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[Intervention Review]

Deep transverse friction massage for treating lateral elbow or lateral knee tendinitis

Laurianne M Loew¹, Lucie Brosseau¹, Peter Tugwell², George A Wells³, Vivian Welch⁴, Beverley Shea³, Stephane Poitras¹, Gino De Angelis³, Prinon Rahman¹

¹School of Rehabilitation Sciences, Faculty of Health Sciences, University of Ottawa, Ottawa, Canada. ²Department of Medicine, Faculty of Medicine, University of Ottawa, Ottawa, Canada. ³Department of Epidemiology and Community Medicine, University of Ottawa, Ottawa, Canada. ⁴Bruyère Research Institute, University of Ottawa, Ottawa, Canada

Contact address: Lucie Brosseau, School of Rehabilitation Sciences, Faculty of Health Sciences, University of Ottawa, 451 Smyth Road, Ottawa, ON, K1H 8M5, Canada. Lucie.Brosseau@uottawa.ca.

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ABSTRACT

Background

Deep transverse friction massage, one of several physical therapy interventions suggested for the management of tendinitis pain, was first demonstrated in the 1930s by Dr James Cyriax, a renowned orthopedic surgeon in England. Its goal is to prevent abnormal fibrous adhesions and abnormal scarring. This is an update of a Cochrane review first published in 2001.

Objectives

To assess the benefits and harms of deep transverse friction massage for treating lateral elbow or lateral knee tendinitis.

Search methods

We searched the following electronic databases: the specialized central registry of the Cochrane Field of Physical and Related Therapies, the Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE, EMBASE, the Cumulative Index to Nursing and Allied Health Literature (CINAHL), Clinicaltrials.gov, and the Physiotherapy Evidence Database (PEDro), up until July 2014. The reference lists of these trials were consulted for additional studies.

Selection criteria

All randomized controlled trials (RCTs) and controlled clinical trials (CCTs) comparing deep transverse friction massage with control or other active interventions for study participants with two eligible types of tendinitis (ie, extensor carpi radialis tendinitis (lateral elbow tendinitis, tennis elbow or lateral epicondylitis or lateralis epicondylitis humeri) and iliotibial band friction syndrome (lateral knee tendinitis)) were selected. Only studies published in English and French languages were included.

Data collection and analysis

Two review authors independently assessed the studies on the basis of inclusion and exclusion criteria. Results of individual trials were extracted from the included study using extraction forms prepared by two independent review authors before the review was begun. Data were cross-checked by a third review author. Risk of bias of the included studies was assessed using the "Risk of bias" tool of The Cochrane Collaboration. A pooled analysis was performed using mean difference (MD) for continuous outcomes and risk ratio (RR) for dichotomous outcomes with 95% confidence intervals (CIs).

Main results

Two RCTs (no new additional studies in this update) with 57 participants met the inclusion criteria. These studies demonstrated high risk of performance and detection bias, and the risk of selection, attrition, and reporting bias was unclear.

The first study included 40 participants with lateral elbow tendinitis and compared (1) deep transverse friction massage combined with therapeutic ultrasound and placebo ointment ($n = 11$) versus therapeutic ultrasound and placebo ointment only ($n = 9$) and (2) deep transverse friction massage combined with phonophoresis ($n = 10$) versus phonophoresis only ($n = 10$). No statistically significant differences were reported within five weeks for mean change in pain on a 0 to 100 visual analog scale (VAS) (MD -6.60, 95% CI -28.60 to 15.40; 7% absolute improvement), grip strength measured in kilograms of force (MD 0.10, 95% CI -0.16 to 0.36) and function on a 0 to 100 VAS (MD -1.80, 95% CI -0.18.64 to 15.04; 2% improvement), pain-free function index measured as the number of pain-free items (MD 1.10, 95% CI -1.00 to 3.20) and functional status (RR 3.3, 95% CI 0.4 to 24.3) for deep transverse friction massage, and therapeutic ultrasound and placebo ointment compared with therapeutic ultrasound and placebo ointment only. Likewise for deep transverse friction massage and phonophoresis compared with phonophoresis alone, no statistically significant differences were found for pain (MD -1.2, 95% CI -20.24 to 17.84; 1% improvement), grip strength (MD -0.20, 95% CI -0.46 to 0.06) and function (MD 3.70, 95% CI -14.13 to 21.53; 4% improvement). In addition, the GRADE (Grades of Recommendation, Assessment, Development and Evaluation) approach was used to evaluate the quality of evidence for the pain outcome, which received a score of "very low". Pain relief of 30% or greater, quality of life, patient global assessment, adverse events, and withdrawals due to adverse events were not assessed or reported.

The second study included 17 participants with iliotibial band friction syndrome (knee tendinitis) and compared deep transverse friction massage with physical therapy intervention versus physical therapy intervention alone, at two weeks. Deep transverse friction massage with physical therapy intervention showed no statistically significant differences in the three measures of pain relief on a 0 to 10 VAS when compared with physical therapy alone: daily pain (MD -0.40, 95% CI -0.80 to -0.00; absolute improvement 4%), pain while running (scale from 0 to 150) (MD -3.00, 95% CI -11.08 to 5.08), and percentage of maximum pain while running (MD -0.10, 95% CI -3.97 to 3.77). For the pain outcome, absolute improvement showed a 4% reduction in pain. However, the quality of the body of evidence received a grade of "very low." Pain relief of 30% or greater, function, quality of life, patient global assessment of success, adverse events, and withdrawals due to adverse events were not assessed or reported.

Authors' conclusions

We do not have sufficient evidence to determine the effects of deep transverse friction on pain, improvement in grip strength, and functional status for patients with lateral elbow tendinitis or knee tendinitis, as no evidence of clinically important benefits was found. The confidence intervals of the estimate of effects overlapped the null value for deep transverse friction massage in combination with physical therapy compared with physical therapy alone in the treatment of lateral elbow tendinitis and knee tendinitis. These conclusions are limited by the small sample size of the included randomized controlled trials. Future trials, utilizing specific methods and adequate sample sizes, are needed before conclusions can be drawn regarding the specific effects of deep transverse friction massage on lateral elbow tendinitis.

PLAIN LANGUAGE SUMMARY

Deep transverse friction massage for the treatment of lateral elbow or lateral knee tendinitis

Review question

We conducted an update of the review of the effects of deep transverse friction massage (DTFM) for people with lateral elbow or knee tendinitis. We found two studies (no new additional studies in this update) with 57 people.

Background: what is tendinitis and what is deep tendon friction massage?

Tendons are fibrous structures that attach muscle to bone. Tendinitis essentially is seen when a tendon suffers from inflammation (painful swelling). The inflammation is due to too much stress on the tendon caused by performing repetitive movements. This causes pain and stiffness in the joint such as the elbow or the knee.

Deep transverse friction massage (DTFM) is a physical therapy technique often used to reduce damage and scarring caused by inflammation. It increases blood flow to the joint, which facilitates healing of the tendon by increasing the supply of oxygen transported to the injury.

Study characteristics

One study with a duration of five weeks reviewed (1) the effects of deep transverse friction massage combined with therapeutic ultrasound and placebo ointment compared with therapeutic ultrasound and placebo ointment in 20 people with lateral elbow tendinitis (tennis elbow), as well as (2) the effects of deep transverse friction massage combined with phonophoresis compared with phonophoresis alone in 20 people with lateral elbow tendinitis (tennis elbow). The other study, with a duration of two weeks, reviewed the effects of deep transverse friction massage with physical therapy intervention compared with physical therapy intervention alone in 17 people with lateral knee tendinitis.

Key results

What happens to people with lateral elbow tendinitis (tennis elbow) who are treated with deep transverse friction massage?

- We are uncertain whether deep transverse friction massage improves pain and function (very low-quality evidence).
- No studies reported pain relief of 30% or greater, quality of life, patient global assessment, adverse events, and withdrawals due to adverse events.

We often do not have precise information about side effects and complications. This is particularly true for rare but serious side effects.

What happens to people with lateral knee tendinitis who are treated with deep transverse friction massage?

- We are uncertain whether deep transverse friction massage improves pain (very low-quality evidence).
- No studies reported pain relief of 30% or greater, function, quality of life, patient global assessment, adverse events, and withdrawals due to adverse events.

We often do not have precise information about side effects and complications. This is particularly true for rare but serious side effects.

SUMMARY OF FINDINGS

Summary of findings for the main comparison. Massage + ultrasound and placebo ointment compared with ultrasound + placebo ointment only for treating lateral elbow tendinitis (tennis elbow)

Massage + therapeutic ultrasound and placebo ointment compared with ultrasound + placebo ointment only (follow-up 2 weeks) for treating tendinitis

Patient or population: patients with extensor carpi radialis tendinitis
Settings: community sports injuries clinic in Canada
Intervention: massage + therapeutic ultrasound and placebo ointment
Comparison: therapeutic ultrasound + placebo ointment only

Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	Number of participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	Control (US + placebo ointment only)	Massage + US and placebo ointment				
Pain Visual analog scale Scale from 0 to 100 (lower is better) Follow-up: mean 2 weeks	Mean change in pain in the control groups was 4.6 mm	Mean change in pain in the intervention groups was 6.6 lower (15.40 lower to 28.60 higher)		20 (1 study)	⊕○○○ Very low a,b,c	MD = -6.60 (-28.60 to 15.40) Absolute improvement = -7% (-29% to -15%) Relative percentage change = 8% (-24% to 37%) Not statistically significant
Proportion reporting pain relief of 30% or greater not measured	See comment	See comment	Not estimable	-	See comment	Not measured
Function Visual analog function index Scale from 0 to 100 (higher is better) Follow-up: mean 2 weeks	Mean function (vas 0 to 100, 0 = worst) in the control groups was 78.1 mm	Mean function (VAS 0-100, 0 = worst) in the intervention groups was 1.8 lower (18.64 lower to 15.04 higher)		20 (1 study)	⊕○○○ Very low a,b,c	MD = -1.80 (-18.64 to 15.04) Absolute improvement = 2% (-19% to 15%) Relative percentage change = -3% (-28% to 23%) Not statistically significant

Quality of life —not measured	See comment	See comment	Not estimable	-	See comment	Not measured
Patient global assessment of success not measured	See comment	See comment	Not estimable	-	See comment	Not measured
Adverse events not measured	See comment	See comment	Not estimable	-	See comment	Not measured
Withdrawals due to adverse events not measured	See comment	See comment	Not estimable	-	See comment	Not measured

*The basis for the **assumed risk** (e.g. median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

CI: Confidence interval; **ECRT:** Extensor carpi radialis tendinitis; **RR:** Risk ratio.

GRADE Working Group grades of evidence.

High quality: Further research is very unlikely to change our confidence in the estimate of effect.

Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.

Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.

Very low quality: We are very uncertain about the estimate.

^aAllocation concealment was unclear. Only assessors were blinded. Baseline imbalance was reported.

^bVery few participants.

^cWide confidence intervals.

Summary of findings 2. Massage + phonophoresis compared with phonophoresis alone for treating lateral elbow tendinitis (tennis elbow)

Massage + phonophoresis compared with control (phonophoresis only) (follow-up 2 weeks) for treating tendinitis

Patient or population: patients with extensor carpi radialis tendinitis

Settings: community sports injuries clinic in Canada

Intervention: massage + phonophoresis

Comparison: phonophoresis only

Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	Number of participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				

	Control (phonophore- sis only) (follow-up 2 weeks)	Massage + phonophoresis				
Pain Visual analog scale Scale from 0 to 100 (lower is better) Follow-up: mean 2 weeks	Mean change in pain in the control groups was 1 mm	Mean change in pain in the in- tervention groups was 1.2 lower (17.84 lower to 20.24 higher)	20 (1 study)	⊕⊕⊕⊕ Very low a,b,c	MD = -1.2 (-20.24 to 17.84) Absolute improvement = -1% (-20% to 18%) Relative percentage change = 6% (-86% to 97%) Not statistically significant	
Proportion re- porting pain relief of 30% or greater not measured	See comment	See comment	Not estimable	-	See comment	Not measured
Function Visual analog scale Scale from 0 to 100 (higher is better) Follow-up: mean 2 weeks	Mean function in the control groups was 78.8 mm	Mean function in the interven- tion groups was 3.7 higher (14.13 lower to 21.53 higher)	-	20 (1 study)	⊕⊕⊕⊕ Very low a,b,c	MD = 3.70 (-14.13 to 21.53) Absolute improvement = 4% (-14% to 22%) Relative percentage change = 5% (-18% to 28%) Not statistically significant
Quality of life not measured	See comment	See comment	Not estimable	-	See comment	Not measured
Patient global as- sessment of suc- cess not measured	See comment	See comment	Not estimable	-	See comment	Not measured
Adverse events not measured	See comment	See comment	Not estimable	-	See comment	Not measured
Withdrawals due to adverse events not measured	See comment	See comment	Not estimable	-	See comment	Not measured

*The basis for the **assumed risk** (e.g. median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

CI: Confidence interval; **ECRT:** extensor carpi radialis tendinitis; **RR:** Risk ratio.

GRADE Working Group grades of evidence.

High quality: Further research is very unlikely to change our confidence in the estimate of effect.

Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.

Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.

Very low quality: We are very uncertain about the estimate.

^aAllocation concealment was unclear. Only assessors were blinded. Baseline imbalance was reported.

^bVery few participants.

^cWide confidence interval.

Summary of findings 3. Deep transverse massage + physical therapy compared with physical therapy alone for treating lateral knee tendinitis

Deep transverse friction massage + physical therapy compared with physical therapy alone

Patient or population: patients with iliotibial band friction syndrome (knee tendinitis)

Settings: community sports injury clinic in South Africa

Intervention: deep transverse massage and physical therapy

Comparison: physical therapy alone

Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	Number of participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	Control	Deep transverse massage				
Daily pain Visual analog scale (VAS) Scale from 0 to 10 (lower is better) Follow-up mean 2 weeks	Mean daily pain in the control groups was 1 point	Mean daily pain in the intervention groups was 0.4 lower (0.8 lower to 0.00 higher)		17 (1 study)	⊕⊕⊕⊕ very low ^{a,b}	MD = -0.4 (-0.8 to 0) Absolute improvement = -4% (-8% to 0%) Relative percentage change = -40% (-80% to 0%) Not statistically significant
Proportion reporting pain relief of 30% or greater not measured	See comment	See comment	Not estimable	-	See comment	Not measured
Function not measured	See comment	See comment	Not estimable	-	See comment	Not measured

Quality of life not measured	See comment	See comment	Not estimable	-	See comment	Not measured
Patient global assessment not measured	See comment	See comment	Not estimable	-	See comment	Not measured
Adverse events not measured	See comment	See comment	Not estimable	-	See comment	Not measured
Withdrawals due to adverse events	See comment	See comment	Not estimable	-	See comment	Not measured

*The basis for the **assumed risk** (e.g. median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

CI: Confidence interval; **ITBF:** Iliotibial band friction syndrome (knee tendinitis); **RR:** Risk ratio.

GRADE Working Group grades of evidence.

High quality: Further research is very unlikely to change our confidence in the estimate of effect.

Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.

Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.

Very low quality: We are very uncertain about the estimate.

^aRandomization and allocation concealment were unclear. Only assessors were blinded. No intention-to-treat analysis was done, and baseline imbalance was reported.

^bVery few participants.

BACKGROUND

Description of the condition

Extensor carpi radialis tendinitis (ECRT) (ie, lateral elbow tendinitis, tennis elbow or lateral epicondylitis, or lateralis epicondylitis humeri) is a local inflammation near the proximal (upper) attachments of wrist extensor muscles, characterized by pain on palpation of the lateral epicondyle of the humerus and in resisted movements against wrist extension ([Struijs 2002](#)). The prevalence of lateral elbow tendinitis (tennis elbow) varies between 1% and 10% of the population; it commonly occurs between the ages of 34 and 74 years ([Allander 1974](#); [Roquelaure 2006](#); [Shiri 2006](#); [Walker-Bone 2004](#)). [Stratford 1989](#) reported that lateral elbow tendinitis (tennis elbow) does not seem to be a degenerative condition, as its prevalence declines after the age of 42 ([Allander 1974](#)). It is a syndrome of overuse (eg, use of computer mouse, racquet sports) that can result in considerable socioeconomic costs resulting from prolonged leave of absence from work ([Struijs 2002](#)).

Iliotibial band friction syndrome (ITBFS) (lateral knee tendinitis) is an overuse musculoskeletal injury that causes lateral knee pain and is frequently observed in long distance runners, cyclists, football players, and military personnel. The incidence of lateral knee tendinitis varies between 1.6% and 52%, depending upon the population studied ([Jordaan 1994](#); [Kirk 2000](#); [Lavine 2010](#); [Pinshaw 1984](#); [Strauss 2011](#)). The mechanism of lateral knee tendinitis appears to be repetitive friction of the iliotibial band moving over the lateral femoral condyle during knee flexion/extension ([Schwellnus 1991](#)). The cause of ITBFS (lateral knee tendinitis) is multifactorial ([Messier 1988](#)). Three main risk factors play a large role in the development of lateral knee tendinitis, according to the current literature: (1) biomechanical factors such as muscle imbalance causing maximal braking forces required to control body movements depending on velocity and angle of inclination ([Messier 1995](#)), (2) anthropometric factors such as abnormalities in leg and/or feet anatomy ([Messier 1988](#)), and (3) training factors such as inadequate warm-up and cool-down training ([Messier 1988](#); [Messier 1995](#)).

Description of the intervention

Treatment of tendinitis consists of medical, physiotherapeutic, and surgical approaches. The medical approach encompasses rest and the prescription of anti-inflammatory agents combined with anti-inflammatory or analgesic medication to control pain and inflammation ([Kirk 2000](#)). Goals of the physiotherapeutic approach in the treatment of tendinitis include (1) control of pain and inflammation ([Cyriax 1975a](#); [Cyriax 1975b](#); [Thaunton 1987](#); [Wilk 2004](#)); (2) correction of biomechanical deficiencies ([Johnson 2007](#); [Thaunton 1987](#)); (3) restoration of motion ([Hart 1994](#)); (4) increase in strength, endurance, and function ([Hart 1994](#); [Reinold 2002](#); [Thaunton 1987](#); [Wilk 2004](#)); (5) prevention of reinjury ([Hart 1994](#); [Reinold 2002](#)); and (6) gradual return to training ([Reinold 2002](#); [Thaunton 1987](#)). The surgical approach includes resection of the impinging portion of the extensor carpi radialis brevis tendon release ([Grewal 2009](#)) or the iliotibial band ([Kirk 2000](#); [Martens 1989](#)).

Deep transverse friction massage (DTFM) is a technique popularized by Dr James Cyriax ([Cyriax 1975a](#); [Cyriax 1975b](#)) for relief of pain and inflammation in musculoskeletal conditions. Deep friction is given transverse to the fiber direction of involved

tissue, and friction massage must be sufficiently deep to impact the affected structure.

How the intervention might work

Deep transverse friction massage is offered in the treatment of various musculoskeletal conditions. This technique attempts to prevent or destroy abnormal fibrous adhesions (cross-links or cross-bridges) by imposing stress transversely to the remodeling collagen of the tissue to soften the adhesion. Thus, DTFM also optimizes the quality of the scar tissue by realigning the collagen of normal soft tissue fibers in a longitudinal way ([Walker 1984](#)). It has been indicated that DTFM enhances normal healing conditions and prevents abnormal scarring. Its mechanical action causes hyperemia (ie, an increase in blood flow to the affected area).

Why it is important to do this review

No meta-analyses or literature reviews have reported the efficacy of this type of massage for lateral elbow or knee tendinitis. Clinicians and patients must be provided with evidence that will enable them to make informed decisions regarding treatment options.

OBJECTIVES

To assess the benefits and harms of deep transverse friction massage for treating lateral elbow or lateral knee tendinitis.

METHODS

Criteria for considering studies for this review

Types of studies

According to an a priori protocol, randomized controlled trials (RCTs) and controlled clinical trials (CCTs) (and CCTs with pseudorandom methods of allocating participants to treatment) were selected because they are defined as comparative controlled trials with the presence of comparison groups, which allow evaluation of DTFM and patients with tendinitis pain compared with other types of interventions and populations. Only articles published in the English language or the French language were included.

Types of participants

Studies were included if study participants were 18 years of age or older and had been diagnosed with tendinitis (lateral elbow tendinitis and knee tendinitis). Participants had to show no signs of psychiatric conditions and had to demonstrate stable physical and medical status. Mixed populations (individuals with multiple conditions other than tendinitis) were not permitted. Inclusion criteria for lateral elbow tendinitis comprised (1) tenderness on palpation over the lateral aspect of the elbow and (2) pain in the lateral aspect of the elbow during resisted wrist extension. For knee tendinitis, inclusion criteria consisted of (1) history of pain on the lateral aspect of the knee during running, (2) tenderness over the lateral femoral condyle at rest, and (3) aggravation of symptoms at 30 degrees of knee flexion. For the complete list of exclusion criteria and the PICOTS (populations, interventions, comparators, outcomes, timing, and setting) framework, see [Table 1](#).

Types of interventions

Trials comparing deep transverse friction massage versus no therapy or active treatments (such as therapeutic ultrasound,

exercise program, or phonophoresis therapy) were accepted, provided they were given equally to all treatment groups. So trials comparing DTFM combined with other physical therapy manipulative interventions were excluded if co-interventions were not applied to the control group (ie, if investigators wished to assess the effects of deep massage therapy alone).

Types of outcome measures

Major outcomes

- Mean (or mean change in) pain.
- Proportion reporting pain relief of 30% or greater.
- Function.
- Quality of life.
- Patient global assessment of success.
- Total number of withdrawals due to adverse effects.
- Number of adverse events.

Minor outcomes

In addition to these outcomes, one of the review authors (LB) has developed a theoretical framework for important outcome measures for physical therapy interventions (Morin 1996). These

outcomes were considered as secondary measures of effectiveness and include the following.

- Joint range of motion (ROM).
- Muscle strength (and grip strength for tendinitis of upper extremities).
- Endurance.

Outcomes were assessed at end of treatment or at end of follow-up.

Search methods for identification of studies

Electronic searches

We searched the specialized register of the Cochrane Field of Physical and Related Therapies, the Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE, EMBASE, the Cumulative Index to Nursing and Allied Health Literature (CINAHL), Clinicaltrials.gov, and the Physiotherapy Evidence Database (PEDro), until July 2014 (Figure 1). The search included deep transverse friction therapy terms and tendinitis pain terms. Full strategies for these databases are provided in Appendix 1 (MEDLINE), Appendix 2 (EMBASE), Appendix 3 (CENTRAL), Appendix 4 (CINAHL), Appendix 5 (PEDro), and Appendix 6 (Clinicaltrials.gov).

Figure 1. Study flow diagram.

Searching other resources

We searched the reference lists of selected articles.

Data collection and analysis

Selection of studies

Two independent review authors (LB, LML) examined the titles and abstracts of the trials identified by the search strategy to select trials that met the inclusion criteria (see [Table 1](#) for more details). All trials classified as relevant by at least one of the review authors were retrieved as full-text articles and were assessed for eligibility. Disagreements were resolved by consensus. When selecting studies for inclusion, we did not consider languages other than French and English.

Data extraction and management

The results of the individual trials were extracted from the included study by two independent review authors (LB, LML) using predetermined extraction forms. Data were cross-checked by a third review author (BS). The extraction forms were developed and pilot-tested on the basis of other forms used by the Cochrane Musculoskeletal Review Group. The extraction form documented specific information about DTFM, including (1) characteristics of the technique and (2) methods of therapeutic application such as duration, frequency, rhythm, pressure, and total number of sessions. Also, forms were designed to collect information about participant characteristics (eg, age, gender, injury type, injury duration), comparator intervention characteristics, and outcomes (including scale of tool, direction of effect [eg, lower score = worse off]). Final data values were based on consensus of the two review authors. In the event of multiple time points, we would collect the last time point.

Assessment of risk of bias in included studies

Two independent review authors (LB, LML) assessed risk of bias using the "Risk of bias" tool of The Cochrane Collaboration ([Higgins 2011](#)); differences were resolved by consensus. This tool assesses seven domains: sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective outcome reporting, and "other issues." For "other issues," we considered baseline imbalance as a potential source of bias. The review authors classified the different items for the two included studies as "high risk," "unclear risk," or "low risk" of bias. A third review author (BS) was consulted when necessary.

Measures of treatment effect

Mean differences (MDs) between experimental and control groups were calculated for continuous data, with the same measurements and standardized mean differences (SMDs) for continuous outcomes with different measurements, and 95% confidence intervals (CIs). For dichotomous data, risk ratios (RRs) and 95% CIs were calculated.

Unit of analysis issues

Individual participants represented the unit of analysis in these studies. No cluster-randomized controlled trials or cross-over design trials were selected. In cases of multiple treatment groups, we made multiple pairwise comparisons between all possible pairs of intervention groups to avoid double-counting of participants in the meta-analyses.

Dealing with missing data

The procedure was to contact the study authors if only an abstract was provided, or if available results were not sufficient for the data analysis, or to identify additional studies. For this review update, it was not necessary to contact the study authors.

Assessment of heterogeneity

We planned to assess heterogeneity using the I^2 statistic when a value of 0% to 40% might "not be important", 30% to 60% may represent "moderate" heterogeneity, 50% to 90% may represent "substantial" heterogeneity, and 75% to 100% represents "considerable" heterogeneity ([Higgins 2011](#)).

Assessment of reporting biases

We intended to assess the possibility of publication bias by using funnel plots.

We also planned to assess trial protocols versus published reports. For example, for studies published after July 1, 2005, we would screen the Clinical Trial Register at the International Clinical Trials Registry Platform of the World Health Organization (<http://apps.who.int/trialssearch>) for the a priori trial protocol. We would evaluate whether selective reporting of outcomes is present (outcome reporting bias).

We planned to compare the fixed-effect estimate against the random-effects model to assess the possible presence of small sample bias (ie, in which the intervention effect is more beneficial in smaller studies) in the published literature. In the presence of small sample bias, the random-effects estimate of the intervention is more beneficial than the fixed-effect estimate ([Higgins 2011](#)).

Data synthesis

We planned to pool the intervention versus a common comparator by using the fixed-effect model of meta-analysis if data were homogenous, and the random-effects model if heterogeneity was substantive (ie, $I^2 > 50\%$).

Subgroup analysis and investigation of heterogeneity

No studies were pooled; therefore exploration of heterogeneity and subgroup analyses were not possible.

Sensitivity analysis

We planned sensitivity analyses based on the risk of bias assessment of included studies (allocation concealment, blinding of participants, intention-to-treat analysis). However, we could not perform sensitivity analyses for this review.

Grading of the evidence and summary of findings tables

We graded the overall quality of the evidence for each outcome using the GRADE (Grading of Recommendations Assessment, Development and Evaluation) approach ([Guyatt 2008](#)), as recommended by The Cochrane Collaboration ([Schünemann 2011a](#)). This approach consists of four levels of quality: high, moderate, low, and very low. Evidence-based randomized studies start at a high quality rating and could be downgraded on the basis of five factors (study limitations, inconsistency of results, indirectness of evidence, imprecision, and publication bias).

We incorporated grading of evidence into the "Summary of findings" table. We also presented other key results in the "Summary of findings" table, as recommended by The Cochrane Collaboration (Schünemann 2011b), including the absolute and relative magnitude of effect of the interventions examined. Main outcomes in the "Summary of findings" table were mean (or mean change in) pain, proportion reporting pain relief of 30% or greater, function, quality of life, patient global assessment of success, total number of withdrawals due to adverse effects, and number of adverse events.

RESULTS

Description of studies

Results of the search

We retrieved 853 references after deduplication and identified 34 potentially eligible articles through electronic database searches (Figure 1). Two review authors evaluated the studies and screened 28 full-text articles on deep transverse friction massage and pain of tendinitis for eligibility. Two full-text articles met our inclusion criteria, and 26 were excluded.

Included studies

Two trials met the inclusion criteria. See the [Characteristics of included studies](#) table.

In the first included RCT (Stratford 1989), all participants were 18 years of age or older. Mean participant age was 43.3 years, and symptom duration was 4.25 weeks. This included RCT examined the efficacy of DTFM in the management of extensor carpi radialis tendinitis (lateral elbow tendinitis or tennis elbow) and included the following comparison groups: (1) deep transverse friction massage combined with therapeutic ultrasound and placebo ointment (n = 11) versus therapeutic ultrasound combined with placebo ointment (n = 9) and (2) deep transverse friction massage and phonophoresis (n = 10) versus phonophoresis alone (n = 10). The study consisted of nine treatment sessions within five weeks.

The second RCT (Schwellnus 1992) compared two groups: One received combined physical therapy interventions with DTFM, and the other received combined physical therapy interventions without DTFM. The study consisted of four consecutive treatment sessions in two weeks. A total of 17 participants with iliotibial band friction syndrome (lateral knee tendinitis) were randomly assigned. All participants in this study were prescribed rest, stretching exercises, cryotherapy and therapeutic ultrasound. Mean participant age was 27.6 years, disease duration was 48.5 weeks, years of running experience were 6.6, and the weekly distance in kilometers was 54.5 for both groups. Injury severity was assessed by grading the pain level (ie, grade 1: pain experienced after running; grade 2: pain experienced during running; grade 3: pain experienced during running associated with restriction of distance or velocity; grade 4: severe pain that prevents running). The grade of injury was 3.4 of a maximum possible of 4 for both groups.

Excluded studies

Twenty-six trials were excluded for the reasons outlined here: (1) healthy participants (Chiarello 1997; Crosman 1984), (2) not tendinitis (Balke 1989; Feehan 1989; Thomee 1997; Zhang 1987), (3) combined modalities (Pellecchia 1994), (4) combination of interventions and co-interventions not applied to the control group (Baltaci 2001; Bisset 2007; Fernandez 2006; Fernandez 2008; Nagrale 2009; Smidt 2002; Stasinopoulos 2004a; Stasinopoulos 2006; Struijs 2006; Viswas 2012), (5) no control group (Kohia 2008; Malier 1986; Mayer 2007; Stasinopoulos 2004b; Verhaar 1995), (6) pilot design (Struijs 2003), and (8) not an RCT (Iwatsuki 2001; Joseph 2012; Zheng 2012). See the [Characteristics of excluded studies](#) table.

Risk of bias in included studies

We assessed the risk of bias for each included study using the "Risk of bias" tool of The Cochrane Collaboration. The risk of bias graph and summary are presented in Figure 2 and Figure 3, respectively.

Figure 2. Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.

Figure 3. Risk of bias summary: review authors' judgements about each risk of bias item for each included study.

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Schwellnus 1992	?	?	-	-	-	+	-
Stratford 1989	+	?	-	?	+	+	-

Allocation

In the RCT for extensor carpi radialis tendinitis (lateral elbow tendinitis) (Stratford 1989), the study authors used a 2 × 2 factorial design and created strata on the basis of pain-free grip strength. Afterward, participants were randomly assigned to one of the four treatment groups using a balanced blocked randomization table. In the second RCT for iliotibial band friction syndrome (lateral knee tendinitis) (Schwellnus 1992), participants were randomly assigned, but the methods of sequence generation and allocation were not described, and so risk was judged as unclear.

Blinding

Participants and personnel were not blinded to treatment. As this is a physical intervention, it is more difficult to blind participants and therapists. Only the outcome assessors were blinded to the treatment groups of participants in both included studies. We did not have enough information to assess the impact on patient-reported outcomes, but detection bias is more likely "high risk" for self-reported subjective outcomes (eg, pain).

Incomplete outcome data

One trial (Schwellnus 1992) reported a 15% dropout rate. Duration of follow-up was mentioned, but investigators did not perform an intention-to-treat analysis. In the second trial (Stratford 1989), withdrawals and dropouts were not mentioned. However, all randomly assigned participants were accounted for in the results.

Selective reporting

Both studies reported planned outcomes whether or not findings were significant (Schwellnus 1992; Stratford 1989). No protocols were found.

Other potential sources of bias

Baseline imbalance was noted in both included studies (Schwellnus 1992; Stratford 1989). The duration of symptoms, for example, was different in the intervention group compared with the control group.

Effects of interventions

See: [Summary of findings for the main comparison](#) Massage + ultrasound and placebo ointment compared with ultrasound + placebo ointment only for treating lateral elbow tendinitis (tennis elbow); [Summary of findings 2](#) Massage + phonophoresis compared with phonophoresis alone for treating lateral elbow tendinitis (tennis elbow); [Summary of findings 3](#) Deep transverse massage + physical therapy compared with physical therapy alone for treating lateral knee tendinitis

No studies were pooled; therefore assessment of heterogeneity and subgroup analyses were not possible. (See [Data and analyses](#) section for additional details.)

Deep transverse friction massage + therapeutic ultrasound and placebo ointment versus therapeutic ultrasound and placebo ointment

The RCT for extensor carpi radialis tendinitis (tennis elbow) ([Stratford 1989](#)) showed no statistically significant differences in pain intensity, grip strength, and functional status after nine consecutive sessions of deep transverse friction massage combined with therapeutic ultrasound and placebo ointment ($n = 11$) compared with therapeutic ultrasound alone ($n = 9$). We found the following: mean change in pain on a 0 to 100 visual analog scale (VAS) (MD -6.60, 95% CI -28.60 to 15.40) ([Analysis 1.1](#)), grip strength in kilograms of force (MD 0.10, 95% CI -0.16 to 0.36) ([Analysis 1.2](#)), function (VAS 0 to 100) (MD -1.80, 95% CI -18.64 to 15.04) ([Analysis 1.3](#)), pain-free function index measured as the number of pain-free items (MD 1.10, 95% CI -1.00 to 3.20) ([Analysis 1.4](#)), and functional status assessed by the physician as the number of successes needed to perform the strengthening program (RR 3.3, 95% CI 0.4 to 24.3) ([Analysis 1.5](#)). This difference was not clinically or statistically significant. The quality of the body of evidence was "very low" according to the GRADE approach.

Pain-free function scores recorded in the two groups at the end of the study were -1.8 ± 2.7 for deep transverse friction massage combined with therapeutic ultrasound and placebo ointment and 2.7 ± 2.1 for therapeutic ultrasound and placebo ointment. We found the following values for the other measures, at the end of the study.

- Pain VAS: 44.8 ± 33.4 for deep transverse friction massage combined with therapeutic ultrasound and placebo ointment and 23.8 ± 17.0 for therapeutic ultrasound alone.
- Function VAS: 76.3 ± 21.9 for deep transverse friction massage combined with therapeutic ultrasound and placebo ointment and 78.1 ± 16.5 for therapeutic ultrasound alone.
- Absolute improvement measures demonstrated reduction in pain by 7% and improvement in function by 2%.
- As a minor outcome, the ratio index of pain-free grip strength scores was as follows: 0.7 ± 0.3 for deep transverse friction massage combined with therapeutic ultrasound and placebo ointment and 0.6 ± 0.3 for therapeutic ultrasound alone.
- Quality of life, patient global assessment of success, adverse events, withdrawals due to adverse events, joint range of motion, and endurance were not assessed or reported. (See [Summary of findings for the main comparison](#).)

Deep transverse friction massage + phonophoresis versus phonophoresis alone

Mean differences and risk ratios were also calculated for the comparison of deep transverse friction massage and phonophoresis ($n = 10$) versus phonophoresis alone ($n = 10$) for pain on a 0 to 100 VAS scale (MD -1.2, 95% CI -20.24 to 17.84) ([Analysis 2.1](#)), grip strength in kilograms of force (MD -0.20; 95% CI -0.46 to 0.06) ([Analysis 2.2](#)), function (VAS 0 to 100) (MD 3.70, 95% CI -14.13 to 21.53) ([Analysis 2.3](#)), pain-free function index measured as the number of pain-free items (MD 0.10, 95% CI -2.27 to 2.47) ([Analysis 2.4](#)), and functional status assessed by the physician as the number of successes needed to perform the strengthening program (RR 0.67, 95% CI 0.1 to 3.2) ([Analysis 2.5](#)) in extensor carpi radialis tendinitis ([Stratford 1989](#)). This difference was not clinically or statistically significant. Again, the quality of the body of evidence received a score of "very low" according to the GRADE approach.

The study authors reported different results for the two groups for pain-free function scores, at the end of the study: 3.7 ± 2.8 for deep transverse friction massage and phonophoresis compared with 3.6 ± 2.6 for phonophoresis alone.

- Pain VAS: 24.6 ± 20.6 for deep transverse friction massage and phonophoresis compared with 21.8 ± 30.4 for phonophoresis alone.
- Function VAS: 82.5 ± 16.3 for deep transverse friction massage and phonophoresis compared with 78.8 ± 23.7 for phonophoresis alone.
- Absolute improvement confirmed reduction in pain by 1% and improvement in function by 4%.
- As a minor outcome, results for the ratio index of pain-free grip strength were as follows: 0.5 ± 0.3 for deep transverse friction massage and phonophoresis compared with 0.7 ± 0.3 for phonophoresis alone.
- Proportion reporting pain relief of 30% or greater, quality of life, patient global assessment of success, adverse events, withdrawals due to adverse events, joint range of motion, and endurance were not assessed or reported. (See [Summary of findings 2](#).)

Deep transverse friction massage and physical therapy versus physical therapy alone

Only one small study with 17 participants looked at this comparison in iliotibial band friction syndrome (knee tendinitis) ([Schwellnus 1992](#)). Although within-group reduction in the three types of pain relief measured was significant (overall daily pain, pain while running, and percentage of maximum pain when running) on a 0 to 10 VAS scale, in both treatment groups after two weeks of follow-up (P value < 0.0005), no statistically significant between-group differences (mean differences (MDs)) were reported for daily pain (MD -0.40, 95% CI -0.80 to 0.00), pain while running measured as the total daily pain of all participants while running (scale from 0 to 150) (MD -3.00, 95% CI -11.08 to 5.08), and percentage of maximum pain while running (MD -0.10, 95% CI -3.97 to 3.77) ([Analysis 3.1](#)). The absolute improvement highlighted a reduction in pain by 4%. It is important to note that the difference in daily pain was significant at P value 0.05 in favor of DTFM, although care in assessing this result must be exercised, as (1) the result is borderline significant and (2) the data are determined from a graph and are subject to interpretation errors. In addition, the quality of the body of

evidence according to the GRADE approach received a score of "very low."

- Mean daily pain scores recorded in the two groups, at the end of the study, were as follows: 0.6 ± 0.3 for the experimental group (combined physiotherapy interventions and DTFM) and 1 ± 0.5 for the control group (physiotherapy interventions only).
- At the same period, the study authors found different results in the two groups for total pain while running: 20 ± 9 for the experimental group and 23 ± 8 for the control group.
- Finally, the percentage of maximum pain experienced during running for the two groups was similar at the end of the study: 8 ± 5 for the experimental group and 8.1 ± 3 for the control group.
- Proportion reporting pain relief of 30% or greater, function, quality of life, patient global assessment of success, number of adverse effects, total number of withdrawals due to adverse effects, joint range of motion, muscle strength, and endurance were not mentioned or reported. (See [Summary of findings 3.](#))

DISCUSSION

Summary of main results

Evidence was insufficient to demonstrate a consistent clinically important benefit of deep transverse friction massage combined with additional physical therapy modalities when compared with a control in the treatment of extensor carpi radialis tendinitis (lateral elbow tendinitis) ([Stratford 1989](#)) and of iliotibial band friction syndrome (knee tendinitis) ([Schwellnus 1992](#)). The additional benefit of deep transverse friction massage was not confirmed, as combined interventions were used. The included studies did not report on adverse events.

Overall completeness and applicability of evidence

Only two clinical trials met the inclusion criteria of this review update. Moreover, these two trials were at high risk of bias. Therefore evidence on the specific benefits of deep transverse friction massage is sparse. Further, results of the intervention looking at deep transverse friction massage and physical therapy versus physical therapy alone may not be applicable to general populations, as participants in the trial were experienced runners. The Philadelphia Panel recommends that evidence is insufficient (level 1, grade C for pain) to include or exclude deep transverse friction massage alone as a therapeutic intervention for treating tendinitis ([Philadelphia 2001](#)). Evaluation of deep transverse friction massage as a single treatment in comparison with other techniques has not been undertaken, so its efficacy has not yet been demonstrated ([Joseph 2012](#)).

Quality of the evidence

For both included RCTs, the two major outcomes (pain and function) received a GRADE score of "very low" for the quality of the body of evidence.

The two RCTs included in this systematic review highlight a common problem among trials of rehabilitation interventions: difficulty or inability to blind participants and personnel, which contributes to the high risk of bias. Although outcome assessors were blinded in both studies, lack of blinding of participants may have an impact on patient-reported outcomes such as pain, leading to overestimation. Both presented baseline imbalance (mean age

and duration of symptoms were different across groups). One of the studies ([Schwellnus 1992](#)) demonstrated high risk of incomplete outcome data, as investigators reported a 15% dropout rate, and no intention-to-treat analysis was performed. The small sample sizes and wide confidence intervals also contribute to the very low quality rating of the body of evidence for reported outcomes.

Confounding variables such as characteristics of the device, characteristics of the therapeutic application, characteristics of the population, characteristics of the disease, and methodological considerations might have contributed to the lack of effect ([Morin 1996](#)). Characteristics of the technique described by Cyriax ([Cyriax 1975a](#); [Cyriax 1975b](#)) such as years of experience of the therapist, characteristics of the application (pressure, rhythm and progression, and frequency), duration of treatment sessions and the treatment schedule, characteristics of the population (age, gender), characteristics of the disease (chronic vs acute conditions), and weakness of methodological considerations (comparison groups, sample size, study duration, nonvalidated outcome measures) in both studies ([Schwellnus 1992](#); [Stratford 1989](#)) may have contributed to inconclusive results on the effectiveness of deep transverse friction massage for tendinitis. Finally, larger and better powered studies are required to confirm findings because of the small number of studies included in this update of the review and the small sample sizes presented by the included trials.

For both studies, further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate. In other words, we obtained very low grades for the main outcomes, principally because of unclear allocation concealment and randomization, single-blind processes, wide confidence intervals, and small sample size.

Potential biases in the review process

It is important to consider whether all relevant trials were identified (whether or not all pertinent data could be obtained) and if the methods used (search strategy, selection of studies, data collection, analysis) could have introduced potential bias. When selecting studies for inclusion, we did not consider languages other than French and English. This could have limited the number of potentially eligible studies found.

Agreements and disagreements with other studies or reviews

This systematic review of deep transverse friction massage for tendinitis was initially conducted as part of a guideline development project entitled the Philadelphia Panel Guidelines on Rehabilitation Interventions for knee pain ([Philadelphia 2001](#)). Other guidelines such as [ACR 1996](#), [ACR 2000](#), [Godlee 2000](#), and [Manal 1996](#) did not evaluate any type of massage as a treatment intervention for knee conditions. To our knowledge, no guidelines on massage for extensor carpi radialis tendinitis are available. The American Physical Therapy Association (APTA) guidelines ([APTA 2001](#)) recommend massage for musculoskeletal conditions, although the APTA guidelines do not differentiate between types of massage. However, these guidelines are not based on evidence from comparative controlled trials.

No meta-analysis or literature reviews have reported the efficacy of this type of massage ([Chapman 1991](#); [Furlan 2008](#); [Green 1998](#); [van der Heijden 1997](#)). Evaluation of deep transverse friction massage

as a single treatment in comparison with other techniques has not been undertaken, so its efficacy has not been yet demonstrated. Comparison of different studies is difficult to perform because of heterogeneity in terms of (1) types of tendinitis, (2) confounding approaches, and (3) varied outcome measures selected (Joseph 2012).

In the included RCT (Stratford 1989), deep transverse friction massage was performed to reduce symptoms of tendinitis. The inflammation and pain observed in tendinitis are frequently due to three main factors: (1) biomechanical factors), (2) anthropometric factors, and (3) training factors. Pain is an indirect symptom. Based on identified factors, pain could be controlled more effectively through other physical therapy interventions such as strengthening and postural exercises, or changes in functional and sporting activities that correct biomechanical deficiencies (Thaunton 1987), restore motion (Hart 1994), increase strength, endurance, and function (Hart 1994; Thaunton 1987), and permit gradual return to training (Thaunton 1987). One included study (Stratford 1989) found that phonophoresis is not superior to ultrasound and placebo ointment, where similar results were obtained. Antich et al (Antich 1986) mentioned that phonophoresis is as good as ice and ultrasound. Halle and colleagues (Halle 1986) confirmed that ultrasound, transcutaneous electrical nerve stimulation (TENS), and cortisone injections represent comparative therapies in terms of efficacy. The second included RCT (Schwellnus 1992) suggested that the addition of deep transverse friction massage might not appear to aggravate clinical outcomes in iliotibial band friction syndrome (knee tendinitis). Therefore, the included study rejected the findings of the first study author, who examined the biologic rationale of this therapy (Griffin 1963) and reported that the success rate was significantly greater in the phonophoresis group compared with the group given ultrasound therapy. Similar success rates for the phonophoresis groups were shown in the work of Kleinkort et al (Griffin 62% vs Kleinkort 66%) (Stratford 1989). However, it is important to note that those study authors did not consider the presence of potential confounding variables, and neither of them reported their diagnostic criteria and the power of their statistical test (Stratford 1989).

Additional well-designed RCTs are needed before this specific type of massage can be excluded for treatment of this condition. Clinicians and patients need to be presented with evidence that will enable them to make informed decisions regarding treatment options.

AUTHORS' CONCLUSIONS

Implications for practice

Evidence was insufficient to reveal the clinically important benefit of deep transverse friction massage (DTFM) in treating tendinitis. Unfortunately, almost no persuasive scientific research about DTFM has been reported. The therapeutic approach consists mainly of reasonable speculation about biology, as the effects of DTFM are based on sound physiologic and pathologic theories. In other words, many patients respond well to any kind of stimulation techniques that may alter a chronically painful condition. Even though the technique seems to work well in practice, the absence of evidence remains a matter of primary concern, as the use of DTFM must absolutely be supported by clinical evidence. Therefore, it is clear that better designed studies are needed before conclusions can be drawn about the efficacy or lack of efficacy of deep transverse friction massage for treating symptomatic tendinitis (Joseph 2012).

Implications for research

To justify the use of deep transverse friction massage in the treatment of tendinitis, large, high-quality randomized trials using validated outcome measures and high-quality reporting methods are needed.

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CHARACTERISTICS OF STUDIES

Characteristics of included studies [ordered by study ID]

Schwellnus 1992

Methods	<p>Study design: randomized, assessor-blinded trial</p> <p>Sample size at entry: 20 G1: deep transverse friction massage (DTFM) group 10 G2: control group 10 Treatment duration: 10 days Follow-up: 14 days</p>
Participants	<p>Setting: visitors to a sports injury clinic with unilateral chronic (> 4 weeks) iliotibial band syndrome causing pain severe enough to restrict running distance or speed (grade 3), or to prevent it altogether (grade 4)</p> <p>Inclusion criteria:</p> <ul style="list-style-type: none"> Age in years (mean ($\pm$ SE)): DTFM group 25 ($\pm$ 6), control group 29 ($\pm$ 5), P value 0.20 student t-test Weeks injured (mean ($\pm$ SE)): DTFM group 23 ($\pm$ 17), control group 74 ($\pm$ 95) Years of running (mean ($\pm$ SE)): DTFM group 7.7 ($\pm$ 5.5), control group 5.4 ($\pm$ 6.2) Kilometers run per week (mean ($\pm$ SE)): DTFM group 45 ($\pm$ 15), control group 64 ($\pm$ 30) Grade of injury (mean ($\pm$ SE)): DTFM group 3.4 ($\pm$ 0.5), control group 3.4 ($\pm$ 0.5) <p>Exclusion criteria: < 18 years old, history of previous knee surgery, concomitant medical therapy</p>
Interventions	<p>Deep transverse friction massage: applied on days 3, 5, 7 and 10</p> <p>Treated anatomical area (most tender area) with constant pressure, such that discomfort was experienced, but not severe pain; 2 minutes of light friction, then 8 minutes of harder friction</p> <p>Technique: Pressure was applied with the index finger and reinforced with the ring finger, with the thumb acting as a pivot; brisk motion was initiated from the therapist's shoulder, with the wrist flexible and the hand stiff</p> <p>Concurrent treatment:</p> <ul style="list-style-type: none"> Rest (apart from 3 * 30 min treadmill exercise tests on days 3, 7 and 14) Ice 20 minutes twice daily

Schwellnus 1992 (Continued)

- Stretch of iliotibial band, daily
- Ultrasound: 1 MHz, 0.5 W/cm/cm (continuous), 5 minutes on days 3, 4, 5 and 6, then 7 minutes on days 7 and 10
- G1 received deep transverse friction massage and concurrent treatment while control group received concurrent treatment only

Outcomes	Mean pain daily recall, total pain while running, % max pain experienced while running (VAS 0 to 10; 0 = no pain) for 3 treatment periods (days 0 to 2, 3 to 6, 7 to 14)
Notes	<p>One participant was excluded for refusal to comply with the treatment group. Two participants were not accounted for in the control group (reasons not provided)</p> <p>Per-protocol analysis</p> <p>Source of funding: "This research project was generously supported financially by Johnson and Johnson Pty Ltd"</p> <p>Declarations of interest of primary researchers not provided</p>

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "patients were divided into two treatment groups on a random basis" Comments: method not described
Allocation concealment (selection bias)	Unclear risk	Comments: Investigators state that they divided the 17 athletes into 2 groups without explaining the method of allocation
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: Participants and personnel were not blinded
Blinding of outcome assessment (detection bias) All outcomes	High risk	Quote: "the efficacy of the treatment was assessed by a different therapist who was blind to the treatment group of the patient" Comments: Insufficient information available to judge whether not blinding the participants had an impact on patient-reported outcomes. More likely at 'high risk' for self-reported subjective outcomes (eg, pain)
Incomplete outcome data (attrition bias) All outcomes	High risk	Comments: This study had a 15% dropout rate (even across treatment groups). Duration of follow-up was mentioned, but investigators did not perform an intention-to-treat analysis
Selective reporting (reporting bias)	Low risk	Comments: The trial presented planned outcomes whether or not the result was significant. No selective reporting was found to be present
Other bias	High risk	Comment: Baseline imbalance was reported; mean age and duration of symptoms were different across groups

Stratford 1989

Methods	<p>Study design: randomized controlled trial, parallel group, combination of interventions</p> <p>Sample size at entry: 40</p> <p>Group 1: ultrasound and placebo ointment without frictions—9</p>
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Deep transverse friction massage for treating lateral elbow or lateral knee tendinitis (Review)

Stratford 1989 (Continued)

Group 2: ultrasound and placebo ointment with frictions—11

Group 3: phonophoresis without frictions—10

Group 4: phonophoresis with frictions—10

male/# female: 20/20

Group 1: 2/7

Group 2: 5/6

Group 3: 5/5

Group 4: 8/2

Treatment duration: 9 sessions within 5 weeks

Follow-up: 5 weeks

Participants	<p>Setting: patients attending a community sports injuries clinic</p> <p>Inclusion criteria: those who complained of discomfort at or about the lateral epicondyle; pain at the lateral aspect of the elbow during resisted wrist extension; radial deviation during complete elbow extension; tenderness in palpation over, or at, one of the following areas: (1) origin of extensor carpi radialis longus tendon, (2) origin of extensor carpi radialis brevis tendon, (3) extensor carpi radialis brevis at tendon body, and (4) extensor carpi radialis brevis tendon with tenderness extending from origin to the tendon body</p> <p>Age (mean in years ($\pm$ SD))</p> <p>Group 1: 43.8 ($\pm$ 9.8)</p> <p>Group 2: 44.6 ($\pm$ 9.8)</p> <p>Group 3: 40.1 ($\pm$ 8.3)</p> <p>Group 4: 44.7 ($\pm$ 8.7)</p> <p>Disease duration (months: mean ($\pm$ SD))</p> <p>Group 1: 4.3 ($\pm$ 3.2)</p> <p>Group 2: 2.1 ($\pm$ 1.2)</p> <p>Group 3: 5.2 ($\pm$ 7.2)</p> <p>Group 4: 5.4 ($\pm$ 4.1)</p> <p>Exclusion criteria: combined lesions; bilateral elbow problems at initial assessment; history of prior surgery; history of an injection to the elbow within the past 6 months</p>
Interventions	<p>Deep transverse friction massage</p> <p>Treated anatomical area (elbow) with friction massage applied perpendicular to the structure of interest for 10 minutes, 3 times per week, 9 treatment sessions within 5 weeks</p> <p>Frictions for groups 2 and 4: position of participant: for lesion at origin of the extensor carpi radialis longus or brevis tendon, elbow flexed at 90 degrees with forearm fully supinated; if lesion at or included tendon body or extensor carpi radialis brevis tendon, elbow flexed at 45 degrees with forearm pronated</p> <p>Concurrent treatment for group 1 and group 2: ultrasound and placebo ointment</p> <p>Ultrasound: Dosage varied from 1.3 w/cm² continuous output to 0.5 w/cm² pulsed (1:4). Application technique: sound head moved in slow concentric circles, while sound head contact with the participant was maintained at the same time. Duration: 6 minutes</p> <p>Concurrent treatment for groups 3 and 4: phonophoresis</p> <p>Phonophoresis: 10% hydrocortisone ointment used with ultrasound treatment</p>
Outcomes	<p>Pain</p> <ul style="list-style-type: none"> Pain-free function (8 pain-free item, 8 = better) Pain VAS (0 to 100 mm; 0 = worst). <p>Grip strength</p> <ul style="list-style-type: none"> Ration index of pain-free grip strength (grip strength: kilograms of force). Ratio is pain-free grip divided by maximum grip of uninvolved limb

Stratford 1989 (Continued)

Function

- Function VAS (0 to 100 mm; 0 = worst)

Functional status (success or failure to perform pain-free strengthening program for the wrist extensor muscles, with the elbow extended, without subsequent regression within 2 weeks of follow-up)

Notes

We extracted the outcome of pain on VAS (0 to 100), not pain-free function, for the review

Source of funding: "This work was supported by the Physiotherapy Foundation of Canada"

Declarations of interest of primary researchers not provided

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "The study design was a two by two factorial design. The subjects were randomly assigned using a balanced blocked randomization table"
Allocation concealment (selection bias)	Unclear risk	Comments: Method of allocation concealment was not described
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: Participants and personnel were not blinded to treatment
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Quote: "Decision was made by the assessor who was blind to both interventions" Comments: Insufficient information was available on which to base judgement if not blinding participants had an impact on patient-reported outcomes
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comments: No description of withdrawals and dropouts was mentioned. However, all randomly assigned participants were accounted for in the results
Selective reporting (reporting bias)	Low risk	Comments: The trial presented all planned outcomes whether or not the result was significant. No selective reporting was found to be present
Other bias	High risk	Comments: Baseline imbalance was reported; the duration of symptoms was different across groups

DTFM: Deep transverse friction massage.

SD: Standard deviation.

SE: Standard error.

VAS: Visual analog scale.

Characteristics of excluded studies [ordered by study ID]

Study	Reason for exclusion
Balke 1989	Not tendinitis
Baltaci 2001	Combination of interventions; co-interventions not applied to the control group

Study	Reason for exclusion
Bisset 2007	Combination of Interventions; co-interventions not applied to the control group
Chiarello 1997	Healthy participants
Crosman 1984	Healthy participants
Feehan 1989	Not tendinitis
Fernandez 2006	Combination of Interventions; co-interventions not applied to the control group
Fernandez 2008	Combination of Interventions; co-interventions not applied to the control group
Iwatsuki 2001	Study was not a randomized controlled trial
Joseph 2012	Study was not a randomized controlled trial
Kohia 2008	No control group
Malier 1986	No control group
Mayer 2007	No control group
Nagrale 2009	Combination of Interventions; co-interventions not applied to the control group
Pellecchia 1994	Combination of Interventions; co-interventions not applied to the control group
Smidt 2002	Combination of Interventions; co-interventions not applied to the control group
Stasinopoulos 2004a	Combination of Interventions; co-interventions not applied to the control group
Stasinopoulos 2004b	No control group
Stasinopoulos 2006	Combination of interventions: Cyriax and Mill's manipulation; co-intervention not applied to the control group
Struijs 2003	Pilot study
Struijs 2006	Combination of Interventions; co-interventions not applied to the control group
Thomee 1997	Not tendinitis
Verhaar 1995	No control group
Viswas 2012	Combination of interventions: Cyriax and Mill's manipulation; co-intervention not applied to the control group
Zhang 1987	Not tendinitis
Zheng 2012	Study was not a randomized controlled trial

DATA AND ANALYSES

Comparison 1. Massage + therapeutic ultrasound (US) and placebo ointment vs US + placebo ointment only

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Pain (VAS 0-100, 0 = worst) (change from baseline)	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
2 Grip strength (ratio index, higher is better)	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
3 Function (VAS 0-100, 0 = worst)	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
4 Function (pain-free function; average number of pain-free items; higher is better)	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
5 Functional status (number of successes to perform strengthening program)	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected

Analysis 1.1. Comparison 1 Massage + therapeutic ultrasound (US) and placebo ointment vs US + placebo ointment only, Outcome 1 Pain (VAS 0-100, 0 = worst) (change from baseline).

Study or subgroup	Treatment		Control		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Stratford 1989	11	-11.2 (30.2)	9	-4.6 (19.7)		-6.6[-28.6,15.4]
					Favours treatment	Favours control

Analysis 1.2. Comparison 1 Massage + therapeutic ultrasound (US) and placebo ointment vs US + placebo ointment only, Outcome 2 Grip strength (ratio index, higher is better).

Study or subgroup	Treatment		Control		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Stratford 1989	11	0.7 (0.3)	9	0.6 (0.3)		0.1[-0.16,0.36]
					Favours control	Favours treatment

Analysis 1.3. Comparison 1 Massage + therapeutic ultrasound (US) and placebo ointment vs US + placebo ointment only, Outcome 3 Function (VAS 0-100, 0 = worst).

Study or subgroup	Treatment		Control		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Stratford 1989	11	76.3 (21.9)	9	78.1 (16.5)		-1.8[-18.64,15.04]
					Favours control	Favours treatment

Analysis 1.4. Comparison 1 Massage + therapeutic ultrasound (US) and placebo ointment vs US + placebo ointment only, Outcome 4 Function (pain-free function; average number of pain-free items; higher is better).

Analysis 1.5. Comparison 1 Massage + therapeutic ultrasound (US) and placebo ointment vs US + placebo ointment only, Outcome 5 Functional status (number of successes to perform strengthening program).

Comparison 2. Massage + phonophoresis vs phonophoresis only

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Pain (VAS 0-100, 0 = worst)	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
2 Grip strength (ratio index, higher is better)	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
3 Function (VAS 0-100, 0 = worst)	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
4 Function (pain-free function; average number of pain-free items; higher is better)	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
5 Functional status (number of successes to perform strengthening program)	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected

Analysis 2.1. Comparison 2 Massage + phonophoresis vs phonophoresis only, Outcome 1 Pain (VAS 0-100, 0 = worst).

Analysis 2.2. Comparison 2 Massage + phonophoresis vs phonophoresis only, Outcome 2 Grip strength (ratio index, higher is better).

Study or subgroup	Treatment		Control		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Stratford 1989	10	0.5 (0.3)	10	0.7 (0.3)		-0.2[-0.46,0.06]
					Favours control	Favours treatment

Analysis 2.3. Comparison 2 Massage + phonophoresis vs phonophoresis only, Outcome 3 Function (VAS 0-100, 0 = worst).

Study or subgroup	Treatment		Control		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Stratford 1989	10	82.5 (16.3)	10	78.8 (23.7)		3.7[-14.13,21.53]
					Favours control	Favours treatment

Analysis 2.4. Comparison 2 Massage + phonophoresis vs phonophoresis only, Outcome 4 Function (pain-free function; average number of pain-free items; higher is better).

Study or subgroup	Treatment		Control		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Stratford 1989	10	3.7 (2.8)	10	3.6 (2.6)		0.1[-2.27,2.47]
					Favours control	Favours treatment

Analysis 2.5. Comparison 2 Massage + phonophoresis vs phonophoresis only, Outcome 5 Functional status (number of successes to perform strengthening program).

Study or subgroup	Treatment		Control		Risk Ratio	Risk Ratio
	n/N		n/N		M-H, Fixed, 95% CI	M-H, Fixed, 95% CI
Stratford 1989	2/10		3/10			0.67[0.14,3.17]
					Favours control	Favours treatment

Comparison 3. Massage + physical therapy vs physical therapy only

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Pain	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
1.1 Daily pain	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
1.2 Pain while running	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
1.3 % of maximum pain while running	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]

Analysis 3.1. Comparison 3 Massage + physical therapy vs physical therapy only, Outcome 1 Pain.

ADDITIONAL TABLES

Table 1. Inclusion and exclusion criteria according to the PICOTS strategy

Inclusion	Exclusion
Participants/Population (P) <ul style="list-style-type: none"> Outpatients or inpatients Diagnosis: tendinitis pain Chronic versus acute conditions Normal weight (BMI < 25 kg/m²) Age groups ≥ 18 years Medically stable Mentally competent 	Participants/Population (P) <ul style="list-style-type: none"> Cancer (and other oncologic conditions) Dermatologic conditions Healthy normal Mixed population Multiple conditions (presenting other chronic problems additional) Neurologic conditions Pediatric conditions Psychiatric conditions Pulmonary conditions Scoliosis Condition in which rapid weight loss or exercise is contraindicated (angina, frailty, advanced osteoporosis) Obese or overweight patient (BMI ≥ 25 kg/m²)
Interventions (I) <ul style="list-style-type: none"> Eligible interventions: deep transverse frictions techniques only, in community or not, and with or without: <ul style="list-style-type: none"> Concurrent programs (eg, stretching exercises, modalities (ultrasound), phonophoresis) Supervision Eligible control groups: conventional therapy, untreated, waiting list, active physical therapy treatments, educational pamphlets 	Interventions (I) <ul style="list-style-type: none"> Surgery (ie, not the effects of surgery) Medication (eg, phonophoresis with medications) Thermal biofeedback
Comparisons (C) <p>Studies were included if they compared an intervention group (eg, deep transverse frictions techniques combined with</p>	Comparisons (C)

Table 1. Inclusion and exclusion criteria according to the PICOTS strategy *(Continued)*

modalities, exercises) with a comparison group (eg, placebo, no treatment, active treatment such as modalities, exercises)	Studies were excluded if they did not compare the intervention group with a comparison group (eg, placebo, no treatment, active treatment such as modalities, exercises)
Outcomes (O) <ul style="list-style-type: none"> • Functional status (self-care activities) • Medication intake (if reported) • Muscle strength • Pain intensity • Participant satisfaction • Quality of life • Compliance 	Outcomes (O) <ul style="list-style-type: none"> • Biochemical measures • Participant compliance with medication • Psychosocial measures (depression, home and community activities, leisure, social roles, sexual functions) • Serum markers (except ESR)
Period of time (P) <p>Studies were included if the intervention period lasted longer than 1 week or 1 treatment session, with or without a follow-up period</p>	Period of time (P) <p>Studies were excluded if the intervention period lasted less than 1 week or 1 treatment session</p>
Study designs (S) <ul style="list-style-type: none"> • Randomized controlled trial • Controlled clinical trial <p>*English and French articles only.</p>	Study designs (S) <ul style="list-style-type: none"> • Case series/case report • Case control studies • Cohort studies • Data (graphic) without a mean and SD • Sample size of fewer than 5 participants per experimental group • Studies with greater than 20% dropout rate

BMI: Body mass index.

ESR: Erythrocyte sedimentation rate.

PICOTS: Populations, interventions, comparators, outcomes, timing, and setting framework.

SD: Standard deviation.

APPENDICES

Appendix 1. MEDLINE search strategy

Ovid MEDLINE(R) In-Process & Other Nonindexed Citations, and Ovid MEDLINE(R) (1946 to July 1, 2014)

- 1 exp Tendinopathy/ (6229)
- 2 tendinopath\$.tw. (1352)
- 3 tend?nit\$.tw. (2331)
- 4 tend?nos\$.tw. (576)
- 5 ECRT.tw. (11)
- 6 tennis elbow.tw. (650)
- 7 lateral\$ epicondylitis.tw. (507)
- 8 ITBFS.tw. (18)
- 9 Iliotibial band friction syndrome.tw. (55)
- 10 exp Cumulative Trauma Disorders/ (10274)

Deep transverse friction massage for treating lateral elbow or lateral knee tendinitis (Review)

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- 11 (repetiti\$ adj (motion disorder or strain)).tw. (358)
- 12 cumulative trauma disorder\$.tw. (273)
- 13 or/1-12 (18667)
- 14 exp Musculoskeletal Manipulations/ (11415)
- 15 physical therapy modalities/ (26485)
- 16 massag\$.tw. (6837)
- 17 Deep transverse friction.tw. (6)
- 18 dtfm.tw. (2)
- 19 Cyriax.tw. (31)
- 20 or/14-19 (41129)
- 21 13 and 20 (534)

Appendix 2. EMBASE search strategy

Database: EMBASE Classic + EMBASE (1947 to July 1, 2014)

- 1 exp massage/ (10894)
- 2 therapeutic touch.mp. (429)
- 3 reflexotherapy.mp. (416)
- 4 exp ROLFING/ (12)
- 5 exp SHIATSU/ (65)
- 6 exp reflexology/ (374)
- 7 myotherapy.mp. (34)
- 8 (polarity adj therapy).mp. (13)
- 9 (myofascial adj release).mp. (114)
- 10 (craniosacral adj therapy).mp. (87)
- 11 exp REIKI/ (184)
- 12 (trager adj psychophysical).mp. (6)
- 13 (hakomi adj method).mp. (2)
- 14 (jin adj shin).mp. (4)
- 15 (neuromuscular adj therapy).mp. (10)
- 16 (pfrimmer adj25 therapy).mp. (4)
- 17 (alexander adj technique).mp. (85)
- 18 exp Alexander Technique/ (35)
- 19 (feldenkrais adj method).mp. (57)
- 20 massag\$.mp. (18532)
- 21 or/1-20 (19890)
- 22 exp tendon injury/ (15552)

- 23 tendinitis/ (6184)
- 24 tenosynovitis/ (4011)
- 25 tendinopathy/ (5701)
- 26 (tend#nitis or tend#nosis or tend#nopathy or tenovaginitis or paratend#nitis or peritend#nitis or tenosynovitis).tw. (7635)
- 27 or/22-26 (25837)
- 28 21 and 27 (172)

Appendix 3. CENTRAL search strategy

Wiley Cochrane Library – CENTRAL Issue 7 of 12, July 2014

- #1 MeSH descriptor: [Tendinopathy] explode all trees
- #2 MeSH descriptor: [Tendon Injuries] explode all trees
- #3 (Tendinitis or Tendinosis or Tendonitis):ti,ab
- #4 lateral epicondylitis
- #5 Iliotibial band friction syndrome
- #6 repetitive motion
- #7 repetitive strain
- #8 #1 or #2 or #3 or #4 or #5 or #6 or #7
- #9 Deep transverse friction
- #10 massage
- #11 MeSH descriptor: [Massage] explode all trees
- #12 MeSH descriptor: [Musculoskeletal Manipulations] explode all trees
- #13 dtfm
- #14 Cyriax
- #15 MeSH descriptor: [Physical Therapy Modalities] explode all trees
- #16 #9 or #10 or #11 or #12 or #13 or #14 or #15
- #17 #8 and #16

Appendix 4. CINAHL search strategy

EBSCO Host CINAHL 1982-July 2014

S15	S9 and S14	120
S14	S10 or S11 or S12 or S13	9452
S13	TX massage	9452
S12	(MH "Deep Tissue Massage")	44

(Continued)

S11	(MH "Sports Massage")	166
S10	(MH "Massage")	5733
S9	S1 or S2 or S3 or S4 or S5 or S6 or S7 or S8	3869
S8	"tendinitis"	407
S7	"repetitive strain"	157
S6	(MH "Cumulative Trauma Disorders")	1667
S5	"ECRT"	1
S4	"lateral epicondylitis"	240
S3	(MH "Elbow Injuries")	579
S2	(MH "Tennis Elbow")	645
S1	(MH "Tendinopathy")	

Appendix 5. PEDro search strategy

PEDro

Therapy: stretching, mobilization, manipulation and massage

Problem: pain

Body part: forearm elbow

Appendix 6. Clinicaltrials.gov search strategy

Clinicaltrials.gov

Conditions: tendinitis OR tenosynovitis OR tendinopathy

Interventions: massage

WHAT'S NEW

Date	Event	Description
1 July 2014	New citation required but conclusions have not changed	New review authors
1 July 2014	New search has been performed	New search; no new studies Added risk of bias tables, summary of findings table and new excluded articles

CONTRIBUTIONS OF AUTHORS

LB and LML were responsible for writing the manuscript, extracting and analyzing data, and selecting trials for the initial review.

LML, PR and GDA performed data extraction and updated selections from the reference list, the analyses, and the interpretation of results.

PR was responsible for the literature search update.

BS, PT, GW, VW and SP contributed methodological expertise and commented on early drafts.

DECLARATIONS OF INTEREST

All the authors have no conflict of interest to declare.

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- Ottawa Health Research Institute, Canada.

External sources

- Holistic Health Research Foundation of Canada, Canada.

DIFFERENCES BETWEEN PROTOCOL AND REVIEW

We used the "Risk of bias" tool to assess the risk of bias in included studies and presented the results in "Summary of findings" tables.

INDEX TERMS

Medical Subject Headings (MeSH)

Combined Modality Therapy; Cryotherapy; Iliotibial Band Syndrome [*therapy]; Massage [*methods]; Ointments [administration & dosage]; Phonophoresis; Randomized Controlled Trials as Topic; Rest; Tennis Elbow [*therapy]; Ultrasonic Therapy

MeSH check words

Humans