Ther 2011;16:52-7.
37. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. BMJ 2009;339:b2535.
38. Martinez-Silvestrini JA, Newcomer KL, Gay RE, Schaefer MP, Kortebein P, Arendt KW. Chronic lateral epicondylitis: comparative effectiveness of a home exercise program including stretching alone versus stretching supplemented

with eccentric or concentric strengthening. J Hand Ther 2005; 18:411-9 [quiz 20].
39. Pedersen MT, Andersen CH, Zebis MK, Sjøgaard G, Andersen LL. Implementation of specific strength training among industrial laboratory technicians: long-term effects on back, neck and upper extremity pain. BMC Musculoskelet Disord 2013;14:287.
40. Peterson M, Butler S, Eriksson M, Svärdsudd K. A randomized controlled trial of exercise versus wait-list in chronic tennis elbow (lateral epicondylosis). Ups J Med Sci 2011;116:269-79.
41. Peterson M, Butler S, Eriksson M, Svärdsudd K. A randomized controlled trial of eccentric vs. concentric graded exercise in chronic tennis elbow (lateral elbow tendinopathy). Clin Rehabil 2014;28:862-72.
42. Stasinopoulos D, Stasinopoulos I, Pantelis M, Stasinopoulou K. Comparison of effects of a home exercise programme and a supervised exercise programme for the management of lateral elbow tendinopathy. Br J Sports Med 2010;44:579-83.
43. Bardak AN, Alp M, Erhan B, Paker N, Kaya B, Onal AE. Evaluation of the clinical efficacy of conservative treatment in the management of carpal tunnel syndrome. Adv Ther 2009; 26:107-16.
44. Moher D, Pham B, Lawson ML, Klassen TP. The inclusion of reports of randomised trials published in languages other than English in systematic reviews. Health Technol Assess 2003;7: 1-90.
45. Moher D, Fortin P, Jadad AR, et al. Completeness of reporting of trials published in languages other than English: implications for conduct and reporting of systematic reviews. Lancet 1996;347:363-6.
46. Morrison A, Polisena J, Husereau D, et al. The effect of English-language restriction on systematic review-based meta-analyses: a systematic review of empirical studies. Int J Technol Assess Health Care 2012;28:138-44.
47. Sutton AJ, Duval SJ, Tweedie RL, Abrams KR, Jones DR. Empirical assessment of effect of publication bias on meta-analyses. BMJ 2000;320:1574-7.