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Does effectiveness of exercise therapy and mobilisation techniques offer guidance for the treatment of lateral and medial epicondylitis? A systematic review

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ABSTRACT

Background Owing to the change in paradigm of the histological nature of epicondylitis, therapeutic modalities as exercises such as stretching and eccentric loading and mobilisation are considered for its treatment.
Objective To assess the evidence for effectiveness of exercise therapy and mobilisation techniques for both medial and lateral epicondylitis.
Methods Searches in PubMed, Embase, Cinahl and Pedro were performed to identify relevant randomised clinical trials (RCTs) and systematic reviews. Two reviewers independently extracted data and assessed the methodological quality.
Results One review and 12 RCTs, all studying lateral epicondylitis, were included. Different therapeutic regimes were evaluated: stretching, strengthening, concentric/eccentric exercises and manipulation of the cervical or thoracic spine, elbow or wrist. No statistical pooling of the results could be performed owing to heterogeneity of the included studies. Therefore, a best-evidence synthesis was used to summarise the results. Moderate evidence for the short-term effectiveness was found in favour of stretching plus strengthening exercises versus ultrasound plus friction massage. Moderate evidence for short-term and mid-term effectiveness was found for the manipulation of the cervical and thoracic spine as add-on therapy to concentric and eccentric stretching plus mobilisation of wrist and forearm. For all other interventions only limited, conflicting or no evidence was found.
Conclusions Although not yet conclusive, these results support the belief that strength training decreases symptoms in tendinosis. The short-term analgesic effect of manipulation techniques may allow more vigorous stretching and strengthening exercises resulting in a better and faster recovery process of the affected tendon in lateral epicondylitis.

INTRODUCTION

Lateral epicondylitis (LE) occurs 7–10 times more often than medial epicondylitis (ME) and affects about 1–3% of the population. Therefore, it represents one of the most frequent causes of lateral elbow pain. The first clinical description of LE by Runge dates from 1873[1] and 10 years later, owing to the perceived association with lawn tennis,[2] it was named the 'lawn tennis elbow'. Over time, this was changed to 'tennis elbow', although in most patients the condition is not related to playing tennis. ME is also called 'golfers' elbow' although it mainly occurs during other activities. For some time, it was assumed that both LE and ME involve an inflammatory process owing to a partial rupture of the origin of the common extensor tendon and the flexor pronator group, respectively, as well as the adjacent periosteum of the lateral and medial epicondyle. Hence, the names LE and ME, which were first used by Coues[3] and Marmor,[4] respectively. Also, because of the assumed inflammatory nature, anti-inflammatory agents and especially corticosteroids have long been the mainstay of treatment.

However, this situation is slowly changing. In 1976, a type of tendon degeneration named tendinosis was first described in the Achilles tendon by Puddu *et al.*[5] In 1979, Nirschl and Pettrone[6] described the results of surgical treatment of 88 patients with LE. Histological analysis of the problem area showed an immature fibroblastic and vascular infiltration of the origin of the extensor carpi radialis brevis, suggesting a degenerative rather than an inflammatory process. This picture was confirmed by subsequent studies.[7] As a result, the name epicondylitis is now generally considered to be incorrect and the condition is considered to result from a degenerative process termed 'tendinosis'.[8]

Because the term epicondylitis is a misnomer, alternative names like lateral or medial elbow tendinopathy[9 10] or epicondylalgia[11 12] have been introduced. However, although the term 'epicondylitis' is incorrect with respect to content, to maintain continuity in terminology, we continue to use this term in this paper.

Epicondylitis is assumed to be caused by the incomplete repair of repetitive microtraumata, although alternative causes are under discussion.[11 13] The pain in tendinopathy is thought to be caused by ingrowing free nerve endings and blood vessels into the degenerated tendon.[14–16] Several occupational factors are associated with the occurrence of lateral and medial elbow tendinopathy, including handling loads >20 kg at least 10 times/day and repetitive movements >2 h/day.[17]

Owing to the change in paradigm with respect to the histological nature of LE and ME, a range of new therapeutic modalities are now considered for its treatment. Based on their positive clinical effects in chronic Achilles tendinosis,[18] exercise in the form of stretching and eccentric loading, and mobilisation techniques have been advocated. Therefore, the aim of the current study is to assess the evidence for the effectiveness of exercise and mobilisation techniques to treat LE and ME.

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METHODS

Search strategy

The Cochrane Library, PubMed, Embase, Cinahl and Pedro were searched to identify relevant systematic reviews and randomised controlled trials (RCTs) on interventions for LE and ME (up to February 2010). Keywords related to epicondylitis such as 'epicondylitis', 'tennis elbow', 'golfers elbow' and 'interventions' were included. The complete search strategy is available on request.

Inclusion criteria

Systematic reviews and/or RCTs were considered eligible for inclusion if they fulfilled all the following criteria: (1) patients with ME or LE were included, (2) epicondylitis was not caused by an acute trauma or any systemic disease as described in the definition of CANS (complaints of the arm, neck and/or shoulder),[19] (3) interventions for treating epicondylitis were evaluated, (4) results on pain, function or recovery were reported and (5) the article was written either in English, French, German or Dutch.

After the full-text articles were examined, the included studies were divided into different treatment groups for which separate reviews could be conducted. The present review concerns the efficacy of exercise therapy and mobilisation techniques.

Study selection

Two reviewers (BMAH, RD/MR/SG) independently applied the inclusion criteria to select potential relevant studies from the title and abstracts of the references retrieved by the literature search. A consensus method was used to solve any disagreements concerning the inclusion of studies, and a third reviewer (BWK) was consulted if disagreement persisted.

Categorisation of the relevant literature

Relevant articles are categorised under three headers: *Systematic reviews* describe all (Cochrane) reviews; *Recent RCTs* contain all RCTs published after the search date of the systematic review on the same intervention; and *Additional RCTs* describe all RCTs concerning an intervention that has not yet been described in a systematic review.

Data extraction

Two authors (BMAH, RD/MR/SG) independently extracted the data. Information was collected on the study population, interventions used, outcome measures and outcome. A consensus procedure was used to solve any disagreement between the authors. The follow-up period was categorised as short-term (≤3 months), mid-term (4–6 months) and long-term (>6 months) follow-up.

Methodological quality assessment

Two reviewers (BMAH, RD/MR) independently assessed the methodological quality of each recent and additional RCT. The 12 quality criteria (table 1) were adopted from Furlan *et al*.[20] Each item was scored as 'yes', 'no' or 'don't know'. High-quality was defined as a 'yes' score of ≥50%. A consensus procedure was used to solve any disagreement between the reviewers.

In a (Cochrane) review, the use of a methodological quality assessment is a standard procedure. We describe the methodological quality scale or criteria used in the review, and used their ratings as high/low quality for the included studies.

Data synthesis

A quantitative analysis of the studies was not possible owing to the heterogeneity of the study populations, interventions and outcome measures. Therefore, we summarised the results using a best-evidence synthesis.[21] A study was included in the best-evidence synthesis only if a comparison was made between the groups and the level of significance was reported. The results of the study were labelled significant if one of the three outcome measures (pain, function and improvement) showed significant results. The levels of evidence for effectiveness were ranked as shown in box 1.

Table 1 Methodological quality assessment

	Sources of risk of bias Item
A	1. Was the method of randomisation adequate?
B	2. Was the treatment allocation concealed?
C	Was knowledge of the allocated interventions adequately prevented during the study?
	3. Was the patient blinded to the intervention?
	4. Was the care provider blinded to the intervention?
	5. Was the outcome assessor blinded to the intervention?
D	Were incomplete outcome data adequately addressed?
	6. Was the drop-out rate described and acceptable?
	7. Were all randomised participants analysed in the group to which they were allocated?
E	8. Are reports of the study free of suggestion of selective outcome reporting?
F	Other sources of potential bias:
	9. Were the groups similar at baseline regarding the most important prognostic indicators?
	10. Were cointerventions avoided or similar?
	11. Was the compliance acceptable in all groups?
	12. Was the timing of the outcome assessment similar in all groups?

RESULTS

Characteristics of the included studies

The initial literature search resulted in five potentially relevant reviews and 227 RCTs. Finally, one review and 12 RCTs on exercise therapy and mobilisation techniques were included (figure 1). The characteristics of the included studies are listed in online supplementary appendix 1.

Box 1 Levels of evidence

- *Strong evidence*: consistent (ie, when ≥75% of the trials report the same findings) positive (significant) findings within multiple higher quality RCTs.
- *Moderate evidence*: consistent positive (significant) findings within multiple lower-quality RCTs and/or one high-quality RCT.
- *Limited evidence:* for effectiveness: positive (significant) findings within one low-quality RCT.
- *Conflicting evidence*: provided by conflicting (significant) findings in the RCTs (<75% of the studies reported consistent findings)
- *No evidence*: RCT(s) available, but no (significant) differences between the intervention and control groups were reported

RCT, randomised control trial.

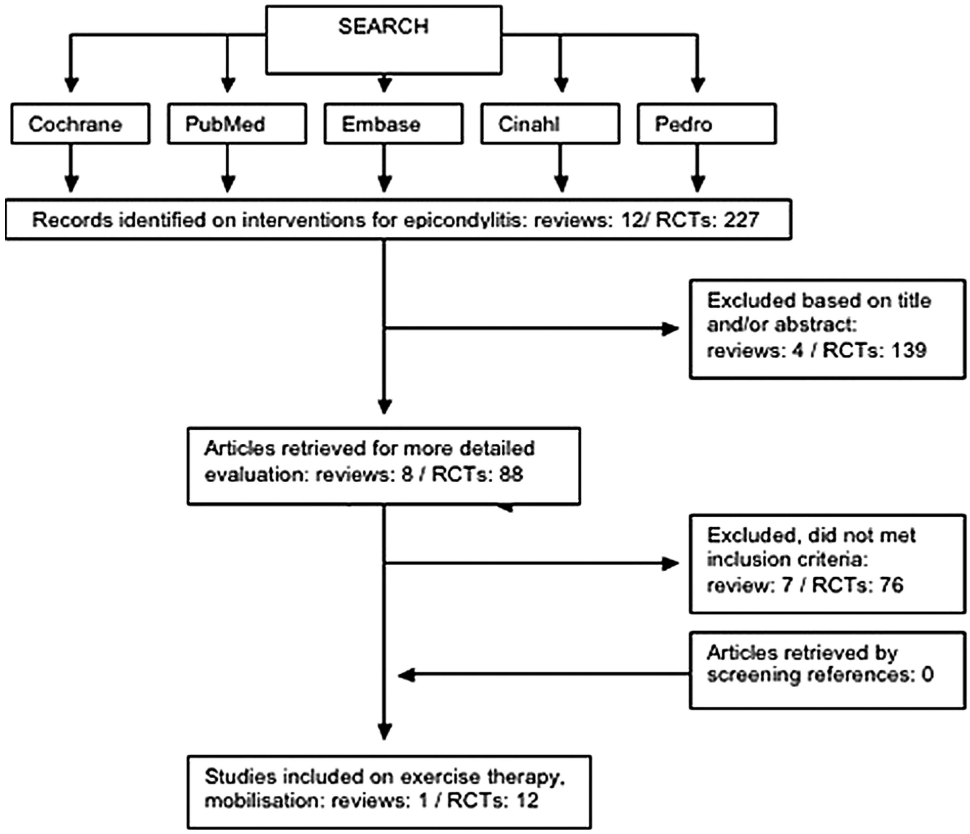

Figure 1 Flowchart of the literature search.

Methodological quality of the included studies

The results of the methodological quality assessment are presented in table 2.

The review of Smidt *et al*[22] used the Amsterdam-Maastricht consensus list (including 12 items comparable with the Furlan criteria) and defined a score >50% '+' as high-quality: one of the three RCTs concerning exercises or mobilisation was of high quality.

The most prevalent methodological shortcomings were no blinding of the care provider (0%) and cointerventions not avoided or similar (17%).

Effectiveness of interventions for ME

No reviews or RCTs were found for ME.

Effectiveness of interventions for LE

One systematic review,[22] 11 recent RCTs and 1 additional RCT were included.

The systematic review of Smidt *et al*[22] on physiotherapy versus placebo, no treatment or another conservative treatment included 23 RCTs; 3 of these RCTs[23–25] concentrated on exercise therapy or mobilisation techniques. Relative risk (RR) and standard mean differences (SMD) were reported if these effect sizes could be calculated.

Further, 11 recent RCTs and 1 additional RCT (studying Chiropractic therapy plus strengthening exercises vs ultrasound) were found.

The evidence for the effectiveness of the various interventions for LE is presented in table 3.

EXERCISE THERAPY

- Stretching and strengthening exercises

Stretching plus strengthening exercises versus ultrasound plus friction massage

Systematic review

One high-quality study[25] (n=19) was found in which the effectiveness of stretching plus strengthening exercises versus friction massage plus ultrasound was studied. At 8 weeks follow-up, a significant benefit in favour of stretching plus strengthening exercises was found on pain (SMD 0.95) (95% CI 0.26 to 1.64).

We concluded that there is moderate evidence for the effectiveness of stretching plus strengthening exercises versus ultrasound plus friction massage on short-term follow-up.

Strengthening plus stretching exercises versus ultrasound

Recent RCT

Pienimaki *et al*[26] (n=30, low-quality) compared a progressive strengthening plus stretching arm exercise programme to local pulsed ultrasound therapy and found significant differences in favour of the exercise therapy on all pain measurements: pain drawing: MD −0.4 (95% CI −2.1 to −0.4), pain at rest: MD −2.3 (95% CI −4.5 to 0.01) and pain at strain: MD −3.1 (95% CI −5.6 to −0.5) at 36 months (range 2–4 years) follow-up.

There is limited evidence for the effectiveness of strengthening plus stretching exercises versus ultrasound therapy on the long term.

Concentric versus eccentric exercises

Recent RCT

Martinez-Silvestrini *et al*[27] (n=94, low-quality) compared three different home exercise programmes to treat LE: stretching plus other conservative therapy (stretching group), stretching plus a concentric strengthening programme (concentric group) or stretching plus an eccentric strengthening programme (eccentric

Table 2 Methodological quality scores of the included studies

References	Adequate randomisation?	Allocation concealment?	Blinding? patients?	Blinding? caregiver?	Blinding? outcome assessors?	Incomplete outcome data addressed? drop-outs?	Incomplete outcome data? ITT analysis?	Free of suggestions of selective outcome reporting?	Similarity of baseline characteristics?	Cointerventions avoided or similar?	Compliance acceptable in all groups?	Timing of the outcome assessment similar?	Score max	Score study	%
25*	+	+	–	–	+	+	+	+	+	+	+	+	12	10	83
32	+	–	+	–	+	+	+	+	?	+	+	?	12	8	67
31	+	?	–	–	?	?	?	+	+	?	+	+	12	5	60
36	+	?	–	–	–	+	+	+	–	?	+	–	12	5	60
35	+	+	–	–	+	+	–	+	+	?	?	+	12	7	58
30	+	+	–	–	–	+	+	+	?	?	+	+	12	7	58
24*	–	+	+	–	+	+	+	–	–	–	+	+	12	7	58
23*	–	–	–	–	–	+	+	+	–	–	+	+	12	5	42
27	?	?	–	–	?	+	+	+	–	–	?	+	12	4	33
29	?	?	+	–	+	?	?	+	?	?	?	+	12	4	33
34	?	–	+	–	+	?	?	+	?	?	?	+	12	4	33
26	?	?	–	–	?	+	?	+	+	?	?	–	12	3	25
11	?	?	–	–	+	?	?	+	?	?	?	+	12	3	25
33	?	?	–	–	–	?	+	+	?	?	?	+	12	3	25
28	?	?	–	–	?	–	–	+	–	–	?	–	12	1	8
Total positive scores per item	6	4	4	0	7	9	8	14	4	2	7	11			

*Articles included in the review of Smidt *et al* 2003 in which the Amsterdam-Maastricht was used to score the methodological quality.
+, yes; –, no; ?, unclear/unsure, ITT, intention-to-treat.
na, not applicable (in a non-time intervention, such as surgery, compliance is not an issue).

Table 3 Evidence for effectiveness of exercise therapy and mobilisation therapy for lateral epicondylitis*

Exercise therapy		Mobilisation techniques	
Stretching and strengthening exercises		Manipulation of the cervical or thoracic spine	
▶ Stretching plus strengthening exercises† vs ultrasound plus friction massage		▶ Manipulation cervical spine† vs placebo or control	
Short-term:	++	Short-term (immediately after treatment):	±
▶ Stretching plus strengthening exercises† vs ultrasound		▶ Oscillatory manipulation cervical spine† vs placebo vs control	
Long-term:	+	Short-term (immediately after treatment):	NE
Concentric vs eccentric exercises		▶ Manipulation cervical and thoracic spine† as add on therapy to concentric and eccentric stretching plus mobilisation of the wrist and forearm	
▶ Conservative therapy vs concentric strengthening vs eccentric strengthening as add on to stretching:		Short-term:	++
Short-term:	NE	Mid-term:	++
Stretching versus eccentric† exercises		Manipulation of the elbow	
▶ Stretching† vs eccentric exercises:		▶ Mobilisation of the radial head and nerve vs ultrasound plus friction massage plus stretching and strengthening of the wrist extensors	
Short-term:	NE	Short-term:	NE
Mid-term:	+	▶ Mulligan mobilisation† as add on therapy to ultrasound and graduated exercises	
Long-term:	NE	Short-term:	+
Exercise therapy plus mobilisation techniques		▶ Lateral-glide mobilisation with movement treatment technique of the elbow† vs placebo vs control	
▶ Chiropractic therapy plus strengthening exercises vs ultrasound†		Short-term (immediately after treatment):	+
Short-term:	+	▶ Lateral-glide mobilisation with movement treatment technique of the elbow: 1.2 N vs 1.9 N vs 2.5 N vs 3.8 N	
		Short-term (immediately after treatment):	
		2.5 N† vs 1.2 N or 1.9 N:	+
		3.8 N vs 2.5 N:	NE
		▶ Oscillating energy manual therapy of the elbow† vs placebo	
		Short-term:	+
		Manipulation of the wrist	
		▶ Manipulation of the wrist† vs ultrasound plus friction massage plus stretching and strengthening exercises	
		Short-term:	+

*For medial epicondylitis no RCTs on exercise therapy or mobilisation techniques were found.
†In favour of.
+, limited evidence found; ++, moderate evidence found; ±, conflicting evidence for effectiveness; NE, no evidence found for effectiveness of the treatment: RCT(s) available, but no differences between intervention and control groups were found.

strengthening group). No significant differences between the groups were found on pain measurements and the DASH after 6 weeks.

We concluded that there is no evidence for the effectiveness of conservative versus concentric strengthening or a combined stretching plus concentric exercise programme as add-on therapy to stretching on the short term.

Stretching versus eccentric exercises

Recent RCT

In another low-quality study[28] of Svernlov *et al*,[28] (n=30) stretching (contract-relax-stretching) and eccentric exercises were compared. Significant differences were found on grip strength at 6 months follow-up (stretching group 54.2 (36.9 to 81.5) (mean (range)) vs eccentric group 67.9 (43.7 to 89.4), but no significant results were found at 3 and 12 months follow-up.

There is limited evidence for the effectiveness of eccentric exercise versus stretching to decrease symptoms of LE on the mid term; for the short and long term, no evidence was found.

MOBILISATION TECHNIQUES

▶ Manipulation of the cervical spine

Manipulation of the cervical spine versus placebo or control

Systematic review

In the systematic review of Smidt *et al*,[22] one high-quality study[24] (n=15) investigated a cervical spine manipulation technique (cervical 5/6) versus placebo (placebo manipulation) and control (no manual contact) in patients with LE. Results were collected immediately after the application. In that study,[24] the results of manipulation and the placebo manipulation and the controls were compared with regard to pain and function. No significant results between the groups were found.

Recent RCTs

The low-quality study of Fernandez-Camero *et al*[11] compared immediate hypoalgesic and motor effects after a single spine manipulation to a placebo intervention (ie, manual contact intervention; total n=10). After the second treatment session, significant differences were found on pressure pain threshold (PPT) and pain-free grip (PFG) in favour of the cervical spine manipulation group (PPT increased by 44.2% (19.0) (mean (SEM)) and PFG decreased by 38.8% (31.9), respectively, versus 4.4% (8.1) and 8.5% (12.6) for the same outcome measures in the placebo group.

Vicenzino *et al* (n=24, low-quality)[29] compared cervical spine lateral glide oscillatory manipulation versus a placebo manipulation versus control. Results were collected immediately after the application. Pain-free grip strength was tested, but no comparisons between the groups were made.

There is conflicting evidence for the effectiveness of cervical spine manipulation versus placebo immediately after treatment. Further, no evidence was found for the effectiveness of oscillatory cervical spine manipulation versus a placebo manipulation or controls immediately after treatment.

▸ Manipulation of the cervical and thoracic spine

Manual therapy of the cervical and thoracic spine as an additive to local treatment:

Recent RCT

Cleland *et al*[30] (n=10, high-quality) reported on manual therapy directed at the cervical and thoracic spine (MTCT) as additive to local treatment (LT ie, stretching of the wrist and forearm (concentric and eccentric), joint mobilisation of the elbow and the wrist). Significant positive results were reported on pain-free grip strength at 6 weeks and 6 months follow-up (FU) (mean differences (mean (95% CI)) between LT and LT plus MTCT groups from baseline to follow-up: 6 weeks FU: 14.6 (9.3 to 19.9) 6 months FU: 19.6 (1.6 to 37.6)). No significant differences were found on the numeric pain rating score at 6 weeks and 6 months follow-up. At 6 weeks follow-up, significant differences were found on the DASH score (differences (mean (95% CI)) between LT and LT plus MTCT groups from baseline to follow-up: 6 weeks FU: 10 (7.7 to 27.7)); no significant differences on the DASH were found at 6 months follow-up.

There is moderate evidence for the effectiveness of manipulation of the cervical and thoracic spine as add-on therapy to concentric and eccentric stretching and mobilisation of the wrist and forearm on both the short term and midterm.

▸ Manipulation of the elbow

Mobilisation of the head of the radius

Systematic review

Dreschler *et al*[23] (n=8, low-quality) compared neural tension (ie, mobilising the head of the radius and a specific physical therapy mobilisation technique to address hypomobility of the radial nerve) to standard treatment (ie, ultrasound, transverse friction massage, strengthening and stretching exercises for the extensors of the wrist) and found no significant differences on occupational, recreational status, the upper limb tension test and grip strength at 3 months post-treatment (ie, after 6–8 weeks treatment). On recreational status and the upper limb tension test, the neural tension group showed positive significant differences ($p<0.05$) at 3 months post-treatment, but no differences between the groups were found.

There is no evidence for the effectiveness of mobilisation of the radial head and nerve versus ultrasound plus friction massage and stretching and strengthening exercises for the extensors of the wrist on the short term.

Mulligan mobilisation at the elbow

Recent RCT

Kochar *et al*[31] (n=46, low-quality) compared Mulligan mobilisation (MM, a manual therapy approach in which the patient performs the pain-producing movement in conjunctions with sustained mobilisation known as mobilisation with movement; this renders the movement painless) as add-on therapy to ultrasound therapy and graduated exercise (ie, progressive resistive exercise with isometric, concentric and eccentric exercises). Significant differences in favour of the MM group were found on pain (VAS) (no exact data given, $p<0.05$), and the weight test (kg) (no exact data given, $p<0.01$) at 3-months follow-up. No significant differences between the groups were found on grip strength.

There is limited evidence for the effectiveness of Mulligan mobilisation as add-on therapy to ultrasound therapy and graduated exercise on the short term.

Lateral-glide mobilisation with movement treatment technique of the elbow versus placebo or control

Recent RCT

One low-quality RCT[32] (n=24) studied the manipulation of the elbow. The treatment consisted of a lateral-glide mobilisation with movement treatment technique for the elbow. Pressure pain and pain-free grip strength were measured immediately after the treatment. Pressure pain increased significantly in the treatment group versus placebo (10.26% increased in the treatment group vs3.88% reduction in the placebo group ($p=0.01$)) and versus control (10.26% increased in the treatment group vs 0.31% increased in the control group ($p=0.049$)). Pain-free grip strength showed a significant increase versus placebo (45.7% increase in the treatment group vs 9.7% increase in the placebo group) and versus control (45.7% increase in the treatment group vs 2.7% reduction in the control group; $p<0.0001$).

There is limited evidence for the effectiveness of movement treatment technique (MWM) of the elbow versus placebo or control treatment immediately after the treatment.

MWM: four force levels compared

Recent RCT

McLean *et al*[33] (n=6, low-quality) reported on differences in pain-free grip strength in force levels in lateral-glide mobilisation with the movement treatment technique of the elbow: 33%, 50%, 66% and 100% of the maximum force (1.2, 1.9, 2.5 and 3.8 N, respectively) were studied immediately after treatment. The two lower forces decreased the change in pain-free grip strength by 16% and 2%, respectively, while the two higher forces increased this outcome by 15% and 18%, respectively. The contrast between 2.5 and 1.2/1.9 N was significant ($p=0.037$), whereas that between 1.2 and 1.9 N as well as between 3.8 and 2.5, 1.9 or 1.2 N was not significant.

Limited evidence for effectiveness was found in favour of MWM with a force of 2.5 N versus a force of 1.2 or 1.9 N immediately after the treatment; no evidence for the effectiveness was found for a force of 1.2 versus 1.9 N or a force of 3.8 versus 2.5, 1.9 or 1.2 N immediately after the treatment.

Oscillating energy manual therapy of the elbow versus placebo

Recent RCT

Nourbakhsh *et al*[34] (n=23, low-quality) found significant differences between oscillating energy manual therapy of the elbow and placebo on pain intensity ($p=0.006$), pain limitations ($p=0.025$), function level (0.003) and grip strength ($p=0.03$), post-treatment (ie, after 2–3 weeks) (no further data given).

There is limited evidence for the effectiveness of oscillating energy manual therapy of the elbow versus placebo on the short term.

▸ Manipulation of the wrist

Manipulation of the wrist versus ultrasound, friction massage plus muscle stretching and strengthening exercises

Recent RCTs

Struijs *et al*[35] (n=31, high-quality) studied the manipulation of the wrist versus ultrasound, friction massage plus muscle stretching and strengthening exercises. At 6 weeks follow-up, they found a significant decrease in pain during the day in favour of the manipulation group (manipulation group from 6.3 (1.3) (mean (SD)) at baseline to 5.2 (2.4) vs control from 6.3 (1.4) at baseline to 3.2 (2.1), p=0.03). Also, better results were found on maximum grip force and global improvement in favour of manipulation, but these results were not significant (p=0.15 and p=0.40, respectively).

We conclude that there is limited evidence for the effectiveness of manipulation of the wrist versus ultrasound, frictions massage plus muscle stretching and strengthening exercises on the short term.

EXERCISES PLUS MOBILISATION THERAPY

Chiropractic therapy plus strengthening exercises versus ultrasound

Additional RCT

In the low-quality study of Langen-Pieters *et al*[36] (n=14) significant positive results in favour of continuous ultrasound therapy versus chiropractic therapy combined with strengthening exercises were found. At 6 weeks follow-up, significant differences on pain (VAS): (ultrasound: from 3.5(1.0) (mean (SD)) at baseline to 0.7 (0.6) at 6 weeks follow-up versus chiropractic: from 5.2 (2.3) at baseline to 2.3 (0.6) at 6 weeks follow-up) and pain-free function (ultrasound: from 5.5 (2.3) (mean (SD)) at baseline to 1.5 (1.4) at 6 weeks follow-up versus chiropractic: from 5.6 (1.8) at baseline to 4.1 (2.3) at 6 weeks follow-up) were found in favour of ultrasound. No significant differences were found on pain-free grip strength.

We found limited evidence for the effectiveness of ultrasound versus chiropractic therapy combined with strengthening exercises on the short term.

DISCUSSION

The aim of this systematic review was to present an overview of the effectiveness of exercise therapy and mobilisation techniques for the treatment of ME and LE.

A fundamental problem in the treatment of epicondylitis is the lack of basic knowledge on the pathophysiology of tendinosis. Apart from being considered multifactorial,[37–41] and mechanical loading playing a major role in its development, little is known about this subject. Consequently, the mechanisms by which various therapies may improve tendinosis are not well-understood.

All studies that we found, concentrated on LE, and in most studies each treatment was compared with another treatment. Unfortunately, no strong evidence for the effectiveness of exercise or mobilisation techniques on symptoms in patients with LE could be found. Two studies[25 30] provided moderate evidence for a positive effect on symptoms in patients with LE.

One study[30] found moderate evidence for the short-term effectiveness of stretching plus strengthening exercises versus ultrasound plus friction massage.

Although different tendons in the human body are subject to different loading conditions that affect tendon metabolism and mechanical properties,[37] our understanding of the biomechanical basis for the development and treatment of tendinopathy is incomplete up to a level that knowledge about these subjects related to one tendon is generally also applied to other tendons.[42] Therefore the findings of this study on LE will be discussed within the broader context of general tendon physiology.

Although stretching plus strengthening is a frequently advocated treatment combination since the 1980s,[37 43–45] the exact mechanism by which it affects the tendon remains unknown.[37 46] Historically, stretching was added because it was supposed to reduce muscle soreness occurring after eccentric exercise.[47] However, it was later concluded that stretching does not confer protection from exercise-derived muscle soreness.[48] Stretching does reduce muscle tendon stiffness[49] and stretching of the tendon fibroblasts increases the production of prostaglandin E2 (PGE2) and leukotriene B4 (LTB4) in humans, both known to be present in inflamed tendons.[37 50–52] However, the clinical relevance of this is not yet clear.

A more specific effect on collagen synthesis was observed in an animal model[53] in which it was found that mechanical stretching facilitated the direct differentiation of rat mesenchymal stem cells into tendon/ligament fibroblasts. However, the clinical relevance of these findings for humans remains unclear. In contrast, more is known about the effects of strength training on collagen synthesis and tendon properties on a cellular level. In response to mechanical loading, tendon fibroblasts produce inflammatory mediators.[54] Simultaneously, collagen synthesis and degradation both increase in the first 24 h after exercise to subside in the following 48 h.[55] Globally, this results in a net loss of collagen in the first 24 h followed by a net synthesis in the following 48 h. However, these are all effects on the level of the fibroblasts. It is not yet clear how these established effects on the cellular level translated into alterations in the composition and the mechanical properties of the tendons. Moreover, the effect of exercise therapy on the neovascularisation[56] and mechanical properties of the affected tendon[57] has been established, these processes are governed by largely unknown interactions of hormones, growth factors and cytokines that could have several additional yet unknown effects. Nevertheless, it is generally accepted that strength training decreases the symptoms in tendinosis[18 56 58] which corroborates the effect found in patients with LE.

A recent development in the treatment of chronic tendon injuries is the injection of autologous growth factors in the form of whole blood or platelet-rich plasma (PRP) at the site of injury. However, although all studies on this subject describe a decrease in pain after PRP injection, when compared to a control group there appeared to be no benefit of this type of treatment.[59 60]

Another study[30] found moderate evidence for the short and mid-term effectiveness of manipulation of the cervical and thoracic spine as add-on therapy to local treatment, that is, stretching of the wrist and forearm (concentric and eccentric) and joint mobilisation of the elbow and the wrist. Because manipulation of the cervical and thoracic spine is unlikely to have an immediate effect on collagen synthesis and the quality of the affected tendon in LE, its effect is most likely predominantly of an analgesic nature. This would corroborate the claim of an immediate analgesic effect after other mobilisations as described by others, such as Mulligan.[61] Although a decrease in pain owing to a direct effect on collagen synthesis seems unlikely, an indirect effect by allowing more vigorous stretching and strengthening exercise training by reducing pain is certainly possible. This would allow better and faster recovery of the affected tendon in LE and may be responsible for more effectiveness, as found in the study of Cleland *et al*[30] for cervical and thoracic manipulation as add-on therapy to the local treatment as described above.

Study limitations

This review has some limitations that should be addressed. First, we refrained from statistical pooling of the results of the individual trials because of the heterogeneity of the included studies. Instead, we settled for use of a best-evidence synthesis, which is the second-best solution. This is a transparent method that is commonly applied in the field of musculoskeletal disorders when statistical pooling is not feasible or clinically viable. Secondly, only 7 of the 15 included RCTs were of high quality, which increase the risk of bias. Thirdly, because in several studies the follow-up period was relatively short (sometimes immediately after treatment), the question remains as to what the (clinically more relevant) long-term effects of these treatments might be. Finally, the statistical power of several studies was relatively low owing to the small number of subjects, which could cause the underestimation of the effects under investigation.

CONCLUSION

In conclusion, no studies could be included studying the interventions to treat ME. All studies included in this review reported on interventions for LE. We found moderate evidence for a short-term effect of stretching plus strengthening exercises compared to ultrasound plus friction massage and for a short-term and mid-term effect of manipulation of the cervical and thoracic spine as add-on therapy to concentric and eccentric stretching plus mobilisation of the wrist and forearm in patients with LE. For all other interventions, only limited, conflicting or no evidence was found. The interpretation of these findings is affected by the lack of knowledge about the exact nature of tendinosis on a cellular level, although the reverse is also true. It is generally accepted that strength training decreases the symptoms in tendinosis. We suggested that the short-term analgesic effect of manipulation techniques may allow the patient to do more vigorous stretching and strengthening exercises and, therefore, allow better and faster recovery of the affected tendon in LE resulting in decreased pain and improved function on the midterm.

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