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Effects of trigger point dry needling on lateral epicondylalgia of musculoskeletal origin: a systematic review and meta-analysis

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Abstract

Objective: This meta-analysis evaluated the effect of dry needling alone or combined with other treatment interventions on pain, related-disability, pressure pain sensitivity, and strength in people with lateral epicondylalgia of musculoskeletal origin.

Data Sources: MEDLINE, CINAHL, PubMed, PEDro, Cochrane Library, SCOPUS and Web of Science databases from their inception to 5 April 2020.

Review Methods: Randomized controlled trials collecting outcomes on pain, related-disability, pressure pain thresholds, or strength where one group received dry needling for lateral epicondylalgia of musculoskeletal origin. The risk of bias was assessed by the Cochrane Guidelines, methodological quality was assessed with the PEDro score, and the quality of evidence by using the GRADE approach.

Results: Seven studies including 320 patients with lateral epicondylalgia were included. The meta-analysis found that dry needling reduced pain intensity (SMD –1.13, 95%CI –1.64 to –0.62) and related-disability (SMD –2.17, 95%CI –3.34 to –1.01) with large effect sizes compared to a comparative group. Dry needling also increased pressure pain thresholds with a large effect size (SMD 0.98, 95%CI 0.30 to 1.67) and grip

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strength with a small size effect (SMD 0.48, 95%CI 0.16 to 0.81) when compared to a comparative group. The most significant effect was at short-term. The risk of bias was generally low, but the heterogenicity of the results downgraded the evidence level.
Conclusion: Low to moderate evidence suggests a positive effect of dry needling for pain, pain-related disability, pressure pain sensitivity and strength at short-term in patients with lateral epicondylalgia of musculoskeletal origin.
Level of Evidence: Therapy, level 1a.
Registration number: OSF Registry - https://doi.org/10.17605/OSF.IO/ZY3E8

Keywords
Dry needling, lateral epicondylalgia, musculoskeletal pain, meta-analysis

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Introduction

Lateral epicondylalgia (tennis elbow) is probably the most common cause of pain in the lateral aspect of the elbow with a point prevalence ranging from 1% to 3% in the general population.[1] Conservative treatment should be the first therapeutic strategy for the management of lateral epicondylalgia before other treatment options, for example, surgery, are considered.[2] Although several conservative interventions such as exercise or manual therapies are proposed for lateral epicondylalgia, their evidence is conflicting.[3,4]

There is evidence supporting a potential role of muscle tissues in the etiology of lateral epicondylalgia. In fact, people with lateral epicondylalgia exhibit neuromuscular control deficits.[5] One potential mechanism associated to deficits in muscle motor control may be myofascial trigger points.[6] It has been observed that the referred pain elicited by trigger points in the wrist extensors reproduce the symptoms experienced by people with lateral epicondylalgia.[7,8] Different therapeutic strategies are advocated for the management of trigger points with dry needling receiving increasing interest.[9] Interestingly, injection therapies such as hyaluronate injection, prolotherapy, platelet-rich plasma or autologous blood injection, but not corticosteroid injections, are proposed for the management of lateral epicondylalgia, although their effects are not clear.[10] All injection interventions introduce substances into the muscle tissue; on the contrary, dry needling is defined as a "intervention using a thin filiform needle that stimulates the skin, trigger points, muscle or connective tissue for the management of musculoskeletal pain disorders"[11] but does not introduce any substance into the tissue. Different meta-analyses support some positive effects of dry needling for the management of temporomandibular pain,[12] neck/shoulder pain,[13] low back pain[14] or plantar heel pain;[15] although more trials are needed. No meta-analysis investigating the effect of dry needling for the teratment of lateral epicondylalgia is available. Therefore, the current systematic review and meta-analysis evaluates the effects of trigger point dry needling alone or combined with other intervention on pain intensity and related-disability in subjects with lateral epicondylalgia of musculoskeletal origin. A secondary objective was to analyze changes in non-clinical outcomes including pressure sensitivity and strength.

Methods

This systematic review and metanalysis adheres to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.[16] The international Open Science Framework Registry link is https://doi.org/10.17605/OSF.IO/ZY3E8

Electronic literature searches were conducted on MEDLINE, CINAHL, PubMed, PEDro, Cochrane Library, SCOPUS and Web of Science databases from their inception to 30 April 2020. When searched databases allowed limits, searches were restricted to randomized clinical trials. We also screened the reference lists of the papers that were

identified in database searches. Bibliographical database search strategies were conducted with the assistance of an experienced health science librarian.

Population: Adults with lateral epicondylalgia of musculoskeletal origin older than 18 years of age. For this aim, the search strategy had to include one of the following key words: *lateral elbow pain* OR *lateral epicondylalgia* OR *epicondylitis* OR *lateral elbow tendinopathy*.

Intervention: Any form of muscular (or tendon) dry needling. Acupuncture was excluded. For this aim, the search strategy had to include one of the following: *dry needling OR muscular needling OR intramuscular stimulation.*

Comparator: Acceptable comparators were any type of placebo, sham, or no intervention. For this aim, the search strategy included one of these key words: *sham OR placebo OR control OR no intervention*. We also included studies performing a comparison of dry needling with another intervention.

Outcomes: The primary outcome measure was *pain* OR *related-disability* OR *function* OR *pressure pain threshold* OR *strength.*

The search strategy for each database is available in Supplemental Appendix 1.

The systematic review included randomized clinical trials where at least one group received dry needling for the management of lateral epicondylalgia of musculoskeletal origin. Due to the heterogenicity in the terminology, we included the following diagnostic terms in the meta-analysis: lateral epicondylalgia, epicondylitis, tennis elbow, or lateral elbow tendinopathy.

The specific inclusion criteria included (1) adult population (>18 years old) with lateral epicondylalgia of musculoskeletal pain origin; (2) one group receiving any type of muscular/tendon dry needling intervention; (3) acceptable comparator with sham, placebo, control or other intervention; and (4) the primary outcome of the study should include pain intensity (e.g. as measured with a visual analog scale or a numerical pain rate scale) or related-disability (e.g. as assessed with a specific-disease questionnaire). Secondary outcomes included pain sensitivity (e.g. as assessed with pressure pain thresholds), or strength (e.g. as assessed with a maximum or pain free hand-grip strength).

We excluded studies including: (1) forearm pain-related to neurological disorders (e.g. post-stroke pain); (2) elbow pain of traumatic origin (e.g. post-operative pain); (3) studies not published as a journal article; (4) retrospective designs; (5) pilot studies; (6) needling using a Traditional Chinese Medicine Approach, that is, acupuncture; or (7) use of other type of injection therapy, for example, corticoid injection, in the dry needling group.

Articles identified from the different databases were independently reviewed by two authors. First, the duplicates were removed. Second, title and abstract of the articles were screened for potential eligibility. Third, a full-text read of potentially eligible studies was conducted. Authors were required to achieve a consensus on the included trials. In case of discrepancy between reviewers, a third author participated in the process to reach the consensus for including the study or not.

Data from each trial including study design, sample size, population, interventions, outcomes, and follow-ups were extracted independently by two authors in a standardized form. Both authors had to achieve a consensus on each item on the data extraction form. If disagreement occurred, a third author participated in the determination.

Risk of bias and methodological quality of the included trials were independently assessed by two authors using the Cochrane Risk of Bias (RoB) assessment tool[17] and the Physiotherapy Evidence Database (PEDro) scale,[18] respectively. The RoB tool includes the following items: selection bias (randomization sequence generation, allocation concealment), performance bias (blinding participants, blinding therapists), detection bias (blinding outcome assessor), attrition bias (incomplete outcome data), reporting bias (source of funding bias/selecting outcome reporting), and other bias (sample size).[17] Each item was classified as low risk, high risk or unclear according to the Cochrane Collaboration's tool.[17] The PEDro score evaluates the quality of the trial by assessing the following items: random allocation; concealed allocation; baseline between-groups similarity; participants

blinding; therapists blinding; assessors blinding; dropouts; intention-to-treat statistical analysis; between-groups statistical comparison; point measures and variability data.[18] A trial was considered of high-quality when the PEDro score was ⩾5 out of 10 points.

To evaluate the quality of the evidence, we used the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach.[19] The level of evidence was classified as high, moderate, low or very low based on the following items: presence of study limitations (RoB), indirectness of evidence, inconsistency of results/unexplained heterogeneity, imprecision of results, and high probability of publication bias.[20] This process was independently performed by two authors, with the participation of a third one when discrepancy occurred.

The meta-analysis was conducted using the Review Manager statistical software (RevMan version 5.3). Data synthesis was categorized by groups according to the follow-up period as short-, mid-, and long-term, if data were available.

We extracted the sample size, means and standard deviations for each variable. When the trial reported only standard errors, they were converted to standard deviations. When necessary, the mean scores and standard deviations were estimated from graphs. Also, if the trial presented non-parametric values (median and interquartile range), they were converted to means and standard deviations.[21,22]

The between-groups mean differences (MD) of the trials were converted to SMD, with their 95% confidence intervals (CI). A random-effects model was used to determine the overall effect size (SMD). An effect size (SMD) of 0.8 or greater was considered large, between 0.5 and 0.8 as moderate and between 0.2 and 0.5 as small. In general, p-values <0.05 were considered statistically significant. The overall effect sizes and calculation of the effect size on pain intensity and related-disability were obtained at immediate (0–72 hours), short- (0–12 weeks) and long- (>24 weeks) terms after treatment.

The heterogeneity of the studies was assessed using the I^2 statistic. The Cochrane group has established the following interpretation of the I^2 statistic: 0% to 40% may not be relevant/important heterogeneity; 30% to 60% suggests moderate heterogeneity, 50% to 90% represents substantial heterogeneity, and 75% to 100% represents considerable heterogeneity.[23]

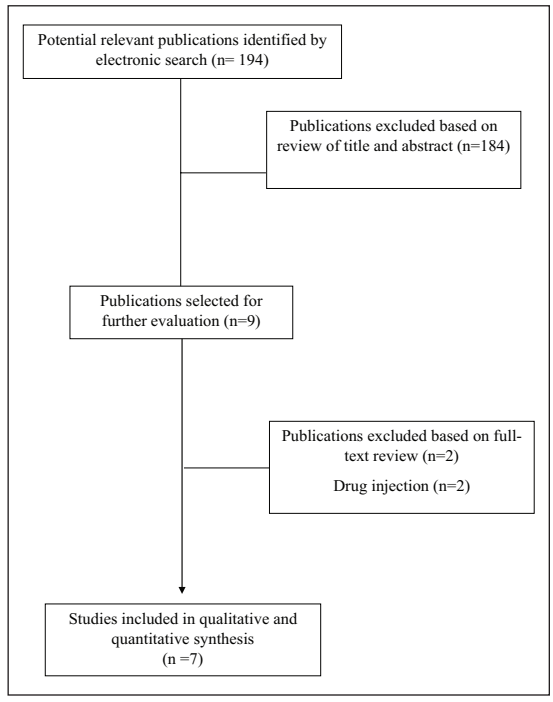

Figure 1. PRISMA flow diagram.

Results

The electronic searches identified 910 potential studies for review. After removing duplicates, 194 studies remained. One hundred eighty-four ($n=184$) were excluded based on examination of their titles and/or abstracts, leaving nine articles for full-text analysis.[24–32] Two articles were excluded because the dry needling intervention was combined with another injection therapy.[25,29] Finally, a total of seven trials were included in the analyses[24,26–28,30–32] (Figure 1).

The characteristics of the included studies are shown in Table 1. Supplemental Appendix 2 summarizes the characteristics of the dry needling intervention applied in each trial. Six studies targeted active trigger points (i.e. those which referred

Table 1. Effects of dry needling on pain, related-disability, pressure pain thresholds, and strength for lateral epicondylalgia.

Study	Intervention(s)	Sample size	Intervention duration (sessions/weeks)	Comparison and outcome measure	Between-groups differences (95%CI) [SMD]
García-Gallego et al.[24]	G1: Dry needling G2: Sham needling G3: Manipulation	*N* = 18 *N* = 15 *N* = 17	1 session	Pain (VAS) G1 vs G2 G1 vs G2 G1 vs G3 G1 vs G3 G2 vs G3 G2 vs G3 PPT (Kg/cm^2) G1 vs G2 G1 vs G2 G1 vs G3 G1 vs G3 G2 vs G3 G2 vs G3 Maximum grip strength G1 vs G2 G1 vs G2 G1 vs G3 G1 vs G3 G3 vs G3 G3 vs G3	1 min: 0.12 (−1.35, 1.59) [0.05] 10 min: 0.20 (−0.49, 0.89) [0.45] 1 min: −0.50 (−2.03, 1.03) [−0.21] 10 min: −0.13 (−1.69, 1.43) [−0.05] 1 min: −0.62 (−2.07, 0.83) [−0.29]] 10 min: −0.58 [−2.05, 0.89] [−0.26] 1 min: 0.51 (0.06, 0.96) [0.73] 10 min: 0.53 (−0.00, 1.06) [0.64] 1 min: −0.07 [−0.61, 0.47] [−0.08] 10 min: 0.29 (−0.27, 0.85) [0.33] 1 min: −0.58 (−1.04, −0.12) [−0.84] 10 min: −0.24 (−0.69, 0.21) [−0.35] 1 min: 1.19 (−7.09, 9.47) [0.10] 10 min: −0.98 (−8.64, 6.68) [−0.09] 1 min: −0.97 (−7.47, 5.53) [−0.10] 10 min: −1.47 (−8.19, 5.29) [0.14] 1 min: −2.16 (−10.25, 5.93) [0.18] 10 min: −0.49 (−3.90, 2.14) [−0.04]
Sukumar et al.[28]	G1: Dry needling plus eccentric exercises G2: Physical therapy (deep friction massage, therapeutic ultrasound and bracing) plus eccentric exercises	*N* = 22 *N* = 22	2–3 × 3 weeks NR × 4 weeks	Pain (Pain PRTEE) G1 vs G2 Function (Function PRTEE) G1 vs G2 Disability (Total score PRTEE) G1 vs G2 Strength (Maximum grip strength) G1 vs G2	0 wk: −2.66 (−4.15, −1.17) [−1.14] 0 wk: −3.18 (−4.49, −1.87) [−1.41] 0 wk: −7.50 (−9.64, −5.36) [−2.03] 0 wk: 7.18 (2.62, 11.74) [0.91]
Sukumar et al.[30]	G1: Dry needling G2: Low level laser therapy	*N* = 18 *N* = 18	2–3 × 2 weeks 5 × 2 weeks	Pain (Pain PRTEE) G1 vs G2 Function (Function PRTEE) G1 vs G2 Disability (Total score PRTEE) G1 vs G2	0 wk: −1.65 (−2.20, −1.10) [−1.14] 0 wk: −2.33 (−3.41, −1.25) [−1.38] 0 wk: −5.00 (−6.98, −3.02) [−1.61]

(Continued)

Table 1. (Continued)

Study	Intervention(s)	Sample size	Intervention duration (sessions/weeks)	Comparison and outcome measure	Between-groups differences (95%CI) [SMD]
Kheradmandi et al.[27]	G1: Dry needling of shoulder muscles plus physical therapy G2: Physical therapy consisting of ultrasound, TENS, hot pack and exercise therapy (eccentric exercises)	*N* = 7 *N* = 7	6 sessions of dry needling 10 sessions of physical therapy 10 sessions of physical therapy	Pain (VAS) G1 vs G2 PPT G1 vs G2 Grip power G1 vs G2	NR: −2.72 (−4.76, −0.68) [−1.31] NR: 0.93 (0.56, 1.30) [2.45] NR: 17.86 (−7.05, 42.77) [0.70]
Uygur et al.[26]	G1: Dry needling G2: NSAID and bracing	*N* = 51 *N* = 41	2 × weeks (5 sessions) 2 pills × day Bracing × 3 weeks	Pain (PRTEE pain score) G1 vs G2 G1 vs G2 Disability (PRTEE functional score) G1 vs G2 G1 vs G2	3 wk: −10.87 (−14.13, −7.61) [−1.44] 6 mo: −23.33 (−27.47, −19.19) [−2.35] 3 wk: −34.99(−40.15, −29.83) [−3.00] 6 mo: −49.57 (−54.08, −45.06) [−4.88]
Bagcier et al.[32]	G1: Dry needling, extracorporeal short-wave therapy, cold application and home exercise program G2: Extracorporeal short-wave therapy, cold application and home exercise program	*N* = 20 *N* = 20	1 × 3 weeks	Pain (Night VAS) G1 vs G2 Pain (Activity VAS) G1 vs G2 Pain (Rest VAS) G1 vs G2 PPT G1 vs G2 Grip strength in a flexion position G1 vs G2 Grip strength in an extension position G1 vs G2 PRTEE (Pain) G1 vs G2 PRTEE (Function) G1 vs G2 PRTEE (Total) G1 vs G2	1 mo: −0.60 (−1.59, 0.39) [−0.37] 1 mo: −1.65 (−2.20, −1.10) [−1.82] 1 mo: −1.15 (−1.71, −0.59) [−1.24] 1 mo: 5.95 [3.12, 8.78] [1.28] 1 mo: 4.95 (−0.02, 9.92) [0.60] 1 mo: 5.90 (0.38, 11.42) [0.65] 1 mo: −2.45 (−5.72, 0.82) [−0.46] 1 mo: −4.80 (−8.50, −1.10) [−0.79] 1 mo: −1.95 (−8.44, 4.54) [−0.18]
Etminan et al.[31]	G1: Dry needling at tendon of common extensor muscles G2: Physiotherapy (therapeutic ultrasound, deep friction massage, muscle stretching and strengthening)	*N* = 22 *N* = 22	3 × 3 weeks	Pain G1 vs G2 PREE (Function) G1 vs G2 Grip strength (Kg) G1 vs G2	1 wk: −0.62 (−1.07, −0.62) [−0.79] 1 wk: −15.91 (−27.28, −4.54) [−0.81] 1 wk: 4.59 (0.59, 8.59) [0.67]

G: Group; PRTEE: Patient Rated Tennis Elbow Evaluation; PREE: Patient Rate Elbow Evaluation; wk: weeks; Mo: months; NR: Not reported; VAS: Visual analog scale; PPT: Pressure Pain threshold.

pain reproduced some of the patient's symptoms) with the needle, whereas the seventh study targeted the tendon. The needling technique was heterogeneous, only one trial used reported the presence of local twitch responses during the needling intervention. Further, there was heterogenicity in the number and the frequency of sessions and the type of sham or comparator.

The methodological quality scores ranged from 6 to 8 (mean: 6.6, SD: 0.8) out of a maximum of 10 points; therefore, all studies were considered of high methodological quality (⩾5 points). The most frequent biases were blinding of the therapists, followed by participant's blinding. Table S1 details scores of the PEDro scale of each trial. The details of the risk of bias assessment of the included trials are displayed in Table S2. No trial was able to blind therapists and all trials had an unclear bias in the item of blinding patients. In general, the risk of bias of the included trials in the current meta-analysis was low.

The meta-analysis found that dry needling exhibited a significant large effect size (SMD –1.13, 95%CI –1.64 to –0.62, $n=430$, $Z=4.31$, $p<0.001$) for decreasing pain intensity versus a comparative group but with high heterogeneity between trials (Figure 2a). Significant large effects sizes for decreasing pain were observed at short- (SMD –1.26, 95%CI –1.54 to –0.99) and long- (SMD –2.35, 95%CI –2.88 to –0.37) terms, but not immediately (Figure 2a).

Dry needling showed a significant large effect size (SMD –2.17, 95%CI –3.34 to –1.01, $n=348$, $Z=3.65$, $p=0.003$) on related-disability versus a comparative group with high heterogeneity (Figure 2b). Significant large effects sizes on related-disability were observed at short- (SMD –1.65, 95%CI –2.52 to –0.77) and long- (SMD –4.88, 95%CI –5.71 to –4.05) terms, but with a high heterogeneity between trials (Figure 2b).

The meta-analysis found that dry needling exhibited a significant large effect size (SMD 0.98, 95%CI 0.30 to 1.67, $n=122$, $Z=2.81$, $p=0.005$) for improving pressure pain sensitivity (i.e., increasing pressure pain thresholds) versus a comparative group but with moderate heterogeneity between studies (Figure 3a). A significant effect was just observed at short-term (SMD –1.67, 95%CI 0.58 to 2.76, Figure 3a).

Dry needling exhibited a small effect size (SMD 0.48, 95%CI 0.16 to 0.81, $n=210$, $Z=2.91$, $p=0.004$) on strength versus a comparative group with low heterogeneity between trials (Figure 3b). A significant effect size was observed at short-term (SMD 0.74, 95%CI 0.40 to 1.08) with no significant effect immediately after dry needling (Figure 3b).

Table 2 displayed the details of GRADE assessment showing RoB, inconsistency of the results, indirectness of evidence, imprecision of results, and high probability of publication bias. In general, the inconsistency or imprecision of the results downgraded the evidence assessment one or two levels leading to low to moderate evidence in most pooled data.

Finally, most trials did not provide data about adverse events[24,27,28,30–32] and only a local hemorrhage in one patient was reported by Uygur et al.[26]

Discussion

The current meta-analysis found low to moderate evidence suggesting a positive effect of dry needling for pain, related-disability, pressure pain sensitivity and strength in lateral epicondylalgia of musculoskeletal origin, mostly at short-term.

The current meta-analysis is the first to analyze the impact of dry needling on pain intensity and related-disability in lateral epicondylalgia of musculoskeletal origin. The results suggest that trigger point dry needling maybe effective for the management of pain and related-disability associated to lateral epicondylalgia (low to moderate evidence); however, it should be considered that most effects were observed at short-term. The first topic to discuss is that dry needling was applied over muscle trigger points in most trials; however, the intervention was not properly described. In fact, only one trial reported that local twitch responses were elicited during needling insertion.[32] Since different methods of dry needling are proposed in the literature,[9] it is important to describe which method has been used in each study to further determine the effects of dry needling. This is an important topic since no consensus exist on the

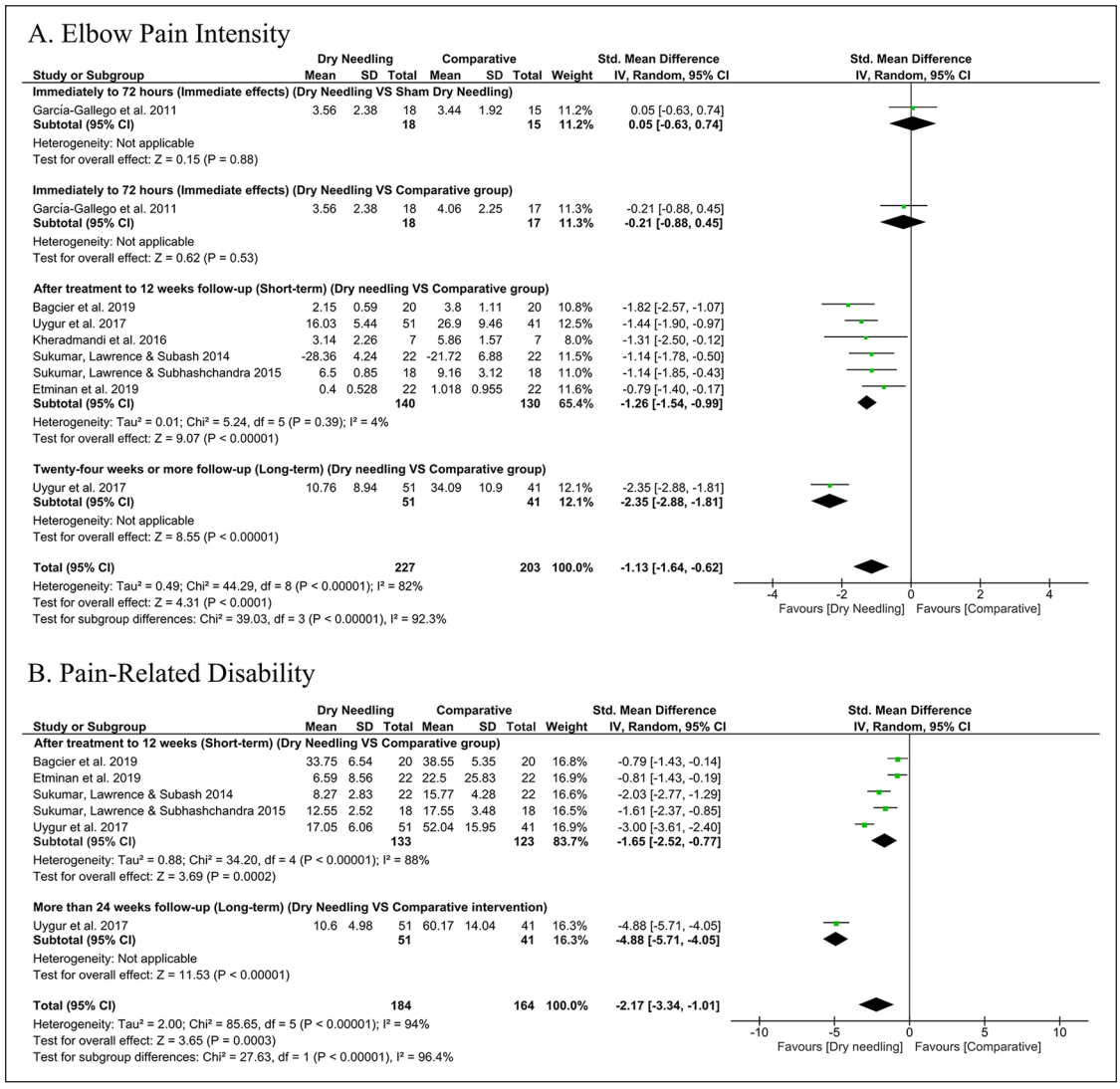

Figure 2. Comparison (standardized mean difference) between the effects of dry needling versus a comparison group on (a) elbow pain intensity and (b) pain-related disability.

number of local twitch responses needed or even if local twitch responses are needed to get a positive response.[33] Similarly, the number and the frequency of sessions and the duration of each session of dry needling should be determined in future trials. We do not know if a homogeneous application of dry needling would lead to more consistent results. This heterogenicity in the needling application could lead to inconsistent results which downgraded the level of evidence.

Another point to discuss is that the current meta-analysis included patients with lateral epicondylalgia. We should note that lateral epicondylalgia is a clinical diagnosis of lateral elbow pain which is usually conducted by exclusion, since there is no imaging standard for its diagnosis. Further, the rational for applying dry needling in this condition is the role of referred pain from trigger points in patients with lateral epicondylalgia.[6,7] In fact, trigger point diagnosis is a matter of

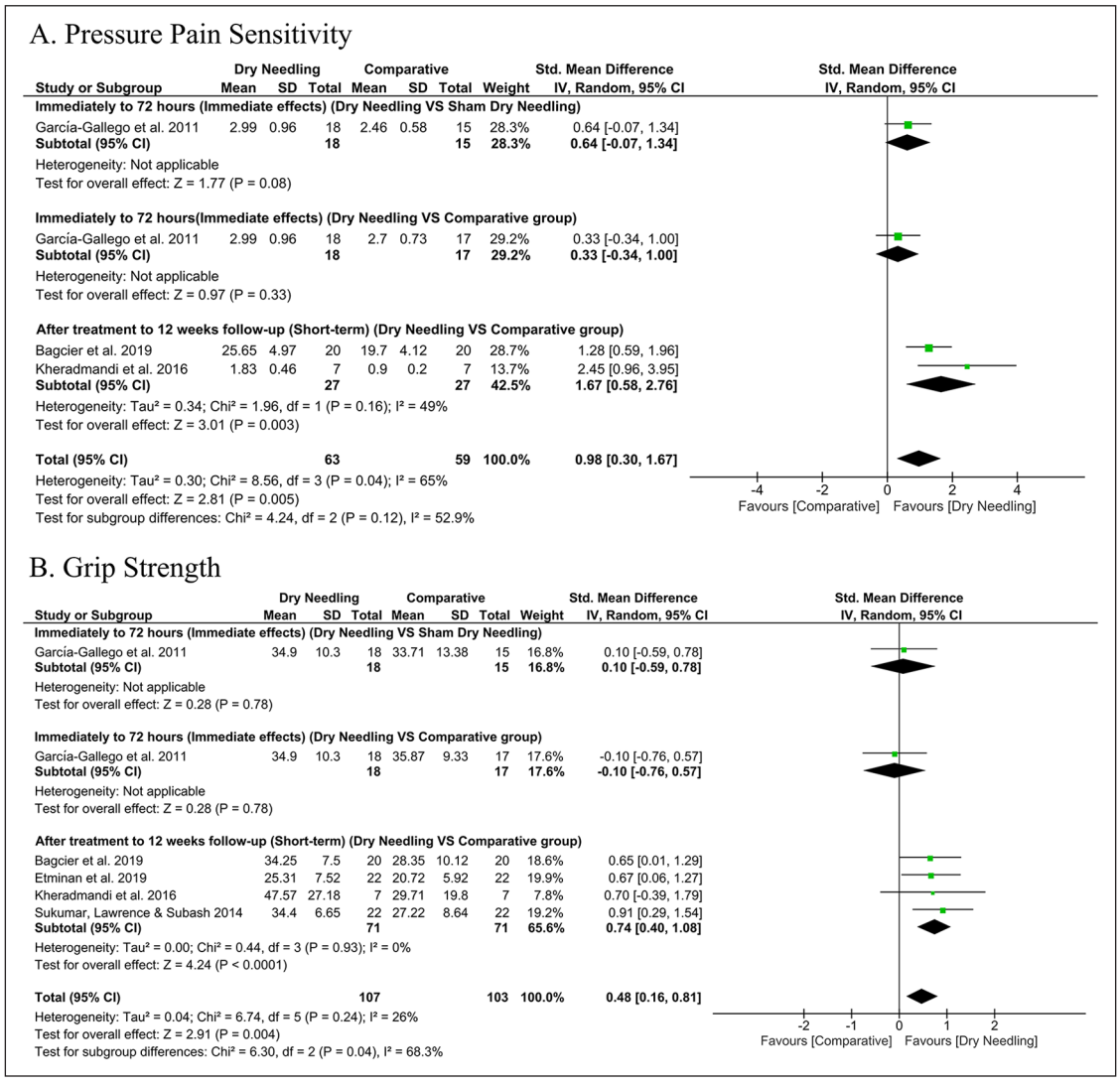

Figure 3. Comparison (standardized mean difference) between the effects dry needling versus comparison group on (a) pressure pain sensitivity and (b) grip strength.

debate, since it is also clinically conducted without the existence of a gold standard. Mora-Relucio et al found that manual palpation and classification of trigger points in the wrist extensors is reliable, reproducible and suitable for diagnosis of lateral epicondylalgia when performed by an experienced clinician.[34] Therefore, the results from the current meta-analysis should be applied to this population and not to other causes of lateral elbow pain, such as radial tunnel syndrome, radio-humeral bursitis, synovitis, posterior interosseous nerve syndrome or osteochondral dissecans. It is possible that trigger point dry needling would have no effects on these other lateral elbow pain conditions not related to muscle impairments.

This meta-analysis also found that trigger point dry needling exerts a hypoalgesic effect (low evidence) as expressed by increases in PPTs. The current findings agree with a previous meta-analysis

Table 2. GRADE Evidence profile for the effects of dry needling for lateral epicondylalgia.

Number of studies	Risk of bias	Inconsistency	Indirectness of evidence	Imprecision	Publication bias	Quality of evidence	SMD [95% CI]
Effects of dry needling on elbow pain intensity							
Overall effect ($n=7$)	No	Very Serious ($I^2=87\%$)	No	No	No	Low	−1.00 [−1.64, −0.37]*
Immediately to 72 hours Dry needling vs Sham ($n=1$)	No	No	No	Very serious	No	Low	0.05 [−0.63, 0.74]
Immediately to 72 hours Dry needling vs comparative ($n=1$)	No	No	No	Very serious	No	Low	−0.21 [−0.88, 0.45]
After 12 weeks follow-up (short-term) Dry needling vs comparative ($n=6$)	No	No ($I^2=4\%$)	No	Serious	No	Moderate	−1.26 [−1.54, −0.99]*
After 24 weeks or longer (long-term) Dry needling vs comparative ($n=1$)	No	No	No	Serious	No	Moderate	−2.35 [−2.88, −1.81]*
Effects of dry needling on pain-related disability							
Overall effect ($n=4$)	No	Very Serious ($I^2=96\%$)	No	No	No	Low	−1.93 [−3.48, −0.38]*
After 12 weeks follow-up (short-term) Dry needling vs comparative ($n=4$)	No	Very Serious ($I^2=93\%$)	No	Serious	No	Very Low	−1.21 [−2.44, 0.02]
After 24 weeks or longer (long-term) Dry needling vs comparative ($n=1$)	No	No	No	Serious	No	Low	−4.88 [−5.71, −4.05]*
Effects of dry needling on pressure pain sensitivity							
Overall effect ($n=3$)	No	Serious ($I^2=66\%$)	No	Serious	No	Low	0.98 [0.30, 1.67]*
Immediately to 72 hours Dry needling vs Sham ($n=1$)	No	No	No	Serious	No	Moderate	0.64 [−0.07, 1.34]
Immediately to 72 hours Dry needling vs comparative ($n=1$)	No	No	No	Very serious	No	Low	0.33 [−0.34, 1.00]
After 12 weeks follow-up (short-term) Dry needling vs comparative ($n=2$)	No	Serious ($I^2=49\%$)	No	Serious	No	Low	1.67 [0.58, 2.76]*
Effects of dry needling on muscle strength							
Overall effect ($n=4$)	No	No ($I^2=11\%$)	No	Serious	No	Moderate	0.38 [0.05, 0.71]*
Immediately to 72 hours Dry needling vs Sham ($n=1$)	No	No	No	Very serious	No	Low	0.10 [−0.59, 0.78]
Immediately to 72 hours Dry needling vs comparative ($n=1$)	No	No	No	Very serious	No	Low	−0.10 [−0.76, 0.57]
After 12 weeks follow-up (short-term) Dry needling vs comparative ($n=3$)	No	No ($I^2=0\%$)	No	Serious	No	Moderate	0.66 [0.26, 1.07]*

showing that trigger point manual treatment also exerts potential mechanical hypoalgesic effects.[35] In fact, there is evidence supporting that the application of dry needling activates mechanical and neurophysiological mechanisms explaining the positive effect on pressure pain sensitivity.[36] For instance, the disruption of dysfunctional endplates and reduction of actin and myosin filaments overlapping are the underlying mechanical effects proposed for dry needling. In addition, preliminary evidence supports that trigger point dry needling reduces peripheral and central sensitization by removing the source of peripheral nociception (trigger point), by modulating dorsal horn neuron activity, and activating central inhibitory pathways.[36] Nevertheless, these hypotheses need to be confirmed in future studies..

Dry needling also showed low evidence for increasing muscle (grip) strength, particularly at short-term (moderate evidence). Our results agree with a previous meta-analysis concluding that low evidence supports an effect of dry needling for improving force production in patients with lateral epicondylalgia.[37] Some evidence supports that muscle trigger points produce muscular fatigability and changes in motor output[38,39] explaining the observed changes in strenght. It is possible that combining dry needling with exercise could lead to better outcomes in this musculoskeletal pain condition.

The topic of proper sham needling intervention should be considered, since it is not possible to confirm that real dry needling would be superior to sham dry needling for the treatment of lateral epicondylalgia of musculoskeletal origin. In fact, only one study compared real versus sham dry needling in lateral epicondylalgia, and this trial evaluated immediate (72 hours) effects. Braithwaite et al concluded that sham needling approaches used in most studies investigating the effects of dry needling are highly heterogeneous limiting comparability of blinding effectiveness across published trials.[40] Development of proper sham needling interventions and proper blinding of patients during dry needling interventions are needed to further elucidate the true effects of dry needling. In fact, the potential role of patient expectations or previous beliefs in the effects of dry needling has been recently discussed in the literature.[36]

We found that dry needling was applied by physical therapists in 50% of the trials included in this meta-analysis. This is also a relevant topic since the clinical reasoning of the health care professional applying a needle intervention can modify its application. In fact, the meta-analysis conducted by Gattie et al is the only one just focusing the attention on dry needling interventions applied by physical therapists.[41] We do not currently know if using different clinical reasoning strategies when applying dry needling interventions would lead to different results.

The safety of dry needling interventions is also a topic of debate. Most studies of the current meta-analysis did not report data about adverse events in patients with lateral epicondylalgia. It has been reported that most adverse events related to the application of dry needling are categorized as minor.[42] The top three adverse events include bleeding (16%), bruising (7.7%), and pain during dry needling (5.9%). Nevertheless, some major adverse events e.g., pneumothorax, were also found with a rate of $<0.1\%$ (1 per 1,024 needling treatments).[42] In the forearm, a case report describing radial nerve damage has been published.[43] There is preliminary data suggesting that dry needling seems to be a safe treatment intervention if properly applied; however, clinicians need to be aware of the risks associated with its application at each particular anatomical location.

Although this is the first meta-analysis analyzing the effects of trigger point dry needling in patients with lateral epicondylalgia of musculoskeletal origin, current results should be analyzed according to its potential strengths and limitations. Strengths of this meta-analysis include a comprehensive literature search, methodological rigor, data extraction, rigorous statistical analysis, and the inclusion of randomized controlled trials of high methodological quality. Among the limitations, we recognized that the number of included trials was small ($n=7$). Additionally, needling interventions were applied with different dosages, that is, sessions, frequency of application, presence/absence of local twitch responses or muscles

treated. Another potential limitation is the heterogeneity and imprecision of the results of some of the trials; therefore, the results should be taken with caution.

The current meta-analysis found low evidence supporting the application of dry needling for the treatment of lateral epicondylalgia of musculoskeletal origin; however, some questions remain to be elucidated in future studies. First, most studies investigated just short-term effects, with only one study investigating long-term (6-months) effects. Therefore, there is clear needed for further randomized clinical trials examining long-term effects of dry needling for lateral epicondylalgia. Second, most trials investigated the isolated application of dry needling which does not represent clinical practice. Future clinical trials should identify if the inclusion of dry needling into a multimodal approach including, for example, exercise[44] is more effective than not including it. Finally, we observed an inadequate reporting of the interventions and which muscles were targeted. It would be interesting to better define needling interventions applied for potential replication of the treatment protocols.

Clinical messages

1. This meta-analysis found low to moderate evidence suggesting a positive short-term effect of dry needling for pain and related-disability in lateral epicondylalgia of musculoskeletal origin.
2. Low to moderate evidence supporting a short-term positive effect of dry needling on pressure pain sensitivity and strength in individuals with lateral epicondylalgia of musculoskeletal origin was also observed.

Author contributions

All authors contributed to the study concept and design. MNS, JSI, GGC and ILUV conducted literature review and did the statistical analysis. All authors contributed to interpretation of data. CFdlP and JC contributed to drafting the paper. All authors revised the text for intellectual content and have read and approved the final version of the manuscript.

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Supplemental material

Supplemental material for this article is available online.

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