Journal of Physiotherapy 61 (2015) 174–181

ELSEVIER

Journal of PHYSIOTHERAPY

journal homepage: www.elsevier.com/locate/jphys

Invited Topical Review

Physiotherapy management of lateral epicondylalgia

Leanne M Bisset [a], Bill Vicenzino [b]

[a] Menzies Health Institute Queensland, Griffith University, Gold Coast; [b] University of Queensland, School of Health and Rehabilitation Sciences: Physiotherapy and the NHMRC Centre for Research Excellence in Spinal Pain, Injury and Health, Brisbane, Australia

KEY WORDS

Tennis elbow
Physiotherapy
Lateral elbow
Physical therapy

CrossMark

[Bisset LM, Vicenzino B (2015) Physiotherapy management of lateral epicondylalgia. *Journal of Physiotherapy* 61: 174–181]

Introduction

Lateral epicondylalgia (LE), more commonly known as tennis elbow, is the most common chronic musculoskeletal pain condition affecting the elbow, causing significant pain, disability and lost productivity. Despite decades of research investigating treatments and the underlying mechanisms of LE, it remains a challenging condition for physiotherapy clinicians and researchers alike. This topical review outlines the prevalence, burden and risk factors associated with LE. Diagnosis, assessment and the principles of management are also presented. The contemporary evidence for treatment efficacy and directions for future research are also discussed.

Prevalence of lateral epicondylalgia

Approximately 40% of people will experience LE at some point in their life.[1] It most commonly presents in men and women aged between 35 and 54 years.[2–4] The reported point prevalence of LE is between 1 and 3% within the general population,[5–7] and four to seven per 1000 patients visiting general medical practitioners.[3,6,8,9] Up to 50% of all tennis players also experience some type of elbow pain, with 75 to 80% of these elbow complaints attributable to LE.[1,10,11]

The burden of lateral epicondylalgia

LE most commonly affects the dominant arm, particularly when performing repetitive activity, so it is not surprising that the greatest burden of LE is among manual working populations where musculoskeletal upper limb injuries account for some of the longest work absences.[12] Up to 17% of workers within industries that involve highly repetitive hand tasks, such as meat processing and factory workers, experience LE.[13–16] This results in an absence from work of up to 219 workdays, with direct costs of US$8099 per person.[17,18] Data from Workcover Queensland indicates that upper limb (shoulder and elbow) injuries account for 18% of all work-related claims (2009 to 2013), which is equal to the prevalence of back injuries.[19]

Clinical course and risk factors for lateral epicondylalgia

In his seminal paper on tennis elbow in 1936, Dr James Cyriax proposed that the natural history of LE was between 6 months and 2 years,[20] which has since been widely cited. In contrast, recent reports have shown that symptoms may persist for many years and recurrence is common.[21–25] Over 50% of patients attending general practice for their elbow pain report not being recovered at 12 months.[21,26] Follow-up of participants in a clinical trial[23] of non-surgical treatments for LE identified that 20% of respondents (27/134) reported ongoing pain after 3 to 5 years (mean 3.9 years) regardless of the treatment received, and that those with high baseline severity were 5.5 times more likely to still have symptoms of LE. Therefore, LE is not self-limiting and is associated with ongoing pain and disability in a substantial proportion of sufferers.

Workers in manual occupations involving repetitive arm and wrist movements are at increased risk of LE[27,28] and are more resistant to treatment, with a poorer prognosis.[29,30] Office work, older age, being female,[31] previous tobacco use and concurrent rotator cuff pathology are also significantly associated with LE.[32]

One plausible reason for persistent pain in LE is the presence of sensitisation of the nervous system,[33,34] given the reduced thresholds to nociceptive withdrawal[35] and greater temporal summation.[36] It has previously been shown that people with LE exhibit widespread hyperalgesia (ie, enhanced pain response to various stimuli), which is associated with high pain scores, decreased function and longer symptom duration.[33,34,37,38]

Diagnosis and assessment

LE is a diagnosis based on clinical history and physical examination, with diagnostic imaging best used when a differential diagnosis is likely. LE is typically diagnosed by the presence of pain over the lateral humeral epicondyle that may radiate distally into the forearm. This pain is aggravated by palpation, gripping and resisted wrist and/or second or third finger extension.[2,39] While LE is thought to result from an overload of the forearm extensor muscles,[11] the pain may have an insidious onset with no specific causal activity.[21]

http://dx.doi.org/10.1016/j.jphys.2015.07.015

To assist prognosis, assessment of pain and disability should be performed at baseline, as there is some evidence to show that people who present with higher pain and disability are more likely to have ongoing pain at 12 months.[37,40] The Patient Rated Tennis Elbow Evaluation is a condition-specific questionnaire that includes both pain and function subscales, which are aggregated to give one overall score of 0 (no pain or disability) to 100 (worst possible pain and disability).[41,42] A minimum change of 11 points or 37% of the baseline score is considered to be clinically important.[43] The most common functional limitation in LE is pain on gripping, and this can be measured as pain-free grip strength, which is a reliable and valid measure that is more sensitive to change than maximal grip strength.[44] With the patient lying supine, the elbow in relaxed extension and the forearm pronated, the patient is asked to grip a dynamometer until the first onset of pain, and the mean of three tests at 1-minute intervals is then calculated.[45]

Elbow, wrist, and forearm range of motion, stress testing of the medial and lateral collateral elbow ligaments, and specific tests for elbow instability (eg, Posterolateral Rotary Drawer Test,[46] and Table Top Relocation Test[47]) should be assessed to aid the differential diagnosis of intra-articular and ligamentous pathology. The clinician needs to be aware that there may be co-pathologies and an overlap in symptoms, particularly in patients presenting with signs of central sensitisation, which may be sensory in nature, or associated with neuropathic lesions such as posterior interosseous nerve entrapment as it passes between the two heads of the supinator muscle. In patients with posterior interosseous nerve entrapment, they may report pain over the dorsal aspect of the forearm and exhibit muscle weakness of the finger and thumb extensors without sensory loss.[48,49]

Evaluation of the cervical and thoracic spine and neurodynamic testing of the radial nerve are also helpful in identifying spinal contribution to pain. While it is currently unclear as to what impact the presence of cervical and thoracic impairments have on the condition, exploratory research indicates that neck pain is more common in people with LE compared with their healthy counterparts.[50] Furthermore, people with LE who also report shoulder or neck pain have a poorer prognosis in both the short term and long term,[40] and impairment at C4 to C5 spinal levels has been identified on manual examination in people with localised symptoms of LE.[51] The role of cervical and thoracic spine impairments in the prognosis of LE requires validation; however, in light of these exploratory studies, the clinician should include cervical and thoracic spine assessment in their examination of the patient presenting with LE.

Imaging studies, such as ultrasound (US) and magnetic resonance imaging, have high sensitivity but lower specificity in detecting LE.[52–54] Structural abnormalities identified on imaging tend to be consistent across all tendinopathies, and include focal hypoechoic regions, tendon thickening, neovascularisation, disruption of fibrils and intrasubstance tears.[52–55] Importantly, structural changes on imaging are present in approximately 50% of healthy, asymptomatic age-matched and gender-matched individuals,[53,54] indicating that caution must be applied in interpreting the relevance of such findings. Notwithstanding this, negative image findings can be used to rule out LE as a diagnosis[52,53] and assist with alternative diagnoses such as instability and/or joint pathology.[54,56] A notable differential diagnosis is the presence of a large tear ($\geq$ 6 mm) within the tendon or lateral collateral ligament, which has been linked to failed conservative treatment.[57]

Management of lateral epicondylalgia

Physical interventions for LE have been widely investigated, with the publication of more than 200 clinical trials and several systematic reviews. Conservative management is recommended as the first line of treatment for LE.

In order to facilitate summary and interpretation of this volume of literature, the present review has focused on summarising the findings for conservative interventions that have been compared to a control, placebo or other interventions in randomised, controlled trials (RCTs) of sound methodological quality (defined for this review as a rating $\geq$ 5/10 on the PEDro scale). It has predominantly focused on physical therapies and has not comprehensively reviewed other medical interventions, including injection therapies (see Coombes et al[58] for further information).

A prevailing notion in tendinopathy management is to regard exercise and load management[59,60] as the key element, with all other physical modalities being adjuncts to speed the recuperation or to enhance the effects of exercise and outcomes. While acknowledging that a variety of outcomes and follow-up times are reported in the literature, this review has focused on short-term follow-up data, wherein the primary aim of adjunctive treatment is to speed up recovery. Outcomes of pain (converted to a 0 to 100 scale; 0 = no pain, 100 = worst pain imaginable) and global rating of success are presented in terms of point estimates of effect (eg, MD, RR), whereas other outcomes are qualitatively reported. A summary of the findings from English language papers (or reports therein of non-English original papers), along with the level of evidence that underpins their use, is provided. The interventions reported in this review include exercise, manual therapy/manipulation, orthoses, laser, US, acupuncture, shock wave therapy (SWT), and multimodal physiotherapy treatment – many of which have been compared to placebo or control.

Figure 1 is a graphic representation of the number of patients in RCTs that have investigated the effects of different interventions in LE, which interventions have demonstrated a superior effect compared to the comparator group, as well as where interventions have not yet been compared head-to-head.

Exercise

Exercise is rarely delivered as a treatment in isolation, with many RCTs studying a variety of exercise types in combination with other interventions. This review identified eight RCTs of sound methodological quality from five systematic reviews[61–65] that investigated the effects of isometric, isokinetic, concentric and eccentric exercises in LE. Three of the trials compared eccentric exercise to other treatments. Tyler et al (n = 21)[66] found a significant benefit of 9 (SD 2) sessions of eccentric exercise over 10 (SD 2) sessions of isotonic extensor exercises, with participants in both groups receiving a multimodal program of stretches, US, friction massage, heat and ice. The eccentric exercises produced greater pain relief and functional improvement, with nine of the 11 participants reporting at least 50% improvement in their pain following eccentric exercise, compared to three out of 10 reporting the same level of improvement in the comparator group. Viswas et al (n = 20)[67] also found that a supervised program of eccentric exercises improved pain and function more than friction massage with Mill's manipulation at short-term follow-up. Similarly, a program of eccentric exercises with an elbow orthosis may provide greater global improvement at the end of treatment (6 weeks RR 4.7, 95% CI 1.1 to 19.8) but no difference in pain relief compared with an elbow orthosis alone (n = 37).[68] In contrast, a 3-month home program of eccentric exercises produced variable results when compared with a program of concentric forearm exercises, with both exercise interventions demonstrating significant improvement over short-term and long-term follow-up.[69]

For exercise programs other than eccentric-only regimens, there was evidence from one RCT that isometric, concentric and eccentric exercises may be superior to US for pain relief (MD 21, 95% CI 1 to 41) and grip strength (MD 101 N, 95% CI 11 to 1914) at 8 weeks.[70] Compared to placebo US, Selvanetti et al (n = 62)[71] found a significant benefit after 4 weeks of eccentric exercises in combination with contract/relax stretching for pain relief at the end of treatment (MD, 95% CI 17 to 21). A 3-month home program of concentric/eccentric forearm exercises reportedly produced greater reductions in pain but not function, when compared with a wait-and-see approach.[72] However, one other study found no

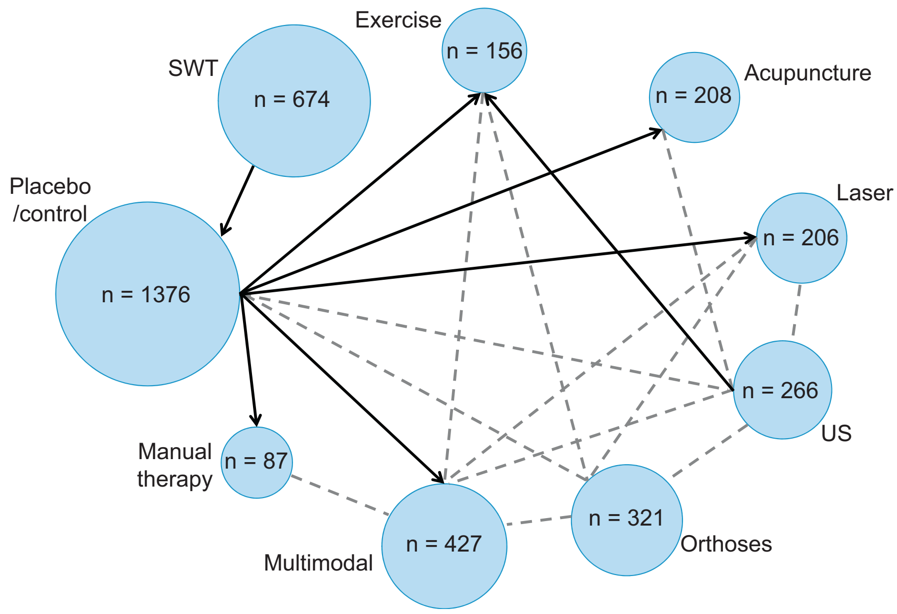

Figure 1. Network comparison of interventions for lateral epicondylalgia.
Note: The size of the circle represents the total number of participants (n) for each intervention, the solid line and direction of the arrow indicates the intervention with known superior effect over the comparator, and the dotted line represents head-to-head comparisons reported in the literature but with no clear benefit of one intervention over another.
SWT = shock wave therapy, US = ultrasound.

difference in pain and function outcomes at 6 weeks between concentric exercises, eccentric exercises and stretching (n = 81).[73]

In summary, despite conflicting findings, there was evidence from several RCTs of sound methodological quality that exercise may be more effective at reducing pain and improving function than other interventions such as US, placebo US, and friction massage, but there may be no difference in effect between different types of exercises.

Manual therapy and manipulation

Six RCTs,[74–79] reported within four systematic reviews,[61,62,64,80] investigated the effects of manual therapy techniques on a range of outcomes in people with LE, but importantly, most of these measured the immediate effects of a single treatment session or the short-term effects after several sessions of manual therapy. Three of the RCTs studied elbow treatments, two studied neck treatments and another treatment to the wrist. There was evidence from two within-subject lab-based studies (n = 48)[77,79] that Mulligan's Mobilisation-with-Movement at the elbow is superior to placebo in providing immediate improvement in pain-free grip (WMD 43 N, 95% CI 30 to 57) and pain on palpation measured as the pressure pain threshold (WMD 25 kPa, 95% CI 6 to 45).[62] A study of 23 participants in which six sessions of a craniosacral technique called 'oscillating-energy manual therapy' (the therapist delivers 'oscillating energy' to the affected elbow via movement of his/her fingertips) reported a significantly greater improvement in pain severity at the end of treatment (2 to 3 weeks in total), compared to placebo (MD 21, 95% CI 1 to 42).[76]

Two further studies of sound methodological quality investigated the effects of spinal manual therapy in the management of LE.[74,75] One small pilot trial (n = 10) investigated the effects of local elbow treatment (stretching, concentric/eccentric strengthening exercises, joint mobilisations to the elbow and wrist), alone and in combination with cervical and thoracic manual therapy techniques (Maitland mobilisations).[74] Extraction of data found a significant difference between groups for pain-free grip strength at the end of treatment (MD 15 kg, 95% CI 10 to 19) but no difference on pain or function outcomes. Another small study investigated the immediate effects of a single cervical spine manipulation versus placebo (manual contact) in a within-subjects study design of 10 people with LE.[75] There was a significant immediate improvement in pressure pain threshold of the affected arm (MD 77 kPa, 95% CI 37 to 116) following cervical manipulation compared with the placebo, but there was no difference between interventions for heat or cold pain threshold.[75]

In a separate trial, a maximum of nine treatments of manipulation/mobilisation of the wrist (posteroanterior glide of the scaphoid) provided superior improvement in pain during the day (MD 20, 95% CI 3 to 37) but not global assessment (RR 1.3, 95% CI 0.8 to 1.9) compared at 6 weeks with a multimodal program of US, friction massage and exercise.[78]

In summary, manual therapy techniques to the elbow, wrist and cervicothoracic spine may reduce pain and increase pain-free grip strength immediately following treatment, although in many instances, meta-analysis was not possible due to heterogeneity between manual therapy techniques and timing of follow-up assessment. There was insufficient evidence of any long-term clinical effects for manual therapy alone.

Orthotics and taping

Due to differences in the types of orthoses, comparator groups, timing of follow-up and outcome measures used, pooling of data was not possible for studies investigating the effects of orthoses in LE. The reported effects of an orthosis compared with placebo or control were contrasting between studies. Data from two RCTs suggested that a dynamic wrist extensor brace[a] or a forearm counterforce orthosis might provide significant improvement in pain and function at 4 to 12 weeks follow-up compared with no treatment or elbow taping (n = 63).[81,82] In contrast, both a standard counterforce orthosis[b] and a forearm-elbow orthosis[c] provided no immediate improvement in pain or grip strength compared with no treatment[83] or placebo.[84] Similarly, there appeared to be little or no added benefit of one orthosis over another in improving pain and function in the short term, when comparing a standard counterforce orthosis against a counterforce orthosis with the addition of a wrist splint[d], (n = 43)[85] or a forearm extension bar that limits supination.[86] Although this latter study found a statistically significant difference in the pain subscale of the Patient Rated Tennis Elbow Evaluation, the between-group difference was too small to be clinically relevant.[43]

Unpooled data from two RCTs revealed that compared with corticosteroid injection, an elbow orthosis might be as effective at relieving pain, improving function or influencing self-perceived improvement in the short term (2 to 6 weeks).[87,88] Compared with a multimodal program of friction massage plus US and exercise, an elbow orthosis[e] alone was inferior in relieving pain and overall satisfaction, but was superior in improving function (ability to perform daily activities) at 6 weeks. There was no difference in overall success between treatments at 6 weeks (RR 1.2, 95% CI 0.9 to 1.7),[89] but adding an elbow brace to the multimodal program did not provide additional pain relief or risk of a successful outcome at 6 weeks (RR 1.1, 95% CI 0.8 to 1.7).

In summary, there was conflicting evidence for the effectiveness of orthoses in providing pain relief or improvement in function compared with placebo or no treatment. Elbow orthoses may be as effective as corticosteroid injection in the short term; however, there was only one study to support this claim. There was no compelling evidence that any one orthosis is superior to another in the short term, or that adding an orthosis to another treatment provides any additional benefit.

Acupuncture/dry needling

Results from four studies indicated that acupuncture may be more effective than placebo in providing pain relief and improvement in function at the end of treatment,[90–93] but this effect was equivocal at 2 to 3 months of follow-up.[90,91] Acupuncture may provide superior pain relief and functional improvement compared with other interventions such as US, where results from two studies suggest that acupuncture was more effective at the end of treatment and at the 6-month follow-up.[94,95] One other study (n = 86) compared acupuncture plus corticosteroid injection with corticosteroid injection alone. Extracted data indicated a significant difference in success (RR 1.5, 95% CI 1.0 to 2.3) but not pain relief (MD 0, 95% CI –1 to 1) between treatments immediately after treatment.[96] While there appears to be conflicting evidence, acupuncture might be more effective than placebo and more effective than US at relieving pain and improving self-assessed treatment benefit in the short term.

Laser

In one systematic review,[97] a subgroup of five trials that used 904 nm lasers and doses from 0.5 to 7.2 Joules, reported significantly improved pain relief (MD 17, 95% CI 9 to 26) and likelihood of global improvement (RR 1.5, 95% CI 1.3 to 1.8) for laser compared with placebo. The present review found an additional three RCTs that used a 904 nm laser, all of which found no benefit from laser compared with the comparator groups in the short term, perhaps because the comparison groups received active interventions such as exercise.[98,99] Two recent RCTs not included in the earlier systematic review[97] studied dual wavelength 980/810 nm (versus placebo)[100] or 820 nm (versus US)[101] and reported no differences. The lack of benefit from laser might be due to an inappropriate selection of wavelength or, in one study, a type II error (n = 16).[100,101]

In summary, 904 nm laser might be beneficial in the short term compared with placebo, but there is likely no difference between laser and other active interventions in the short term or long term. Laser wavelengths other than 904 nm do not appear to have any benefit over that of a placebo.

Ultrasound and phonophoresis

Pooled data from four RCTs (n = 266)[102–105] found no difference in the likelihood of global improvement in the short term (up to 12 weeks) between US and placebo (RR 1.3, 95% CI 0.9 to 1.9). There was low-level evidence from three RCTs that US is no different to phonophoresis alone,[106,107] combined with an elbow orthosis,[106] acupuncture,[94] or friction massage in relieving pain.[107] The conclusions drawn from previous systematic reviews[61,62] remain unchanged: US appears to be no more effective than placebo for pain relief or self-perceived global improvement in the short term.[61,62]

Shock wave therapy

Based on the results of nine placebo-controlled trials (1006 participants), a 2005 Cochrane review concluded the SWT provides little or no benefit in reducing pain or improving function in LE.[108] There is clinical controversy as to which method of application for SWT is most efficacious (eg, radial or extracorporeal, with or without local anaesthetic), but no studies could be found that have validated one technique over another. The present review found an additional five RCTs comparing SWT with placebo,[109,110] US with hot pack and friction massage,[111] corticosteroid injection,[111,112] and surgery.[113] One study reported significant differences in favour of SWT over a placebo for pain and function measures after treatment and at a 6-month follow-up, but that data were not included in pooled analyses due to a lack of clarity in the statistics reported therein.[109] Gunduz et al found no difference in pain relief or function between SWT, US with friction massage and corticosteroid injection at any time point.[111] Shock wave therapy appeared to be no different to corticosteroid injection or autologous blood injections in improving pain or function at 12 weeks[112] and no better than surgical percutaneous tenotomy in providing pain relief or functional improvement.[113] Pooled data from the Cochrane review plus one additional study[110] found that compared with placebo, SWT induced no greater pain relief (MD – 8, 95% CI –17 to 3) at 6 weeks. Similarly, the pooled mean difference for pain on resisted wrist extension (Thomsen test) at 4 to 6 weeks follow-up was not significantly different between SWT and placebo (MD –15, 95% CI –36 to 6).

In summary, pooling data from a previous review and new data supports the conclusion that SWT is no more effective than placebo or other treatments for relieving pain in LE.

Multimodal programs

Several studies have combined a range of physical modalities in the rehabilitation program. A commonly reported multimodal program involving friction massage in various combinations with Mill's manipulation, US, and stretches has been compared with exercise,[66,67,114] laser,[115] wrist manipulation,[78] manual therapy,[116] elbow brace,[89] wait-and-see,[117] and corticosteroid injection.[117,118] While the heterogeneity between comparator groups limits pooling, in almost all studies, this approach was either inferior or no different to the comparison. One study (n = 60) did show superior pain relief and functional improvement after 4 weeks of a Cyriax program (friction massage plus Mill's manipulation) compared with phonophoresis plus supervised exercise.[114] A second study (n = 125) found equivocal results between a program of friction massage, US and exercise compared with an elbow orthosis[f] at a 6-week follow-up, with the multimodal treatment delivering superior pain relief and functional improvement, but the brace treatment favoured ability of daily activities and less inconvenience, with no difference between groups for measures of success (RR 1.2, 95% CI 0.9 to 1.7), severity of complaints, pain-free grip strength, maximum grip strength and pressure pain threshold.[89] Despite the diversity of comparisons and outcomes, it seems that on balance, the majority of the evidence does not support the use of friction massage in combination with other treatments in the management of LE.

Two large RCTs compared a multimodal program of Mulligan's Mobilisation-with-Movement and exercise (one with placebo injection) with wait-and-see (or placebo injection) and corticosteroid injection.[22,23] Pooled data (n = 205) revealed that physiotherapy was superior to wait-and-see in providing a successful outcome in the short term (6 to 8 weeks, RR 2.3, 95% CI 1.6 to 3.3). At 52 weeks there was a significant, but very small, benefit of physiotherapy over wait-and-see in terms of the number of participants deeming their treatment a success (pooled data RR

1.1, 95% CI 1.0 to 1.1). Physiotherapy was similar to corticosteroid injection in providing a successful outcome in the short term (pooled data RR 0.9, 95% CI 0.7 to 1.1), but was superior to corticosteroid injection at 52 weeks follow-up (RR 1.3, 95% CI 1.1 to 1.5).[22,23]

In summary, a multimodal program of Mobilisation-with-Movement and exercise is likely superior to wait-and-see and placebo injection in the short term, and superior to corticosteroid injection in the long term. Multimodal treatment involving friction massage may be no different or worse than other treatments in providing pain relief.

Evidence-informed clinical reasoning

While many treatments for LE have been researched, many have small effects that occur in the short term (eg, 6 to 12 weeks) and few have shown consistent effectiveness over other treatments. Figure 1 highlights the lack of between-intervention superiority, with significant treatment effects largely seen only when an intervention is compared with placebo or control (no treatment). It is also apparent from Figure 1 that several treatments have not yet been compared head-to-head. Notwithstanding these limitations, the current evidence suggests that exercise may be beneficial in the short term compared with other interventions such as US, friction massage, and stretches for reducing pain and improving function. The issue with exercise for the clinician is that there is insufficient evidence to support any one type of exercise over another, and the optimal dose of exercise for LE has yet to be established. Elbow orthoses may also be useful in providing pain relief and improvement in function compared with placebo or doing nothing; however, as with exercise, the type of orthosis appears to be less critical. Manual therapy techniques to the elbow, wrist and cervicothoracic spine may be helpful in providing immediate pain relief and improvement in function in people with LE. A multimodal program of Mulligan's Mobilisation-with-Movement and exercise may be superior to wait-and-see and placebo injection in the short term, and superior to corticosteroid injection in the long term. In contrast, multimodal treatment involving friction massage may be no different or worse than other treatments in providing pain relief. For electrophysical agents, laser using 904 nm wavelengths may be beneficial in the short term compared to placebo; however, there is likely no difference between laser and other active interventions in the short or long term. Laser wavelengths other than 904 nm do not appear to have any benefit over that of a placebo. Ultrasound appears to be no more effective than placebo in the short term; however, acupuncture may be more effective than US and/or placebo in the short term. Lastly, despite the addition of new RCTs, the conclusions drawn from a previous Cochrane review remain unchanged for SWT, which appears to be no more effective than placebo for relieving pain in LE.

It is proposed that when consulting a patient with LE, there might be merit in considering treatment recommendations on the basis of presenting patient characteristics that are known to be associated with the risk of a good or poor prognosis (Figure 2). It is recommended that patients with features indicating a good prognosis (eg, pain duration of < 3 months, no concomitant neck or other arm pain, Patient-Rated Tennis Elbow Evaluation (PRTEE) $< 54/100$) be counselled on their condition, load management including tools and work station, self-management and that adopting a wait-and-see approach is likely to be of benefit within 12 weeks. This approach is likely of merit for those patients who are unwilling to perform exercises or visit the physiotherapist for a number of sessions of Mobilisation-with-Movement with exercise. In contrast, if the patient would prefer to speed up the process, then exercise and Mobilisation-with-Movement would be undertaken because there is evidence of its benefit.

If a patient presents with features that are known to be associated with poorer outcomes (eg, concomitant neck and arm

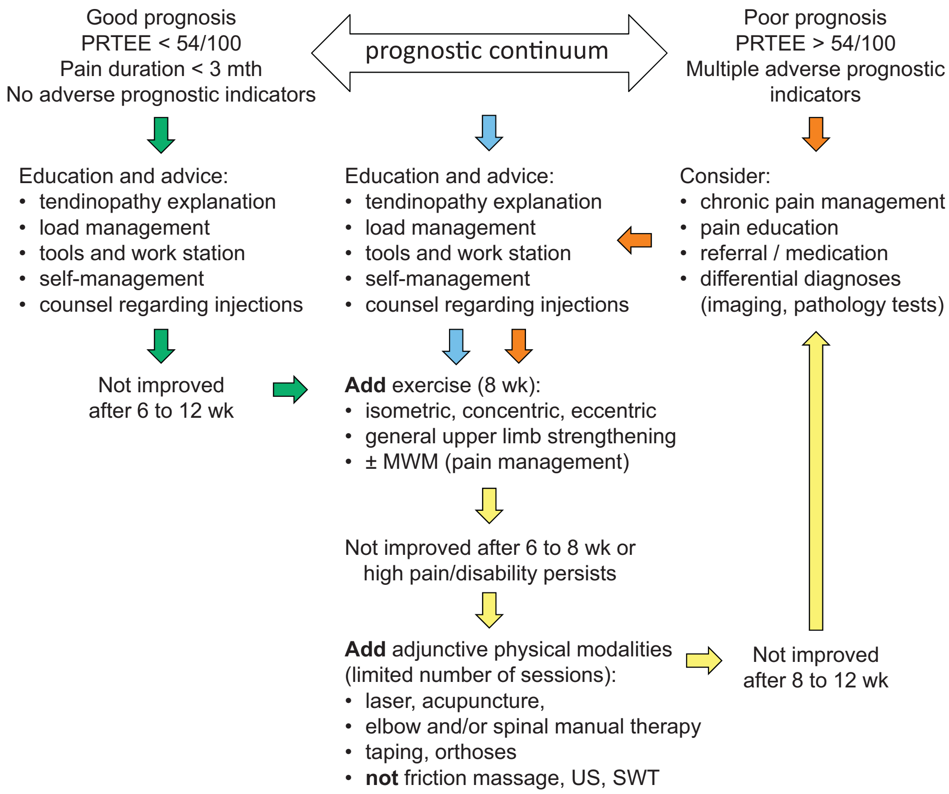

Figure 2. Evidence-based clinical pathway for the physiotherapy management of lateral epicondylalgia (assuming accurate clinical diagnosis at outset). The green arrows represent the clinical pathway for patients with characteristics indicative of a good prognosis; the orange arrows represent the clinical pathway for patients with characteristics highly indicative of a poor prognosis; the blue arrows represent the initial clinical pathway for patients that fall within the prognostic continuum (ie, exhibit one or more poor prognostic indicators); the yellow arrows represent the additional treatment options for patients at risk of a poor prognosis who fail to respond to evidence-based treatment with education, advice, exercise therapy and Mobilisation-with-Movement manual therapy techniques.
MWM = Mobilisation-with-Movement, PRTEE = Patient-Rated Tennis Elbow Evaluation, SWT = shock wave therapy, US = ultrasound.

pain, highly repetitive manual work, higher levels of pain and disability such as a PRTEE > 54/100, cold hyperalgesia with cold pain thresholds above 13 °C) then a more involved process ought to be considered. The approach should be more in line with management of persistent or chronic pain, possibly involving pain education, referral for medication and – in severe protracted cases – the involvement of pain clinic specialists, in addition to the education and advice that all patients with LE should receive. In addition, there should be a confirmation of the diagnosis/differential diagnosis through use of diagnostic imaging. It is important to understand that patients are likely to present along a continuum of prognostic features, which requires the clinician to use clinical reasoning skills to navigate the management approach in consultation with the patient. For example, a patient that appeared to have a good prognosis at the initial consultation but is no better at 6 to 12 weeks could be encouraged to undertake exercise and Mobilisation-with-Movement. If the condition does not improve with a graduated progressive exercise program, other passive pain relieving techniques might be introduced to speed up the resolution (eg, Mobilisation-with-Movement (if not already trialled), laser, acupuncture, spinal manipulation, orthoses). When introducing passive interventions it is important not to engender a patient's reliance on these interventions, as most of them have only small effects of short-term duration and they do not facilitate self-management by the patient. A patient's failure to respond when incorporating passive techniques and exercises over 8 to 12 weeks should be regarded by the clinician as an indication to escalate the management program to one like that for the patient presenting with features associated with a poor prognosis (Figure 2).[5,37,40,51]

Future directions for research and practice

A significant gap in the current literature, and an area of growing interest, is the effect of potentially confounding variables on treatment outcomes. Certain clinical characteristics and/or underlying pathophysiological characteristics may modify treatment effects. For example, one study has found that the presence of a tear in the lateral collateral ligament and the size of an intrasubstance tendon tear detected by US were each significantly associated with poorer prognosis in patients with LE, and indicated greater likelihood of failing conservative management, including an eccentric exercise program.[57] While certain characteristics are known prognostic factors for long-term pain and disability, the question remains: what is the optimal treatment for individuals who exhibit one or more of these characteristics? Prognostic factors that have been identified through retrospective data analysis obtained from clinical trials require confirmation of their role in modifying treatment effects through prospective evaluation. If clinical outcomes for LE are to be improved, it is important to understand how these prognostic factors modify treatment effects.

The role of exercise in managing LE across the severity spectrum should be clarified, including optimal dosage and type of exercise for people with mild, moderate or severe symptoms of LE. Given that exercise is considered to be the cornerstone of rehabilitation, it is understudied compared with other interventions. There is a need for further well-controlled RCTs investigating the effects of exercise and the role that supervision of exercise has to play in terms of patient compliance. Recent work on patellar tendinopathy has highlighted the effectiveness of isometric exercises compared with isotonic exercises in producing pain relief in the short term,[60] which corresponded to normalising cortical inhibition.[119] While exercise is generally considered to have an analgesic effect and prevent the development of chronic pain, exercise-induced analgesia is impaired in some musculoskeletal conditions that exhibit central sensitisation, and in some cases, may even increase pain.[120] The effectiveness of alternative exercise regimens such as isometric exercise in people with LE is worthy of investigation, as are other treatments that specifically target central sensitisation.

LE is a challenging tendinopathic condition with a complex underlying aetiology. There is a growing body of evidence that provides some clarity as to what we should and should not be considering in our management of the patient with LE. With contemporary knowledge of pain processes as well as local tendon changes, physiotherapists who use a clinical-reasoning-based approach to managing musculoskeletal conditions are well placed to manage patients with LE, as conservative treatment remains the best practice approach for this population.

Footnotes: www.pedro.org.au. [a] Carp-X, The Netherlands. [b] Thermoskin, Australia or Count'R-Force Tennis elbow brace, Arlington, USA. [c] Go-strap, Australia. [d] Thämert orthoflex brace, Netherlands. [e] Epipoint, Zeulenroda, Germany. [f] Epipoint, Bauerfeind, Germany.

Ethics approval: Not applicable.

Competing interests: Nil.

Source(s) of support: Nil.

Acknowledgements: Aoife Stephenson for conducting the database searches, Prue Tilley for assistance with data extraction and Brooke Coombes for collaborating on the concepts of clinical pathways.

Provenance: Commissioned. Not peer-reviewed.

Correspondence: Bill Vicenzino, University of Queensland, School of Health and Rehabilitation Sciences: Physiotherapy and the NHMRC Centre for Research Excellence Spinal Pain, Injury and Health, Brisbane, Australia. Email: b.vicenzino@uq.edu.au

References

1. Gruchow HW, Pelletier D. An epidemiologic study of tennis elbow. Incidence, recurrence, and effectiveness of prevention strategies. *Am J Sports Med.* 1979;7:234–238.
2. Haker E. Lateral epicondylalgia: Diagnosis, treatment and evaluation. *Crit Rev Phys Rehabil Med.* 1993;5:129–154.
3. Hamilton PG. The prevalence of humeral epicondylitis: a survey in general practice. *J R Coll Gen Pract.* 1986;36:464–465.
4. Roquelaure Y, Ha C, Leclerc A, Touranchet A, Sauteron M, Melchior M, et al. Epidemiologic surveillance of upper-extremity musculoskeletal disorders in the working population. *Arthritis Rheum.* 2006;55:765–778.
5. Shiri R, Viikari-Juntura E, Varonen H, Heliovaara M. Prevalence and determinants of lateral and medial epicondylitis: a population study. *Am J Epidemiol.* 2006;164:1065–1074.
6. Verhaar JAN, Tennis elbow - Anatomical, epidemiologic and therapeutic aspects. *Int Orthop.* 1994;18:263–267.
7. Walker-Bone K, Palmer K, Reading I. Occupation and epicondylitis: a population-based study. *Rheumatol.* 2012;51:305–310.
8. Allander E, Prevalence. incidence and remission rates of some common rheumatic diseases or syndromes. *Scand J Rheumatol.* 1974;3:145–153.
9. Bot SDM, van der Waal JM, Terwee CB, van der Windt DAWM, Schellevis FG, Bouter LM, et al. Incidence and prevalence of complaints of the neck and upper extremity in general practice. *Ann Rheum Dis.* 2005;64:118–123.
10. Kelley J, Lombardo S, Pink M, Perry J, Giangarra C. Electromyographic and cinematographic analysis of elbow function in tennis players with lateral epicondylitis. *Am J Sports Med.* 1994;22:359–363.
11. Nirschl R, Tennis. Elbow. *Orthop Clin North Am.* 1973;4:787–800.
12. National Research Council and Institute of Medicine. *Musculoskeletal disorders and the workplace: Low back and upper extremities.* Washington DC: USA; 2001.
13. Chiang HC, Ko YC, Chen SS, Yu HS, Wu TN, Chang PY. Prevalence of shoulder and upper limb disorders among workers in the fish-processing industry. *Scand J Work Environ Health.* 1993;19:126–131.
14. Devereux J, Vlachonikolis I, Buckle P. Epidemiological study to investigate potential interaction between physical and psychosocial factors at work that may increase the risk of symptoms of musculoskeletal disorder of the neck and upper limb. *Occup Environ Med.* 2002;59:269–277.
15. Gold J, d'Errico A, Katz J, Gore R, Punnett L. Specific and non-specific upper extremity musculoskeletal disorder syndromes in automobile manufacturing workers. *Am J Ind Med.* 2009;52:124–132.
16. Kurppa K, Viikari Juntura E, Kuosma E, Huuskonen M, Kivi P. Incidence of tenosynovitis or peritendinitis and epicondylitis in a meat-processing factory. *Scand J Work Environ Health.* 1991;17:32–37.
17. Silverstein B, Viikari Juntura E, Kalat J. Use of a prevention index to identify industries at high risk for work-related musculoskeletal disorders of the neck, back, and upper extremity in Washington State, 1990-1998. *Am J Ind Med.* 2002;41:149–169.
18. Verhaar J. *Tennis Elbow (thesis).* Maastricht: Maastricht University Press; 1992.
19. Workcover Queensland. *Workcover Queensland annual report 2012-2013.* Brisbane Qld, Australia; 2013.
20. Cyriax J. The pathology and treatment of tennis elbow. *J Bone Joint Surg.* 1936;18:921–940.
21. Binder A, Hazleman B. Lateral humeral epicondylitis - a study of natural history and the effect of conservative therapy. *Br J Rheumatol.* 1983;22:73–76.
22. Bisset L, Beller E, Jull G, Brooks P, Darnell R, Vicenzino B. Mobilisation with movement and exercise, corticosteroid injection, or wait and see for tennis elbow: randomised trial. *Br Med J.* 2006;333:939–941.

23. Coombes BK, Bisset L, Brooks P, Khan A, Vicenzino B. Effect of corticosteroid injection, physiotherapy, or both on clinical outcomes in patients with unilateral lateral epicondylalgia: A randomized controlled trial. *JAMA.* 2013;309:461–469.
24. Hudak PL, Cole DC, Haines AT. Understanding prognosis to improve rehabilitation: the example of lateral elbow pain. *Arch Phys Med Rehabil.* 1996;77:586–593.
25. Murtagh J. Tennis elbow. *Aust Fam Physician.* 1988;17:9091, 94–95.
26. Bot SD, van der Waal JM, Terwee CB, van der Windt DAWM, Bouter LM, Dekker J. Course and prognosis of elbow complaints: a cohort study in general practice. *Ann Rheum Dis.* 2005;64:1331–1336.
27. Bernard BP. *Musculoskeletal disorders and workplace fractures: A critical review of the epidemiological evidence for work-related musculoskeletal disorders of the neck, upper extremity and low back. NIOSH Publication 97–141.* Washington D.C: National Institute for Occupational Safety and Health; 1997.
28. Herquelot E, Bodin J, Roquelaure Y, Ha C, Leclerc A, Goldberg M, et al. Work-related risk factors for lateral epicondylitis and other cause of elbow pain in the working population. *Am J Ind Med.* 2013;56:400–409.
29. Coonrad R, Hooper W. Tennis elbow: its course, natural history, conservative and surgical management. *J Bone Joint Surg Am.* 1973;55:1177–1182.
30. Haahr JP, Andersen JH. Prognostic factors in lateral epicondylitis: a randomized trial with one-year follow-up in 266 new cases treated with minimal occupational intervention or the usual approach in general practice. *Rheumatol.* 2003;42:1216–1225.
31. Bugajska J, Zolnierczyk-Zreda D, Jedryka-Goral A, Gasik R, Hildt-Ciupinska K, Malinska M, et al. Psychological factors at work and musculoskeletal disorders: a one year prospective study. *Rheumatol Int.* 2013;33:2975–2983.
32. Titchener AG, Fakis A, Tambe AA, Smith C, Hubbard RB, Clark DI. Risk factors in lateral epicondylitis (tennis elbow): a case-control study. *J Hand Surg Eur Vol.* 2013;38:159–164.
33. Coombes B, Bisset L, Vicenzino B. Thermal hyperalgesia distinguishes those with severe pain and disability in unilateral lateral epicondylalgia. *Clin J Pain.* 2012;28:595–601.
34. Fernandez-Carnero J, Fernandez-de-las-Penas C, Sterling M, Souvlis T, Arendt-Nielsen L, Vicenzino B. Exploration of the extent of somato-sensory impairment in patients with unilateral lateral epicondylalgia. *J Pain.* 2009;10:1179–1185.
35. Lim ECW, Sterling M, Pedler A, Coombes BK, Vicenzino B. Evidence of spinal cord hyperexcitability as measured with nociceptive flexion reflex (NFR) threshold in chronic lateral epicondylalgia with or without a positive neurodynamic test. *J Pain.* 2012;13:676–684.
36. Jespersen A, Amris K, Graven-Nielsen T, Arendt-Nielsen L, Bartels EM, Torp-Pedersen S, et al. Assessment of pressure-pain thresholds and central sensitization of pain in lateral epicondylalgia. *Pain Med.* 2013;14:297–304.
37. Coombes B, Bisset L, Vicenzino B. Cold hyperalgesia associated with poorer prognosis in lateral epicondylalgia: a 1-year prognostic study of physical and psychological factors. *Clin J Pain.* 2015;31:30–35.
38. Sterling M, Hendrikz J, Kenardy J, Kristjansson E, Dumas P, Niere K, et al. Assessment and validation of prognostic models for poor functional recovery 12 months after whiplash injury: a multicentre inception cohort study. *Pain.* 2012;153:1727–1734.
39. Palmer K, Coggon D, Cooper C, Doherty M. Work related upper limb disorders: getting down to specifics. *Ann Rheum Dis.* 1998;57:445–446.
40. Smidt N, Lewis M, van Der Windt D, Hay E, Bouter L, Croft P. Lateral epicondylitis in general practice: course and prognostic indicators of outcome. *J Rheumatol.* 2006;33:2053–2059.
41. Newcomer KL, Martinez-Silvestrini JA, Schaefer MP, Gay RE, Arendt KW. Sensitivity of the Patient-Rated Forearm Evaluation Questionnaire in lateral epicondylitis. *J Hand Ther.* 2005;18:400–406.
42. Rompe JD, Overend TJ, MacDermid JC. Validation of the patient-rated tennis elbow evaluation questionnaire. *J Hand Ther.* 2007;20:3–10.
43. Poltawski L, Watson T. Measuring clinically important change with the Patient-Rated Tennis Elbow Evaluation. *Hand Ther.* 2011;16:52–57.
44. Stratford PW, Levy DR. Assessing valid change over time in patients with lateral epicondylitis at the elbow. *Clin J Sports Med.* 1994;4:88–91.
45. Lim EC. Pain free grip strength test. *J Physiother.* 2013;59:59.
46. O'Driscoll SW. Classification and evaluation of recurrent instability of the elbow. *Clin Orthop.* 2000;370:34–43.
47. Arvind CH, Hargreaves DG. Table top relocation test - New clinical test for posterolateral rotatory instability of the elbow. *J Shoulder Elbow Surg.* 2006;15:500–501.
48. Kotnis NA, Chiavaras MM, Harish S. Lateral epicondylitis and beyond: imaging of lateral elbow pain with clinical-radiologic correlation. *Skeletal Radiol.* 2012;41:369–386.
49. Tennent T, Woodgate A. Posterior interosseous nerve dysfunction in the radial tunnel. *Curr Orthop.* 2008;22:226–232.
50. Berglund KM, Persson BH, Denison E. Prevalence of pain and dysfunction in the cervical and thoracic spine in persons with and without lateral elbow pain. *Man Ther.* 2008;13:295–299.
51. Coombes BK, Bisset L, Vicenzino B. Bilateral cervical dysfunction in patients with unilateral lateral epicondylalgia without concomitant cervical or upper limb symptoms: a cross-sectional case-control study. *J Manip Physiol Ther.* 2014;37:79–86.
52. du Toit C, Stieler M, Saunders R, Bisset L, Vicenzino B. Diagnostic accuracy of power-doppler ultrasound in patients with chronic tennis elbow. *Br J Sports Med.* 2008;42:872–876.
53. Heales LJ, Broadhurst N, Mellor R, Hodges PW, Vicenzino B. Diagnostic ultrasound imaging for lateral epicondylalgia: A case control study. *Med Sci Sports Exerc.* 2014;46:2070–2076.
54. Pasternack I, Tuovinen EM, Lohman M, Vehmas T, Malmivaara A. MR findings in humeral epicondylitis. A systematic review. *Acta Radiol.* 2001;42:434–440.
55. Toprak U, Baskan B, Ustuner E, Oztuna D. Common extensor tendon thickness measurements at the radiocapitellar region in diagnosis of lateral elbow tendinopathy. *Diagn Interv Radiol.* 2012;18:566–570.
56. Kalainov DM, Cohen MS. Posterolateral rotatory instability of the elbow in association with lateral epicondylitis. A report of three cases. *J Bone Joint Surg Am.* 2005;87:1120–1125.
57. Clarke AW, Ahmad M, Curtis M, Connell DA. Lateral elbow tendinopathy: correlation of ultrasound findings with pain and functional disability. *Am J Sports Med.* 2010;38:1209–1214.
58. Coombes BK, Bisset L, Vicenzino B. Efficacy and safety of corticosteroid injections and other injections for management of tendinopathy: a systematic review of randomised controlled trials. *Lancet.* 2010;376:1751–1767.
59. Khan K, Scott A. Mechanotherapy: how physical therapists' prescription of exercise promotes tissue repair. *Br J Sports Med.* 2009;43:247–252.
60. Rudavsky A, Cook J. Physiotherapy management of patellar tendinopathy (jumper's knee). *J Physiother.* 2014;60:122–129.
61. Bisset L, Coombes B, Vicenzino B. Tennis elbow. *BMJ Clin Evid.* 2011;06:1117.
62. Bisset L, Paungmali A, Vicenzino B, Beller E. A systematic review and meta-analysis of clinical trials on physical interventions for lateral epicondylalgia. *Br J Sports Med.* 2005;39:411–422.
63. Cullinane FL, Boocock MG, Trevelyan FC. Is eccentric exercise an effective treatment for lateral epicondylitis? A systematic review. *Clin Rehabil.* 2014;28:3–19.
64. Hoogvliet P, Randsdorp MS, Dingemanse R, Koes BW, Huisstede BM. Does effectiveness of exercise therapy and mobilisation techniques offer guidance for the treatment of lateral and medial epicondylitis? A systematic review. *Br J Sports Med.* 2013;47:1112–1119.
65. Woodley BL, Newsham-West RJ, Baxter GD. Chronic tendinopathy: effectiveness of eccentric exercise. *Br J Sports Med.* 2007;41:188–199.
66. Tyler TF, Thomas GC, Nicholas SJ, McHugh MP. Addition of isolated wrist extensor eccentric exercise to standard treatment for chronic lateral epicondylosis: a prospective randomized trial. *J Shoulder Elbow Surg Am.* 2010;19:917–922.
67. Viswas R, Ramachandran R, Korde Anantkumar P. Comparison of effectiveness of supervised exercise program and Cyriax physiotherapy in patients with tennis elbow (lateral epicondylitis): a randomized clinical trial. *Sci World J.* 2012;2012:939645.
68. Soderberg J, Grooten WJ, Ang BO. Effects of eccentric training on hand strength in subjects with lateral epicondylalgia: a randomized-controlled trial. *Scand J Med Sci Sports.* 2012;22:797–803.
69. Peterson M, Butler S, Eriksson M, Svardsudd K. A randomized controlled trial of eccentric vs. concentric graded exercise in chronic tennis elbow (lateral elbow tendinopathy). *Clin Rehabil.* 2014;28:682–872.
70. Pienimaki TT, Tarvainen TK, Siira PT, Vanharanta H. Progressive strengthening and stretching exercises and ultrasound for chronic lateral epicondylitis. *Physiother.* 1996;82:522–530.
71. Selvanetti A, Barrucci A, Antonaci A, Martinez P, Marra S, Necozione S. Role of the eccentric exercise in the functional reeducation of lateral epicondylitis: A randomised controlled clinical trial. *Medicina dello Sport.* 2003;56:103–113.
72. Peterson M, Butler S, Eriksson M, Svardsudd K. A randomized controlled trial of exercise versus wait-list in chronic tennis elbow (lateral epicondylosis). *Ups J Med Sci.* 2011;116:269–279.
73. Martinez-Silvestrini JA, Newcomer KL, Gay RE, Schaefer MP, Kortebein P, Arendt KW. Chronic lateral epicondylitis: comparative effectiveness of a home exercise program including stretching alone versus stretching supplemented with eccentric or concentric strengthening. *J Hand Ther.* 2005;18:411–419.
74. Cleland JA, Flynn TW, Palmer JA. Incorporation of manual therapy directed at the cervicothoracic spine in patients with lateral epicondylalgia: A pilot clinical trial. *J Man Manip Ther.* 2005;13:143–151.
75. Fernandez-Carnero J, Fernandez-de-las-Penas C, Cleland JA. Immediate hypoalgesic and motor effects after a single cervical spine manipulation in subjects with lateral epicondylalgia. *J Manip Physiol Ther.* 2008;31:675–681.
76. Nourbakhsh MR, Fearon FJ. The effect of oscillating-energy manual therapy on lateral epicondylitis: a randomized, placebo-control, double-blinded study. *J Hand Ther.* 2008;21:4–13.
77. Paungmali A, O'Leary S, Souvlis T, Vicenzino B. Hypoalgesic and sympathoexcitatory effects of mobilization with movement for lateral epicondylalgia. *Phys Ther.* 2003;83:374–383.
78. Struijs PA, Damen PJ, Bakker EW, Blankevoort L, Assendelft WJ, van Dijk CN. Manipulation of the wrist for management of lateral epicondylitis: a randomized pilot study. *Phys Ther.* 2003;83:608–616.
79. Vicenzino B, Paungmali A, Buratowski S, Wright A. Specific manipulative therapy treatment for chronic lateral epicondylalgia produces uniquely characteristic hypoalgesia. *Man Ther.* 2001;6:205–212.
80. Herd CR, Meserve BB. A systematic review of the effectiveness of manipulative therapy in treating lateral epicondylalgia. *J Man Manip Ther.* 2008;16:225–237.
81. Faes M, van den Akker B, de Lint JA, Kooloos JGM, Hopman MTE. Dynamic extensor brace for lateral epicondylitis. *Clin Orthop.* 2006;442:149–157.
82. Kachanathu SJ, Miglani S, Grover D, Zakaria AR. Forearm band versus elbow taping: as a management of lateral epicondylitis. *J Musculoskel Res.* 2013;16:1350003.
83. Bisset LM, Collins NJ, Offord SS. Immediate effects of 2 types of braces on pain and grip strength in people with lateral epicondylalgia: a randomized controlled trial. *J Orthop Sport Phys Ther.* 2014;44:120–128.
84. Wuori JL, Overend TJ, Kramer JF, MacDermid J. Strength and pain measures associated with lateral epicondylitis bracing. *Arch Phys Med Rehabil.* 1998;79:832–837.
85. Van De Streek MD, Van Der Schans CP, De Greef MH, Postema K. The effect of a forearm/hand splint compared with an elbow band as a treatment for lateral epicondylitis. *Prosthet Orthot Int.* 2004;28:183–189.
86. Forogh B, Khalighi M, Javanshir MA, Ghoseiri K, Kamali M, Raissi G. The effects of a new designed forearm orthosis in treatment of lateral epicondylitis. *Disabil Rehabil Assist Technol.* 2012;7:336–339.
87. Haker E, Lundeberg T. Elbow-band, splintage and steroids in lateral epicondylalgia (tennis elbow). *Pain Clin.* 1993;6:103–112.
88. Jensen B, Bliddal H, Danneskiold-Samsoe B. Comparison of two different treatments of lateral humeral epicondylitis - "tennis elbow". A randomized controlled trial. *Ugeskr Laeger.* 2001;163:1427–1431.

89. Struijs PA, Kerkhoffs GM, Assendelft WJ, Van Dijk CN. Conservative treatment of lateral epicondylitis: brace versus physical therapy or a combination of both - a randomized clinical trial. *Am J Sports Med.* 2004;32:462–469.
90. Fink M, Wolkenstein E, Karst M, Gehrke A. Acupuncture in chronic epicondylitis: a randomized controlled trial. *Rheumatol.* 2002;41:205–209.
91. Haker E, Lundeberg T. Acupuncture treatment in epicondylalgia: a comparative study of two acupuncture techniques. *Clin J Pain.* 1990;6:221–226.
92. Irnich D, Karg H, Behrens N, Lang PM, Schreiber MA, Krauss M, et al. Controlled trial on point specificity of acupuncture in the treatment of lateral epicondylitis (Tennis elbow). *Phys Med Rehab Kuror.* 2003;13:215–219.
93. Molsberger A, Hille E. The analgesic effect of acupuncture in chronic tennis elbow pain. *Br J Rheumatol.* 1994;33:1162–1165.
94. Davidson JH, Vandervoort A, Lessard L, Miller L. The effect of acupuncture versus ultrasound on pain level, grip strength and disability in individuals with lateral epicondylitis: a pilot study. *Physiother Can.* 2001;53:195–202211.
95. Grua D, Mattioda A, Quirico PE, Lupi G, Allais G. Acupuncture in the treatment of lateral epicondilitis: evaluation of the effectiveness and comparison with ultrasound therapy. *Giornale Italiano di Riflessoterapia ed Agopuntura.* 1999;11:63–69.
96. Li X, Zhou K, Zhang E, Sun W, Xu L, Cai Y, et al. Therapeutic effect of electroacupuncture, massage, and blocking therapy on external humeral epicondylitis. *J Tradit Chin Med.* 2014;34:261–266.
97. Bjordal JM, Lopes-Martins RA, Joensen J, Couppe C, Ljunggren AE, Stergioulas A, et al. A systematic review with procedural assessments and meta-analysis of low level laser therapy in lateral elbow tendinopathy (tennis elbow). *BMC Musculoskel Dis.* 2008;9:75.
98. Emanet SK, Altan LI, Yurtkuran M. Investigation of the effect of GaAs laser therapy on lateral epicondylitis. *Photomed Laser Surg.* 2010;28:397–403.
99. Haker E, Lundeberg T. Is low-energy laser treatment effective in lateral epicondylalgia? *J Pain Symptom Manage.* 1991;6:241–246.
100. Roberts DB, Kruse RJ, Stoll SF. The effectiveness of therapeutic class IV (10 W) laser treatment for epicondylitis. *Lasers Surgery Med.* 2013;45:311–317.
101. Skorupska E, Lisinski P, Samborski W. The effectiveness of the conservative versus myofascial pain physiotherapy in tennis elbow patients: double-blind randomized trial of 80 patients. *J Musculoskel Pain.* 2012;20:41–50.
102. Binder A, Hodge G, Greenwood AM, Hazleman BL, Page Thomas DP. Is therapeutic ultrasound effective in treating soft tissue lesions? *Br Med J (Clin Res Ed).* 1985;290:512–514.
103. D'Vaz AP, Ostor AJ, Speed CA, Jenner JR, Bradley M, Prevost AT, et al. Pulsed low-intensity ultrasound therapy for chronic lateral epicondylitis: a randomized controlled trial. *Rheumatol.* 2006;45:566–570.
104. Haker E, Lundeberg T. Pulsed ultrasound treatment in lateral epicondylalgia. *Scand J Rehabil Med.* 1991;23:115–118.
105. Lundeberg T, Abrahamsson P, Haker E. A comparative study of continuous ultrasound, placebo ultrasound and rest in epicondylalgia. *Scand J Rehabil Med.* 1988;20:99–101.
106. Holdsworth LK, Anderson DM. Effectiveness of ultrasound used with a hydrocortisone coupling medium or epicondylitis clasp to treat lateral epicondylitis: Pilot study. *Physiother.* 1993;79:19–25.
107. Stratford PW, Levy DR, Gauldie S, Miseferi D, Levy K. The evaluation of phonophoresis and friction massage as treatments for extensor carpi radialis tendinitis: a randomized controlled trial. *Physiother Can.* 1989;41:93–99.
108. Buchbinder R, Green S, Youd J, Assendelft W, Barnsley L, Smidt N. Shock wave therapy for lateral elbow pain. *Cochrane Database Syst Rev.* 2005;4:CD003524.
109. Spacca G, Necozione S, Cacchio A. Radial shock wave therapy for lateral epicondylitis: a prospective randomised controlled single-blind study. *Eura Medicophys.* 2005;41:17–25.
110. Staples MP, Forbes A, Ptasznik R, Gordon J, Buchbinder R. A randomized controlled trial of extracorporeal shock wave therapy for lateral epicondylitis (tennis elbow). *J Rheumatol.* 2008;35:2038–2046.
111. Gunduz R, Malas FU, Borman P, Kocaoglu S, Ozcakar L. Physical therapy, corticosteroid injection, and extracorporeal shock wave treatment in lateral epicondylitis: Clinical and ultrasonographical comparison. *Clin Rheumatol.* 2012;31: 807–812.
112. Ozturan KE, Yucel I, Cakici H, Guven M, Sungur I. Autologous blood and corticosteroid injection and extracoporeal shock wave therapy in the treatment of lateral epicondylitis. *Orthopedics.* 2010;33:84–91.
113. Radwan YA, Elsobhi G, Badawy WS, Reda A, Khalid S. Resistant tennis elbow: shock-wave therapy versus percutaneous tenotomy. *Int Orthop.* 2008;32: 671–677.
114. Nagrale AV, Herd CR, Ganvir S, Ramteke G. Cyriax physiotherapy versus phonophoresis with supervised exercise in subjects with lateral epicondylalgia: a randomized clinical trial. *J Man Manip Ther.* 2009;17:171–178.
115. Vasseljen O. Low-level laser versus traditional physiotherapy in the treatment of tennis elbow. *Physiother.* 1992;78:329–334.
116. Drechsler WI, Knarr JF, Snyder-Mackler L. A comparison of two treatment regimens for lateral epicondylitis: a randomized trial of clinical interventions. *J Sport Rehabil.* 1997;6:226–234.
117. Smidt N, van der Windt DA, Assendelft WJ, Deville WL, Korthals-de Bos IB, Bouter LM. Corticosteroid injections, physiotherapy, or a wait-and-see policy for lateral epicondylitis: a randomised controlled trial. *Lancet.* 2002;359:657–662.
118. Verhaar J, Walenkamp G, van Mameren H, Kester A, van der Linden A. Local corticosteroid injection versus Cyriax-type physiotherapy for tennis elbow. *J Bone Joing Surg Br.* 1996;78:128–132.
119. Rio E, Kidgell D, Purdam C, Gaida J, Moseley GL, Pearce AJ, et al. Isometric exercise induces analgesia and reduces inhibition in patellar tendinopathy. *Br J Sport Med.* 2015. http://dx.doi.org/10.1136/bjsports-2014-094386. published online 15 May 2015.
120. Nijs J, Kosek E, Van Oosterwijck J, Meeus M. Dysfunctional endogenous analgesia during exercise in patients with chronic pain: to exercise or not to exercise? *Pain Physician.* 2012;15:ES205–ES213.