Effectiveness of trigger point dry needling for multiple body regions: a systematic review

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Background: Trigger point dry needling (TDN) is commonly used to treat musculoskeletal pain related to myofascial trigger points (MTrPs). To date, no systematic review of high-quality randomised controlled trials (RCTs) investigating TDN to multiple body regions exists.
Purpose: The aim of this review is to determine the effectiveness of TDN based on high-quality RCTs for all body regions.
Methods: To ensure thorough reporting, Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed as the methodological basis for this systematic review. PubMed, Physiotherapy Evidence Database (PEDro), Cinahl, Cochrane and reference lists were searched for the years 2000–2014 and the terms 'TDN', 'dry needling NOT trigger point', 'functional dry needling' and 'intramuscular manual therapy'. Inclusion criteria: RCTs with PEDro scores 6–10 investigating TDN. Exclusion criteria: duplicates, non-human participants, non-English language, exclusive focus on acupuncture or medicinal injections. Three investigators searched databases, applied criteria, read and assigned PEDro scores to every RCT. Nineteen studies met the criteria. As compared to either baseline or control groups, significant differences were found for pain (14 studies), range of motion (ROM) (five studies) and at least one item on function and quality of life measures (six studies).
Limitations: This review was limited by inclusion criteria, timeframe, language and databases searched.
Conclusion: The majority of high-quality studies included in this review show measured benefit from TDN for MTrPs in multiple body areas, suggesting broad applicability of TDN treatment for multiple muscle groups. Further high-quality research is warranted to standardise TDN methods to determine clinical applicability.

Keywords: Myofascial pain syndrome, Systematic review, Trigger point dry needling

Introduction

Trigger point dry needling (TDN) is an intervention used to treat myofascial pain syndrome and associated impairments. Myofascial pain syndrome is characterised by the presence of one or more symptomatic myofascial trigger points (MTrPs) located in skeletal muscle. Myofascial trigger points are palpable, localised areas of hyperalgesic muscle tissue typically located in a taught band of fibres.[1,2] Myofascial trigger points have been theorised to develop following a bout of heavy eccentric and/or concentric loading.[1] This loading can lead to localised muscle contractures due to an excessive release of acetylcholine, increased activation of nicotinic receptors and inhibition of acetylcholinesterase at the motor endplate.[1,3–5] In addition, research indicates active MTrPs have greater concentrations of inflammatory and nociceptive agents, as well as a lower pH, compared to non-pathologic muscle fibres.[6–8] These physiologic changes are the most likely causative factors behind the physical impairments associated with the presence of MTrPs, such as loss of range of motion (ROM), weakness and painful contractions.[9] Trigger point dry needling is a treatment method widely used to treat the aforementioned impairments by targetting and eliminating local MTrPs.[1,3,9,10] Several hypotheses exist to explain the physiological drivers behind sign and symptom reduction with TDN. It has been suggested that TDN hyperstimulates the pain-generating area and thereby normalises the local sensory inputs.[11] Another hypothesis suggests that TDN causes natural opioid-mediated pain suppression by stimulating local alpha–delta nerve fibres.[2] Furlan *et al.*[12] proposed that TDN stimulates inhibitory interneurons, preventing normal pain transmission to the sensory cortex. Finally, evidence supports the idea that TDN may correct the altered chemical milieu found in the trigger point itself.[6,7,13] These proposed drivers of symptom reduction are supported by limited, poor-quality evidence.

Trigger point dry needling is administered by inserting a thin, solid filiform needle directly into the palpable trigger

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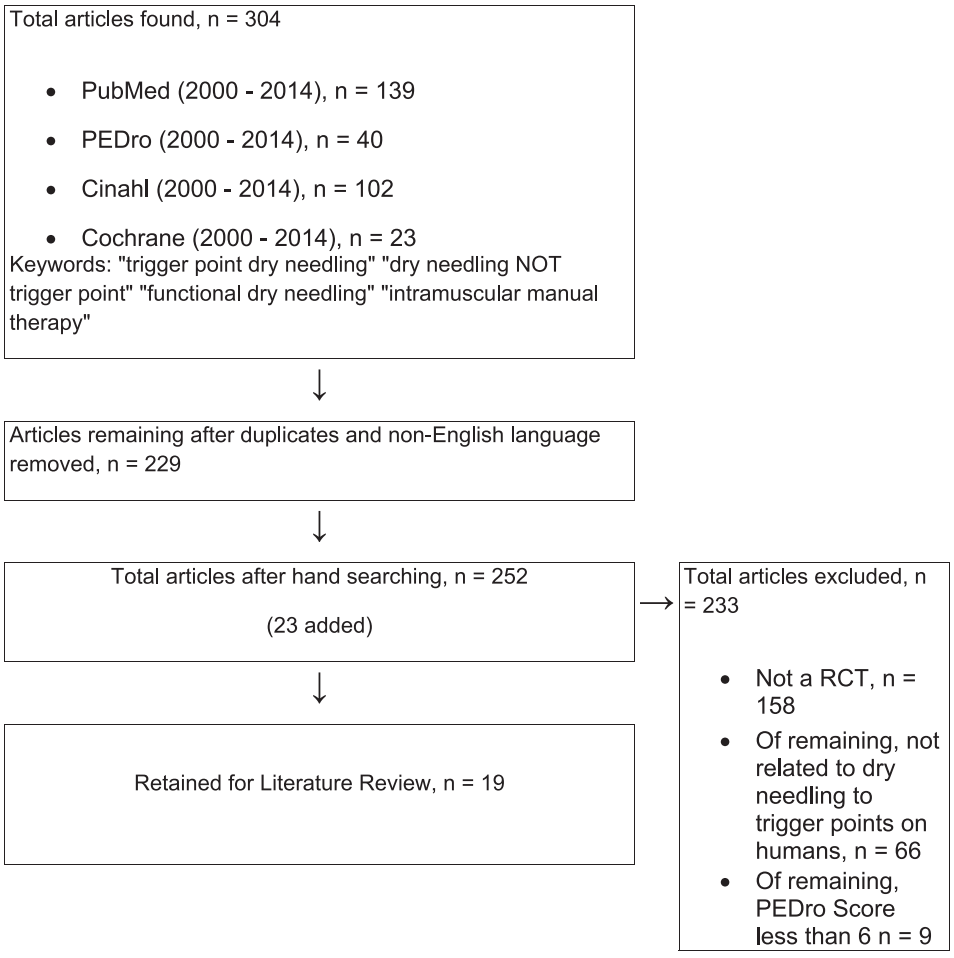
DOI 10.1179/2042618615Y.0000000014

point.[1,2,9,10] Trigger point dry needling can be performed either superficially (to a depth of 5–10mm) or in depth, with penetration of the involved muscle belly.[9,10] In most deep TDN procedures, the needle is then incrementally manipulated within the tissue in order to elicit a localised twitch response (LTR) and removed once the MTrP has been released.[1,2] A LTR is characterised by a rapid, involuntary contraction of the muscle fibres that contain the MTrP.[1,4,9,10,14]

Risks of needle insertion are relatively low with the TDN method.[15] A recent study by Brady *et al.*[15] found that the most common adverse events with regular TDN treatment include bruising, bleeding and pain, occurring at a rate of 20%. These events were classified as mild because they were short-term and did not require further medical treatment.[15] Moderate to severe adverse events causing significant distress or further medical treatment (e.g., fainting, headache, nausea) occurred at a rate of $<0.04\%$.[15] Additional risks associated with TDN may include haematoma, infection, pneumothorax and nerve lesions.[9,16] Several recent systematic reviews have shown positive results with TDN; however, these reviews reported limited conclusions due to low-quality studies.[17–19] The purpose of this systematic review is to evaluate high-quality randomised controlled trials (RCTs) to determine the effectiveness of TDN as a treatment for impairments related to MTrPs located in multiple body regions.

Methods

In order to determine the effectiveness of TDN on various conditions, a protocol was established specifying search strategies, inclusion criteria, data extraction and evaluation criteria. A preliminary search of the literature was conducted in January 2013 under the search terms: 'trigger point dry needling', 'functional dry needling' and 'intramuscular manual therapy'. In order to find all possible articles on TDN and avoid excessive duplication of results, the term 'dry needling NOT trigger point' was also searched, yielding articles which use only the term 'dry needling' for the same technique referred to here as TDN. PubMed, (PEDro), Cinahl and Cochrane databases were searched between the year 2000 and January 2013. A total of 173 articles were found in this search. Three of the researchers were each assigned databases to search. The inclusion and exclusion criteria were initially applied to each article by individual researchers according to assigned databases, and the group then agreed upon final exclusion decisions.



Abbreviations: *TDN, trigger point dry needling; RCT, randomized controlled trial*

Figure 1 Flow diagram of search strategy and results

Subsequent searches were conducted for all articles published in the years 2013 and 2014 in order to ensure inclusion of the most recently published articles. The same databases and search criteria were applied as described above, with a total of 26 articles found published in 2013, and 87 articles in 2014. Duplicate articles found among the databases were excluded. Hand searching was conducted by searching reference lists in relevant articles and unpublished research. After hand searching, 23 relevant articles were found, of which only one met the criteria for this systematic review.

Articles were excluded based on the following criteria: duplicates, non-human studies and non-English language studies. All articles meeting search terms were scrutinised to ensure that dry needling to one or more trigger points was executed as either an intervention or control group of interest, and articles in which this did not occur were excluded. The inclusion criteria were: high quality RCT's investigating TDN treatment.

Data were extracted from each included article using a standard form (based on the Cochrane data extraction template) including the following information: patient characteristics, similarity between groups, intervention and control information, blinding, outcome measures, times to outcomes, statistics used and results with supporting data. All outcome measures were considered for the purpose of this review. Once all inclusion and exclusion criteria were applied, a total of 19 RCT's were retained for review from all searches. Figure 1 illustrates the search strategies applied to this review.

The PEDro scoring system was used to evaluate research quality. The PEDro score is based on 11 criteria, 10 of which contribute to the overall score of an article. An article may obtain a maximum of 10 points on the PEDro score, reflecting internal validity and sound statistical analysis. The first criteria point relates to external validity and is not part of a study's score. Randomised controlled trials with a PEDro score of 6 or greater were included in this systematic review. According to Maher *et al.*,[20] the PEDro score provides a reliable judgement of physical therapy RCT quality when determined through consensus. Maher *et al.*[20] determined that repeated consensus scoring is within two points 99% of the time. By setting a cutoff score of 6 for this review, there is a high level of confidence that the lowest quartile of evidence has been excluded, and that the articles included here contain high internal validity. Three of the researchers independently scored every RCT that met inclusion criteria. If articles did not explicitly state criteria required for a point, the point was not awarded, unless PEDro scoring instructions indicated otherwise. When the individual researchers scored articles differently, score discrepancies were resolved by reviewing articles together as a group and evaluating each scored item together. In this way, consensus was reached among all researchers for every RCT without disagreement. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist was utilised to ensure clear, thorough reporting in this review.

Results

A total of 19 studies met our inclusion criteria, which are listed in chronological order in Table 1 through Table 5. Table 1 summarises the inclusion and exclusion criteria for each study retained for review. Inclusion criteria varied by study, but all patients presented with myofascial pain syndrome. Exclusion criteria generally encompassed any patients with contraindications for needling, recent history of needling, blood clotting disorders, use of medications affecting blood clotting or diagnoses of neurologic or systemic disease.

Table 2 provides information about study patients including age ranges and duration of symptoms, if it was provided. All patients were adults whose ages ranged from 24 to 72 years. Patients in 13 studies[8,21–31] reported chronic pain lasting from 3 months to 5 years. In four studies,[28,29,32,33] patients reported pain for < 3 months. Four studies did not report any symptom duration.[34–37] All of the studies consisted of male and female patients, except for the study by Myburgh *et al.*,[35] which consisted of female patients only.

Table 3 summarises the interventions, outcome measures and times to outcome. Twelve studies compared TDN to sham needling.[21,23,25–28,32–37] In other studies, 12 different comparison groups were used instead of TDN, sham and/or placebo, which consisted of standard acupuncture,[23] acupuncture inserted at distal points,[21] lidocaine injection,[24,38] percutaneous electrical nerve stimulation,[8] active stretching,[22] oral flurbiprofen,[38] no treatment, MTrP manual therapy, ultrasound-guided TDN, ultrasound-guided minispcalpel-needle release and superficial versus deep dry needling.[27,29–31,35] Studies included in this review targetted TDN treatments towards muscles surrounding the following joints and regions: tempormandibular,[25,32] cervical spine and shoulder,[21,23,24,27,29–31,35,37,38] distal upper extremity,[26] lumbar spine,[8] proximal lower extremity[8,34,36] and distal lower extremity.[28,33] The study by Edwards and Knowles[22] pragmatically treated patient impairments and did not specifically state muscles or regions receiving TDN. Ten studies required the elicitation of at least one LTR as part of their protocol.[21,24–26,28–30,33,35,38] Times to outcome ranged from immediate[21,22,25–27,29,35,37] to 6 months[8,22–24,28–36,38] with six studies reporting either immediate decreases in pain or an increase in pressure pain thresholds (PPTs).[25–27,29,35,37] On follow-ups between 1 day and 6 months, 12 studies reported that TDN was effective in reducing pain or increasing PPTs.[22–24,27–33,36,38]

Table 4 describes the key findings and quality of evidence via PEDro scores. Significant decreases in pain outcome measures were seen in 15 studies compared to baseline.[22–31,33–36,38] Nine of those studies also showed a significant decrease compared to either controls or another treatment group.[22,23,25–29,33,36] Significant changes in ROM were seen in five studies compared to controls.[25,26,29,33,38]

Table 1 Inclusion and Exclusion Criteria by Study

Study	Inclusion Criteria	Exclusion Criteria
Irnich et al[17]	• Chronic pain of greater than 2 months in duration • Limited ROM in cervical spine • Diagnosis of cervical MPS as characterized by pain and limited ROM associated with MTrP's or "irritation syndrome" (diffuse intense pain and irritated soft tissues with prolonged aggravation after motion and pressure)	• Cervical spine radicular syndrome, segmental instability, fracture, or surgery • Contraindications to acupuncture • Drug treatment, physical therapy, or manual treatment within the past 4 weeks
Edwards and Knowles[8]	• At least 18 y/o • Presence of active trigger point • Patient agreement not to receive additional treatment for painful condition during trial (apart from NSAIDS and pain medications) • Patient capable of complying with the trial	• Acute condition requiring treatment within 6 weeks • Skin lesion, infection, or inflammatory edema at trigger point site • Needle phobia • Previous adverse reaction to acupuncture or anesthetic • Serious neurological or systemic disorder
Hugeunin et al[16]	• Gradual onset of hamstring pain • Reproduction of recognizable hamstring pain with pressure on their gluteal trigger points • Good understanding of written and spoken English • Able to attend all sessions	• History of hamstring tear within the previous 6 wk • Clinical evidence of a hamstring tear • MRI evidence of a hamstring tear • Significant lower back injury within 6 wk • Clinical evidence of significant lumbar or sacroiliac joint contribution to pain • Clinical evidence of a radiculopathy or neurological impairment • Needle phobia • Bleeding disorder • Anticoagulant medication • Previous experience with drying needling for myofascial pain • Inability to reproduce symptoms with trigger point palpation
Itoh et al[18]	• Neck pain >6 mo • Non-radiating neck pain • Normal neurological examination findings of cervical nerve function (deep tendon reflexes, voluntary muscle action, sensory function) • At least 45 y/o	• Major trauma or systemic disease • Other conflicting or on-going treatments except those which had been medicated with a consistent dosage for at least 1 mo
Ay et al[1]	• Clinical diagnosis of MPS as characterized by regional pain, taut band(s), referred trigger point pain and sensory change, extreme sensitivity in taut band, decreased ROM • At least 1 active trigger point in upper trapezius • Symptom duration for at least 1 mo	• Fibromyalgia • Systemic disease • Cervical disc lesion • History of MTrP injection • Physical therapy treatment in past 6 mo • Pregnancy • History of neck or shoulder surgery • Drug allergies • Abnormal lab results
Fernandez-Carnero et al[11]	• Primary diagnosis of myofascial pain according to the Research Diagnostic Criteria for TMD • Pain involving the masseter muscle • Duration of symptoms of at least 6 mo • Pain on palpation of the jaw muscles • Limitation of mandibular movement • Mean intensity of pain corresponding to a weekly average of at least 3 cm on a 10 cm VAS	• Cervical trauma (whiplash injury) • Any systematic joint or muscle disease (e.g. fibromyalgia, rheumatoid arthritis) • Needle phobia • Bleeding disorders • Metabolic disease (diabetes) • Any neurological disorder (e.g. trigeminal neuralgia) • Any vascular disease • Previous acupuncture, dry needling, or physical therapy treatment in the 6 mo prior to the study
Perez-Palomares et al[28]	• At least 18 y/o • Chronic low back pain duration 4 mo or greater • Little or modest improvement in pain with pharmacological treatment (NSAIDs and/or analgesics)	• Suspected or diagnosed fibromyalgia syndrome • Suspected or diagnosed structural lesions in the lumbar column • Concomitant non-pharmacological treatments (acupuncture, homeopathy) • Medical conditions or circumstances that, in the researcher's judgment, might have interfered in the results

Table 1 (Continued)

Study	Inclusion Criteria	Exclusion Criteria
Srbely et al[34]	• Presence of active trigger point within each of the supraspinatus, infraspinatus and gluteus medius on the right side • Trigger point baseline pain pressure threshold value of 35 N or less	• Neurologic conditions • Use of medications (antidepressants, opioids) • Acute cervico-thoracic injury (whiplash, facet irritation, acute discopathy)
Diracoglu et al[5]	• Symptoms at least 6 wk • Two or more trigger points in TMJ	• TMJ degeneration • Reducible or non-reducible disc replacements • TMJ subluxation • TMJ Neoplasm • Inflammatory diseases involving TMJ • Diseases involving TMJ • TMJ ankylosis • Fracture in bones forming the TMJ • History of TMJ surgery • Radiotherapy to TMJ region • Occlusion anomaly • Major anomalies in the mandible, teeth and gums • Hypermobility syndrome • Blood dyscrasias • Trigeminal neuralgia • Major psychiatric disorders
Eftekhar-Sadat et al[9]	• At least 18 y/o • Clinical diagnosis of plantar heel pain in accordance with the Function, Disability, and Health from the Orthopedic Section of the American Physical Therapy Association • History of plantar heel pain >1mo • First step a pain during the previous week rated at least 40 mm on a 100 mm VAS • Ability and willingness to attend the Physical Medicine and Rehabilitation outpatient of Imam Reza Hospital of Tabriz for an initial assessment and then being randomly assigned into one of the study groups • Willingness to discontinue taking all pain relieving medications for at least 14 d prior to the baseline assessment and during the study period • Ability to walk 50 meters without aid of support • Having MTrPs on initial physical examination on plantar muscles cuff • Absence of Raynaud's disease	• Participant refusal to be needled • Participant refusal of receiving routine physical therapy (e.g. cooling, stretch, massage therapy and/or footwear modifications) • The presence of coagulopathy or use of anticoagulants (except for acetylsalicylic acid at dosages up to 325 mg/d) • Pregnancy • Dermatological disease within dry needling areas • History of TDN or acupuncture treatment for any reason • Inability to understand instructions or complete a questionnaire • Presence of peripheral arterial vascular disease (failure to palpate at least one pedal pulse and an ankle/brachial index <0.9, history of intermittent claudication, history of chronic limb ischemia including rest pain and or lower limb and foot ulceration, history of chronic lower limb and foot edema, history of vascular surgery of the lower limb or foot) • History of connective tissue disease • Presence of a chronic medical condition that might preclude participation in the study such as: malignancy, systemic inflammatory disorders (e.g., rheumatoid arthritis, psoriatic arthritis, ankylosing spondylitis, septic arthritis), neurological abnormalities, sciatica, and/or chronic pain. • History of plantar fascia surgery • History of injection therapy in the heel during the previous three months • Known hypersensitivity to metals
Myburgh et al[27]	• Female gender • 20 - 46 y/o • Perform office work for four hours or more a day • MTrP's present in upper trapezius muscle	• History of chronic, systemic pathology • Pre-existing neck/shoulder pathology/ surgical procedures • Clinical depression • Involvement in health-related legal action • Pregnancy • Use of anti-inflammatory and/or chronic pain medication • Receiving dry needling for shoulder/neck disorder within 6 mo prior to the study • Needle phobia • Body Mass Index >31

Table 1 (Continued)

Study	Inclusion Criteria	Exclusion Criteria
Tsai et al[38]	• Unilateral shoulder pain caused by digital compression of MTrP in the upper trapezius (MTrP diagnosed as tenderness and pain reproduction with palpation of a tight band)	• Contraindication for TDN, such as local infection or trauma • Anticoagulant medication • Pregnancy with threatened abortion • Problem that might interfere with pain/pain threshold assessment • Cognitive deficit • Needling treatment in past
Eroglu[10]	• Complaints of neck and back pain • Diagnosis of MPS originating from neck and back muscles	• Disease or medications that could lead to neuropathy • Systemic diseases such as inflammatory rheumatic, cardiovascular, or pulmonary disease • Fibromyalgia syndrome • Cervical radiculopathy or myelopathy • Trigger point injection within the preceding two mo because of MPS • Patients whose personalities were thought to be unsuitable for complying with protocol requirements • Bleeding disorders, including medications that could promote bleeding • Prior neck or shoulder surgery • Pregnancy
Mayoral et al[24]	• Diagnosis of knee osteoarthritis and scheduled for total knee replacement surgery • Presence of active or latent MTrPs in at least one of the muscles included in the examination protocol	• Presence of any other condition that could cause myofascial or neuropathic pain in the lower limb, such as lumbar radiculopathy, saphenous nerve entrapment, or myalgia paresthetica • Presentation of any condition usually considered a perpetuating factor of MTrPs such as fibromyalgia, hypothyroidism, or iron deficiencies
Tekin et al[35]	• Presence of at least one active MTrP • 24 - 65 y/o • Symptom duration >6 mo	• Concomitant fibromyalgia • Pregnancy • Cervical nerve root irritation • Abnormal laboratory results • Thoracic Outlet Syndrome • Upper extremity entrapment syndromes
Cotchett et al	• At least18 y/o • Plantar heel pain • Symptom duration at least 1 mo • First step pain rated at least 2/10 on VAS • No history of acupuncture or TDN	• Contraindications to TDN • Serious causes of heel pain (e.g., fracture, cancer, infection) • Systemic inflammatory disorders • Treatment for planter heel pain in previous 4 wk
Mejuto-Vazquez et al	• Acute mechanical idiopathic unilateral neck pain • Referred to physical therapy • Symptom duration < 7days • Active MTrP in upper trapezius	• History of whiplash • Previous surgical surgery • Cervical radiculopathy or myelopathy • Diagnosis of fibromyalgia • Physical therapy intervention in the previous 12 mo • Fear of needles • Any sign of vertebrobasilar insufficiency or upper cervical spine ligamentous instability • Contraindications to TDN
Zheng et al	• At least 18 y/o • Symptom duration > 3 mo • Chronic neck pain > 3/10 on VAS • Presence of MTrPs	• Pregnancy • Prior acupuncture, TDN, Miniscalpal-needle release • Vertebral column surgery • Disc protrusion or prolapse with neurological symptoms • Infectious spondylopathy • Inflammatory, malignant, or autoimmune disease causing neck pain • Congenital deformation of spine, except slight lordosis and scoliosis • Compression fracture caused by osteoporosis • Spinal stenosis • Spondylolysis or spondylolisthesis

Table 1 (Continued)

Study	Inclusion Criteria	Exclusion Criteria
Llamas-Ramos et al	• Active MTrP in upper trapezius • Chronic idiopathic mechanical neck pain • Referred to physical therapy	• Whiplash injury • Previous surgical surgery • Cervical radiculopathy or myelopathy • Diagnosis of Fibromyalgia • Any physical therapy intervention in previous year • Fear of needles • Contraindications for TDN

Abbreviations: *ROM, Range of Motion; TDN, Trigger Point Dry Needling; MPS, Myofascial Pain Syndrome; MTrP, Myofascial Trigger Point; NSAID, Non-steroidal anti-inflammatory drug; TMD, Temporomandibular Disorder; TMJ, Temporomandibular Joint; VAS, Visual Analog Scale*

Significant changes in PPT were seen in seven studies compared to controls.[25,26,29,30,32,37,38] Significant changes were seen in five studies for the following outcome measures: Neck Disability Index,[23] Oswestry Disability Index,[8] Foot Function Index,[33] Nottingham Health Profile,[38] Foot Health Status Questionnaire[28] and Short Form (36) Healthy Survey,[27] as compared to controls. Scores for each of the 11 subsections of the PEDro scores for each article are shown in Table 5. PEDro scores ranged from 6 to 9 for all studies. Studies by Ay *et al.*,[24] Edwards and Knowles[22] and Eftekar-Sadat *et al.*[33] have PEDro scores of 6, indicating the weakest internal validity of the articles included in this review.

Table 6 describes the key methodological issues and outcomes by study. Eight studies did not include either a sham or intervention group.[8,21,24,25,30,31,35,38] In 14 studies, the examiner was blinded to group allocation.[8,21,23,25–32,34,35,37] Sample size was justified by power analysis in five studies.[28–31,34] In 14 studies, TDN was shown to be effective in reducing pain.[22–25,27–30,33–36,38] No studies specifically

Table 2 Participant Characteristics by Study

Study	Sample Size, n	Age, y*	Duration of Symptoms
Irnich et al[17]	36 entered, 34 completed‡	51.9‡§¶	36.7 mo‡§¶
Edwards and Knowles[8]	40	57 ± 12‡	16 ± 23 mo‡
		55 ± 17¶	10 ± 12 mo¶
		57 ± 19§	16 ± 19 mo§
Huguenin et al[16]	59	--	--
Itoh et al[18]	40 entered, 32 completed	62.3 ± 10.1‡	2.9 ± 2.7 y‡
		62.3 ± 11.0§	3.2 ± 3.1 y§
		65 ± 10.5§	3.3 ± 3.9 y§
		65.0 ± 10.5¶	2.3 ± 1.5 y¶
Ay et al[1]	80	38.1 ± 9.8‡	34.3 ± 40.9 mo‡
		37.2 ± 10.1§	30.6 ± 37.2 mo§
Fernandez-Carnero et al[11]	12 (all female)	25 ± 6‡¶	49.2 mo ± 23.2‡¶
Perez-Palomares et al[28]	122 entered, 112 completed	45.85 ± 14.4‡§	> 4 mo‡§
Srbely et al[34]	40	48.2 ± 15.2‡	--
		45.4 ± 17.8¶	--
Diracoglu et al[5]	52 entered, 50 completed	33 ± 12.7‡	> 6 wk‡
		35.88 ± 9.6¶	
Eftekhar-Sadat et al[9]	20	50.3 ± 9.0‡	>1 mo‡
		50.9 ± 8.9¶	>1 mo¶
Myburgh et al[27]	77	46.07‡	--
		32.46¶	--
Tsai et al[38]	35	46.4 ± 12.2‡	7.5 + 3.9 mo‡
		41.5 ± 10.4¶	6.8 + 4.5 mo¶
Eroglu[10]	60	33.75 ± 8.10‡	48 mo‡
		32.85 ± 9.06§	36 mo§
		34.55 ± 8.30§	24 mo§
Mayoral et al[24]	40 entered, 31 completed	71.65 ± 6.06‡	--
		72.90 ± 7.85¶	--
Tekin et al[35]	39	42.9 ± 10.9‡	63.5 ± 50.7 mo‡
		42.0 ± 12.0¶	57.9 ± 48.3 mo¶
Cotchett et al	84	54.4± 12.4‡	13.6 ± 12.2 mo
		57.8± 12¶	
Mejuto-Vazquez et al	17	25 ± 4‡	3.1 ± 0.8‡ d
		24± 7¶	3.4± 0.7¶ d
Zheng et al	155	42.4 ± 13.7‡	5.3 ± 2.9‡ y
		39.0 ± 14.2§	4.7 ± 2.3§ y
Llamas-Ramos et al	94	31 ± 3‡	7.4± 2.6‡ mo
		31± 2§	7.1± 2.9§ mo

*Values are reported mean ± SD where those data were provided by the authors
‡Dry-needling group
§Comparison group
¶Control (placebo or sham) group

Table 3 Summary of Intervention Groups and Outcome Measures by Study

Study	Intervention Group	Region Treated	Local Twitch Response Elicited	Outcome Measure	Time to Outcomes
Irnich et al[17]	• TDN • Acupuncture (nonlocalized; needles inserted at distant points) • Sham laser acupuncture	• Neck (trapezius, splenius capitus, SCM, levator, paravertebrals, scalenes, semispinalis capitus)	• Yes; part of protocol	• Pain with motion (VAS) • Cervical spine ROM (custom device) • Change of general complaints (-5 to +5 scale)	• Immediate (15-30min)
Edwards and Knowles[8]	• Superficial dry needling to MTrP's and acupuncture points; active stretching home exercise program (multiple interventions over 3 wk) • Active stretching alone (lasting 3 wk) • Control: no intervention	• Multiple; not reported	• Not reported	• Pain (SFMPQ) • PPT (algometry)	• Prior to treatment, 3 wk (immediately following final intervention), 6 wk
Hugeunin et al[16]	• TDN • Placebo TDN	• Gluteal muscles	• Yes; part of protocol	• SLR to first onset of stretch for hamstring length • SLR to max ROM for hamstring length • Hip internal rotation ROM • VAS	• All outcome measures were collected before, immediately after, 24 hr after and 72 hr after intervention
Itoh et al[18]	• TDN • TDN on non-trigger points • Standard Acupuncture • Sham (needles blunted to prevent penetrating skin)	• Cervical and proximal upper extremity muscles	• Yes; part of protocol	• Pain (VAS) • Pain disability (NDI)	• VAS prior to treatment, 1-3 wk, 6-9 wk, and 12 wk • NDI prior to treatment, 3, 6, 9, and 12 wk
Ay et al[1]	• TDN • Lidocaine injection • Stretching exercises (both groups)	• Upper Trapezius	• Yes; part of protocol	• Pain (VAS) • Cervical spine ROM (goniometry) • Beck Depression Inventory	• 4 wk, 12 wk
Fernandez-Camero, et al[11]	• TDN • Sham TDN • (crossover design)	• Masseter muscle	• Yes; part of protocol	• Pain (NPRS) • PPT (algometry) • Pain-free maximal jaw opening	• Prior to treatment, Immediate (5 min)
Perez-Palomares, et al[28]	• TDN once per wk for 3 wk, followed by spray and stretch • PENS 3 times per wk for 3 wk	• Deep lumbar paraspinal, quadratus lumborum, gluteus medius muscles	• Yes; part of protocol	• Pain (VAS) • Sleep quality (VAS) • PPT (algometry) • QoL (ODI)	• VAS prior to treatment, prior to 2nd TDN session, prior to 6th PENS session, and 3 wk • PPT and QoL: prior to treatment and 3 wk
Srbely et al[34]	• TDN • Sham TDN	• Supraspinatus, infraspinatus, and gluteus medius muscles on the right	• Yes, but not mandatory	• PPT	• Pre-treatment, 1,3,5,10, and 15 min post-treatment
Diracoglu et al[5]	• TDN • Sham superficial TDN away from trigger points in temporo-mandibular region	• Temporo-mandibular muscles	• Not reported	• PPT (algometry) • Pain (VAS)	• Prior to treatment, 1 wk post

Table 3 (Continued)

Study	Intervention Group	Region Treated	Local Twitch Response Elicited	Outcome Measure	Time to Outcomes
Eftekhar-Sadat et al[9]	• TDN • Sham TDN	• Gastrocnemius and "cuff muscles" relating to the leg and foot	• Yes; part of protocol	• Pain (VAS) • Dorsiflexion ROM dorsiflexion • Plantarflexion ROM • SEM5, and MDC7 for Foot Functional Index	• 4 wk, and 4 wk after withdrawing treatment
Myburgh et al[27]	• Symptomatic superficial TDN • Symptomatic deep TDN • Asymptomatic superficial TDN • Asymptomatic deep TDN	• Upper Trapezius	• Yes; for deep TDN only	• Pain (NRS - 101) • PPT • Maximum voluntary contraction of affected muscle • Rate of force development of affected muscle	• All variables measured prior to treatment, immediately post-intervention, and 48 hr post intervention
Tsai et al[38]	• TDN • Sham Needling	• Extensor carpi radialis muscles	• Yes; part of protocol	• Pain (NPRS) • Pressure pain threshold (algometry) • Cervical spine ROM (goniometry)	• Immediate
Eroglu et al[10]	• TDN • Lidocaine Injection • Oral flurbiprofen	• trapezius, supraspinatus, rhomboids	• Yes; part of protocol	• PPT (algometry) • Pain (VAS) • Cervical left lateral flexion AROM • Cervical left rotation AROM • Cervical right rotation AROM • QoL via NHP	• Pre-treatment, 3 d post-treatment, 14 d post-treatment
Mayoral et al[24]	• TDN • Sham needling	• tensor fascia lata, hip adductors, hamstrings, quadriceps, gastrocnemius, popliteus	• Yes; but not mandatory	• VAS pain (0-100mm) • VAS <40mm • VAS=0 • Prevalence of MPS • WOMAC • ROM of knee • Peak Isometric strength Flex • Peak isometric strength ext • postoperative demand for analgesics	• Before treatment, 1 mo, 3 mo, and 6 mo
Tekin et al[35]	• TDN • Sham TDN	• 8 cervicothoracic sites	• Not reported	• VAS • QoL via SF-36	• VAS and SF-36 before treatment • VAS after first treatment • VAS and SF-36 after 6th treatment
Cotchett et al	• TDN • Sham TDN	• Distal LE (soleus, gastrocnemius, quadratus plantae, flexor digitorum brevis, abductor hallicus, adbuctor digiti minimi, flexor hallicus longus)	• Yes; part of protocol	• VAS • Foot Health Status Questionnaire • SF-36 • DASH 21 • Likert Scale	• Before treatment, 2 wk, 4 wk, 6 wk, 12 wk post treatment
Mejuto-Vazquez et al	• TDN • No treatment	• Upper trapezius	• Yes; part of protocol	• PPT • NPRS • All cervical ROM	• Before treatment, 10 min post, 1 wk post treatment

Table 3 (Continued)

Study	Intervention Group	Region Treated	Local Twitch Response Elicited	Outcome Measure	Time to Outcomes
Zheng et al	• Ultrasound-Guided Miniscalpal-needle • Ultrasound-Guided TDN	• Lateral to C6	• No	• VAS • NDI • SF-36	• Before treatment, 3 mo post, 6 mo post
Llamas-Ramos et al	• TDN • MTrP Manual Therapy	• Upper trapezius	• Yes; part of protocol	• NPRS • Norwick-Park Neck Pain Questionnaire • PPT • All cervical ROM	• Before treatment, 1 day after final treatment, 1 wk post treatment, 2 wk post treatment

Abbreviations:
AROM, Active Range of Motion; LTR, Local Twitch Response; MDC7, Minimal Detectable Change 7; MPS, Myofascial Pain Syndrome; MTrP, Myofascial Trigger Point; NDI, Neck Disability Index; NHP, Nottingham Health Profile; NPRS, Numeric Pain Rating Scale; NRS, Numeric Rating Scale NSAID, Non-steroidal anti-inflammatory drug; ODI, Oswestry Disability Index; PENS, Percutaneous Electrical Nerve Stimulation; PPT, Pressure Pain Threshold; QoL, Quality of Life; ROM, Range of Motion; SEM5, Standard Error of Measurement 5; SF-36, Short Form (36) Health Survey; SFMPQ, Short Form McGill Pain Questionnaire; SLR, Straight Leg Raise; TMD, Temporo-mandibular Disorder; TDN, Trigger Point Dry Needling; TMJ, Temporo-mandibular Joint; VAS, Visual Analog Scale; WOMAC, Western Ontario and MacMaster Universities Arthritis Index

reported minimal clinical important difference (MCID) scores for pain results and few discussed the clinical implications.

Discussion

The results of this review indicate that TDN appears to be an effective treatment intervention for relief of trigger point-associated pain at various points in time, regardless of body region. For outcome measures related to pain reduction, TDN is more effective than stretching and percutaneous electric nerve stimulation (PENS), and at least equally as clinically effective as manual MTrP release and other needling treatments.[8,21–24,30,38] More research is needed to determine the role of the local twitch response (LTR) and other protocol-related variables.

Methodological considerations

While the articles included in this review are of high quality according to the PEDro scoring system, more thorough reporting and more robust analyses could have strengthened results. Several studies initially read for this review were rejected due to low PEDro scores partially because critical components to the scoring system were not reported in the published article. In order to strengthen the body of literature surrounding TDN, it is recommended that researchers utilize a scoring system, such as PEDro, when drafting their manuscripts in order to ensure that important reporting information is included.

Furthermore, studies should report power analysis and analysis of clinical meaningfulness to add validity to their data. Adequate power is important to substantiate research findings, particularly in studies where no difference is found between intervention and control groups.[39] Only the studies by Huguenin *et al.*,[34] Cotchett *et al.*,[28] Zheng *et al.*[31] and Llamas-Ramos *et al.*[30] reported justification of sample size by a power analysis of at least 0.8 for all of the data presented. Five studies that found no difference between groups for at least one outcome measure after intervention did not report adequate power analysis.[8,21,24,35,38] These studies, therefore, contain the risk that an insufficient number of participants were recruited to reveal what may have been a true difference between groups and a benefit from TDN. This degree of ambiguity suggests that these studies should be replicated with adequate power before their data can be considered conclusive.

Among the studies that found significant differences between groups after intervention, few reported measurable attainment of MCID and effect size scores. While statistically significant values play an important role in determining the influence of an intervention on outcomes, clinical meaningfulness is often a more relevant indicator of potential patient benefit in the practice of physical therapy.[39,40] For the purpose of this review, three authors identified when MCID was met for pain scale outcome measures, which occurred in 15 out of 17 studies, as identified in Table 6.[40] The authors were unable to find evidence in the literature for MCID cutoff scores for PPT. Effect size calculations also offer the reader a sense of clinical meaningfulness by providing a more informed picture of the breadth of the difference between groups.[39] Only the studies by Cotchett *et al.*,[28] Mujeto *et al.*[29] and Llamas-Ramos *et al.*[30] reported effect sizes for their data. Cotchett *et al.*[28] and Llamas-Ramos *et al.*[30] reported medium and large effect sizes when comparing TDN to sham and no intervention, respectively.[28,29] Llamas-Ramos *et al.*[30] reported large effect size when comparing results of TDN treatment to baseline. The other 16 studies that did not report effect sizes create a potential for statistical significance to provide a misleading indicator of clinical effectiveness. Therefore, physical therapists may choose to look to MCID attainment in VAS scores as an indicator of TDN effectiveness for pain reduction, and use clinical

Table 4 Summary of Key Findings, Quality Scores, and Level of Evidence by Study

Study	Key Findings	Quality/Level of Evidence*
Irnich et al[17]	• Decreased pain in nonlocalized acupuncture group (P<0.001) • Improved CS ROM in DN group (P<.05) and nonlocalized acupuncture group (P<0.05) • Significant improvement in assessment of change for nonlocalized acupuncture group as compared to TDN group and control groups (P=0.008 and P=0.001, respectively) No significant difference between TDN and sham groups (P=0.8)	7
Edwards and Knowles[8]	• Decreased pain in group 1 (TDN and stretching) as compared to group 3 (control) at 3 wk follow up (P<0.05) • Improved PPT in group 1 as compared to group 2 (stretch alone) at 3 wk follow up (P<0.05) • Significant correlation between increased PPT and decreased pain scores in group 1 only (R=-0.67, P=0.009)	6
Hugeunin et al [16]	• DN and sham DN equally able to reduce VAS scores during activity but not resting (P<0.05)	8
Itoh et al[18]	• Decreased pain for TDN group as compared to baseline at 3 wk and through end of study (P<0.05) • Decreased pain for TDN group as compared to all other groups at 9 and12 wk (P<0.01) • Decreased disability score on NDI for TDN group as compared to baseline at 3 wk through end of study (P<0.01) • Decreased disability score on NDI for TDN as compared to all other groups at 9 and 12 wk (P<0.01)	7
Ay et al[1]	• Decreased pain for both groups (TDN and Lidocaine) at 4 wk and 12 wk (P<.001) • Improved CS ROM for both groups at 4 wk and 12 wk (P<.05) • Improved depression scale scores for both groups at 4 wk and 12 wk (P<.001) • No significant differences between groups	6
Fernandez-Carnero et al[11]	• Improved PPT scores for TDN group significantly greater than sham group (P<0.001) • Improved active mouth opening ROM for TDN group significantly greater than sham group (P<0.001)	9
Perez-Palomares et al[28]	• Decreased disability score on ODI for "lifting weight" in TDN group only (P<0.05) • No change in pain, PPT, or sleep quality for either group	7
Srbely et al[34]	• Improved PPT scores (P<0.05) at 3 and 5 min post-intervention in segmentally related MTrP's	7
Diracoglu et al[5]	• Improved PPT scores for both TDN and sham groups (P<0.005), but greater improvement for TDN as compared to sham (P<0.001) • No change in jaw opening ROM for either group • Decreased pain for both TDN and sham groups (P<0.001)	8
Eftekhar-Sadat et al[9]	• Mean VAS scores significantly lower than baseline and lower than control group 4 wks post intervention (P<0.001) • No significant change in ankle ROM for TDN and control groups at any time period	6

Table 4 (Continued)

Study	Key Findings	Quality/Level of Evidence*
	• FFI scores significantly improved in TDN group over the control group 4 wks post intervention (P<0.001)	
Myburgh et al[27]	• Significant difference (P=0.01) for 48-hr post-intervention soreness; 50.6% of participants reported soreness from strength test and 9.1% from TDN • No significant difference among groups for maximum voluntary contraction force or rate of force development • Pain significantly decreased from baseline to follow-up for both superficial and deep TDN groups (P<0.05) with no significant difference between groups • Significantly improved PPT scores in all groups over time (P=0.029); no significant changes for treatment groups immediately post-needling or at 48-hour follow up	8
Tsai et al[38]	• Decreased pain in TDN group (P<0.05) compared to sham needling • Improved pressure pain threshold in TDN group (P0<.05) compared to sham needling • Improved CS ROM lateral flexion in TDN group (P0<.05) compared to sham needling	7
Eroglu et al[10]	• Significantly improved PPT and pain for all groups on 3rd and 14th d (P<0.001); no difference between groups • Significantly increased cervical active ROM for all groups on 3rd and 14th d (P<0.001) no difference between groups • Significantly improved QoL for all groups at 3rd and 14th d (P<0.001) with exception of fatigue item on 3rd day for Lidocaine group; no difference between groups for all other measures	7
Mayoral et al[24]	• Significant change from baseline in the number of patients with pain below 40 on VAS at 1 mo for TDN group (P<0.05) but not for sham group • Significantly different variation rates of VAS scores greater than 40 at 1 mo favoring the TDN group P<0.05 • Significantly greater number (p=0.042, 9% difference) of pain-free subjects at 1 mo for TDN group as compared to sham • Nearly a three-fold difference in MPS prevalence at 1 mo favoring the TDN group without significant difference in variation rate between groups; no correlation found between VAS scores and MPS • No differences between groups for WOMAC • No differences between groups for ROM and strength • Significantly decreased use of analgesic medication in the TDN group (31.8%) compared to sham group (68.2%) (P=0.01) • TDN group achieved the same average degree of pain reduction on VAS in 1 month that the control group achieved in 6 months	8
Tekin et al[35]	• Significantly decreased VAS scores immediately after first treatment (P=0.034) and after 6th treatment (P<0.001) for TDN group compared to control	8

Table 4 (Continued)

Study	Key Findings	Quality/Level of Evidence*
	• All SF-36 scores increased in the TDN group (P<0.05) and only scores relating to vitality increased in the sham group	
Cotchett et al	• Significantly greater decrease in VAS scores for TDN group as compared to sham TDN at 6 wk (P=0.002) • •Significantly greater decrease in FHSQ pain scores for TDN group as compared to sham TDN at 6 wk (P=0.029) • MID for FHSQ (13 points) not met for between group comparison	9
Mejuto-Vazquez et al	• Significant decrease in pain on NPRS scores at 10 min and 1 wk (P< 0.001) • MCID met at 1wk for pain on NPRS scores. • Significantly improved PPT (P< 0.001) for cervical region • Significantly improved PPT (P< 0.01) for second metacarpal • Significantly improved PPT (P=0.009) for tibialis anterior • Significantly improved ROM cervical lateral flexion (P=0.004), cervical rotation (P=0.009), cervical flexion (P=0.008), cervical extension (P=0.01)	8
Zheng et al	• Significantly decreased VAS scores at 3 mo and 6 mo (P=0.0001) for Miniscal-pal-needle group compared to TDN group • Significantly decreased NDI scores at 3 mo and 6 mo (P=0.0001) for Miniscalpal-needle group compared to TDN group • Significantly decreased SF-36 physical component scores at 3 mo (P=0.013) and 6 mo (P=0.024) for Miniscalpal-needle group compared to TDN group • No difference between groups for SF-36 mental component score at 3 mo (P=0.778) and 6 mo (P=0.871) • VAS decreased 51.5% at 3 mo and 44.1% at 6 mo in the Miniscalpal-needle group. • VAS decreased 40.8% at 3 mo and 18.3% at 6 mo for the TDN group.	9
Llamas-Ramos et al	• Significant decrease in VAS score in TDN and manual groups (P<0.001) • Significant decrease in disability from baseline in TDN and manual groups (P<0.001) • Significantly improved PPT scores in TDN and manual groups, compared to baseline (P<0.001) • Improved PPT scores in TDN greater than manual group with large effect size (0.91<standardized mean difference<1.22)) • Significant increase in all ranges of cervical ROM for TDN and manual groups (P<0.001)	9

Abbreviations*:*

FFI, Foot Function Index; FHSQ, Foot Health Status Questionnaire; MPS, Myofascial Pain Syndrome; MTrP, Myofascial Trigger Point; ODI, Oswestry Disability Index; PPT, Pain Pressure Threshold; QoL, Quality of Life; ROM, Range of Motion; SF-36, Short Form (36) Health Survey, TDN, Trigger Point Dry Needling; VAS, Visual Analog Scale; WOMAC, Western Ontario and MacMaster University Arthritis Index

*PEDRO score (range 0-10) with scores of 6 or greater indicating high quality evidence. Level-of-evidence ratings were assigned by RMPF, DR, EIB

judgement, along with statistical significance, as a guide when considering whether or not to treat other impairments with TDN.

Finally, out of the 10 studies which compared TDN to sham, only three[23,28,34] performed an analysis of blinding to sham techniques. In order to truly control the potential placebo effects, participants must be blind to the fact that they are receiving sham treatments when allocated to a control group.[39] An analysis of this blinding strengthens the internal validity of studies, which use this type of design. Due to the potential benefits of superficial dry needling, needling in segmentally related areas and palpation for reducing pain[10] using these options as a sham technique for TDN research makes this issue of establishing a true, blinded control group even more important and challenging. This is particularly relevant in studies that reveal no difference between groups for at least one outcome measure. When statistical analysis reveals a significant difference between experimental and control groups, it may be assumed that the method of control, whether treatment or placebo, was appropriate.

Overview of study designs and protocols

Among the studies reported in this review, multiple outcome measures were reported for impairments relating to pain, sleep quality, ROM, muscle length, disability, depression, function, quality of life and strength. The variety of outcome measures represented by the studies in this review provides insight into the impairments that may be influenced by TDN and the ways in which benefits can be measured. It appears that TDN, as performed and measured in each study, does not influence strength, variably improves ROM and function, and frequently decreases pain. These trends must be considered with caution, however, due to methodological issues discussed above and differing methods represented for the collection of some outcome measures. Clinicians are advised to keep these limitations in mind when drawing conclusions regarding the applicability of TDN to multiple impairments.

The most commonly used outcome measures were VAS for pain[8,21,23,24,28,31–34,36,38] and algometry for PPT.[8,22,25,26,29,30,32,35,37,38] The majority of studies indicate that TDN treatment decreases pain at various points in time after treatment. While immediate measures of pain reduction may be influenced by post-needling soreness, as suggested by Irnich *et al.*,[21] studies by Huguenin *et al.*[34] and Perez-Palomares *et al.*[8] found no pain reduction at 72hours (during activity) and 6weeks, respectively.[8,21,34] These results indicate that variables in addition to time are at play and should be examined in future research.

The results of this review indicate that multiple protocol-related variables may influence TDN outcomes. Individual study designs included here differently manage potential key variables, such as pain chronicity, needling technique, elicitation of LTR, number of treatment sessions, presence of adjunct interventions, outcomes measured and time to outcome measurement. More studies are needed to evaluate the influence that these variables may have on patient outcomes. In order to truly isolate variables, future TDN studies should be carried out in a progressive manner. Until more evidence is available, physical therapists should utilise clinical judgement to determine whether or not a particular patient is a good candidate for TDN, considering treatment effects, such as post-needling soreness, as well as patient-related factors, including level of comfort with needles and individual pain behaviours.

Role of the LTR

The role of the LTR as it pertains to TDN outcomes is the source of key conceptual and procedural discrepancies in the literature. Among the articles included in this review, conflicting opinions exist as to whether or not the presence of an LTR is mandatory for successful treatment. Theoretically, the elicitation of a LTR is a critical component of TDN treatment because it confirms accurate needle placement. Some research has shown a positive correlation between the presence of a LTR in treatment with positive clinical outcomes as well as physiologic changes within the muscle to a more normalised chemical state.[41] Out of the 15 studies included in this review, seven required and definitively reported at least one LTR per treatment as part of the study protocol.[21,24–26,33,35,38] Of these seven studies, mixed results were reported. Irnich *et al.*[21] found no significant difference immediately after intervention between TDN and sham needling groups for pain and subjective complaint report. As previously mentioned, the authors state that this measure may not represent the clinical effectiveness of TDN because no measures were taken over time.[21] Mybergh *et al.*[35] found no significant difference immediately and 48hours after intervention between a deep dry needling group in which LTRs were evoked and a superficial dry needling group in which they were not. The other five studies which reported LTRs found significant improvement ($P<0.5$) in key outcome measures for the intervention group as compared to the control.[24–26,33,38] Caution should be taken in comparing the results of these studies, however, because participants, protocols and outcome measures were not the same among them.

Six additional studies in this review included an attempt to elicit LTRs as a mandatory part of their protocols, but the authors did not report whether, or how many, LTRs were actually elicited per participant.[8,23,28–30,34] There are mixed results among these studies, with three finding significant difference between intervention and controls for the most important outcome measures,[23,28,29] one finding equal effectiveness of TDN compared to manual MTrP release,[30] and two finding minimal benefit from TDN compared to controls.[8,34] Due to different research methods, poor or absent power analysis and insufficient data from the articles in this review, no conclusion can be made here regarding the role of LTRs in the successful application

Table 5 PubMed, Physiotherapy Evidence Database (PEDro) scores for the individual items.

	Item											
Study	1*	2	3	4	5	6	7	8	9	10	11	Total
Irnich *et al.*[21]	Y	Y	Y	N	Y	N	Y	Y	N	Y	Y	7
Edwards and Knowles[22]	Y	Y	Y	Y	N	N	N	Y	N	Y	Y	6
Hugeunin *et al.*[34]	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	8
Itoh *et al.*[23]	Y	Y	N	Y	Y	N	Y	N	Y	Y	Y	7
Ay *et al.*[24]	Y	Y	Y	Y	N	N	N	Y	N	Y	Y	6
Fernandez-Carnero *et al.*[25]	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	9
Perez-Palomares *et al.*[8]	Y	Y	Y	Y	N	N	Y	Y	N	Y	Y	7
Srbely *et al.*[37]	Y	Y	Y	N	Y	N	Y	Y	N	Y	Y	7
Diracoglu *et al.*[32]	Y	Y	N	Y	Y	N	Y	Y	Y	Y	Y	8
Eftekhar-Sadat *et al.*[33]	Y	Y	Y	Y	N	N	N	N	N	Y	Y	6
Myburgh *et al.*[35]	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	8
Tsai *et al.*[26]	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y	7
Eroglu *et al.*[38]	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y	7
Mayoral *et al.*[36]	N	Y	N	Y	Y	N	Y	Y	N	Y	Y	7
Tekin *et al.*[27]	N	Y	N	Y	Y	N	N	Y	N	Y	Y	8
Cotchett *et al.*[28]	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	9
Mejuto-Vazquez *et al.*[29]	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8
Zheng *et al.*[31]	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	9
Llamas-Ramos *et al.*[30]	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	9
% 'Yes'	89	100	68	89	74	0	74	89	37	100	100	
Average PEDro score												7.5

PEDro criteria Item 1: (*not scored) eligibility criteria specified. Item 2: subjects were randomly allocated. Item 3: allocation was concealed. Item 4: groups were similar at baseline for most important prognostic indicators. Item 5: there was blinding of all subjects. Item 6: there was blinding of all therapists. Item 7: there was blinding of assessors of outcomes. Item 8: measures of at least one key outcome were collected from 85% of subjects initially allocated. Item 9: intention-to-treat analysis was performed. Item 10: between-group comparisons reported for at least one key outcome. Item 11: study provided point measures and measures of variability for at least one key outcome.

of TDN. Future studies should isolate the LTR variable in order to determine its role in TDN treatment.

TDN effectiveness by region

To the best of our knowledge, this is the first systematic review to investigate the effectiveness of TDN specifically for multiple body regions. The pragmatic study by Edwards and Knowles[22] is the only one that treated MTrPs in multiple regions. They found significant decreased pain and tenderness over time for all participants, but did not provide analysis of results by body region.[22]

Temporomandibular joint

Two studies of TDN to muscles surrounding the temporomandibular joint report effectiveness for reducing pain compared to sham groups, but the studies found conflicting results for ROM.[25,32]

Cervical spine and shoulder

For MTrPs in muscles attaching to the cervical spine and shoulder, TDN appears to be effective in reducing pain and tenderness and improving ROM over time, with results being significantly better than sham and at least equivalent to other treatments such as manual MTrP release, pharmaceutical injections, acupuncture, and oral anti-inflammatories.[21,23,24,27,29,30,35,37,38] According to the study by Zheng *et al.*,[31] TDN does not appear to be as effective as miniscalpel needle release to cervical paraspinals.

Upper extremity

Tsai *et al.*[26] conducted the only study relating to the distal upper extremity and found significant improvements in pain, tenderness and cervical spine ROM with interventions targetted to the extensor carpi radialis muscles.

Lumbar spine

Little benefit from TDN was found for treatment to lumbar paraspinal muscles in the only included study for this body region, by Perez-Palomares *et al.*[8]

Lower extremity

Two studies looked at interventions to the proximal lower extremity; Hugeunin *et al.*[34] performed TDN to glutaeal muscles with minimal benefit while Mayoral *et al.*[36] found statistically significant and more rapid improvements in pain following total knee arthroplasty with treatment to the lower extremity, as compared to a control group. For the distal lower extremity, the study by Eftekhar-Sadat *et al.*[33] found significant improvements in pain and function for TDN treatment to posterior leg muscles. Similarly, Cotchett *et al.*[28] found significant improvements in pain and subjective foot health report for TDN to the plantar foot as compared to sham needling.

In general, there appears to be no difference in the results of TDN treatment to various body regions for pain reduction and PPT improvement. For regions that were represented by only one study in this review, there is insufficient high-quality evidence to draw firm conclusions.

Clinical relevance of findings

The majority of high-quality studies included in this review show statistically significant benefit from TDN for the reduction in pain related to MTrP's in multiple body areas, suggesting broad applicability of TDN treatment for

Table 6 Summary of Key Methodological Issues and Outcomes by Study

Study	True Control (Sham or Placebo)	Examiner Blinded to Group Allocation	Sample Size Justified by Power Analysis	TDN Group: Effectiveness for Pain Reduction from Baseline (Statistical Significance)	Clinical Meaningfulness of Magnitude of Pain Reduction (MCID) Met*
Irnich et al[17]	No	Yes	No	No	No
Edwards and Knowles[8]	Yes	No	No analysis	Yes§	-
Huguenin et al[16]	Yes	Yes	Yes; 80% power achieved	Yes‡	Yes
Itoh et al[18]	Yes	Yes	No analysis	Yes§¶	Yes
Ay et al[1]	No	No	No	Yes¶	Yes
Fernandez-Carnero et al[11]	No	Yes	No analysis	Yes‡, PPT	No
Perez-Palomares et al[28]	No	Yes	No analysis	No	Yes
Srbely et al[34]	Yes	Yes	No analysis	No	-
Diracoglu et al[5]	Yes	Yes	Yes; 99% achieved in post-hoc analysis for algometric measurements only	No	Yes
Eftekhar-Sadat et al[9]	Yes	No	No	Yes¶	Yes
Myburgh et al[27]	No	Yes	Not for subgroup analysis	Yes§	Yes
Tsai et al[38]	Yes	Yes	No	Yes‡	Yes
Eroglu et al[10]	No	No	No	Yes§	Yes
Mayoral et al[24]	Yes	No	No	Yes¶	Yes
Tekin et al[35]	Yes	Yes	No analysis	Yes‡¶	Yes
Cotchett et al	Yes	Yes	Yes; 80% power achieved	Yes	Yes
Mejuto-Vazquez et al	Yes	Yes	No analysis	Yes‡§	Yes§
Zheng et al	No	Yes	Yes; 80% power achieved	No analysis	Yes
Llamas-Ramos et al	No	Yes	Yes; 90% power achieved	Yes	Yes

‡Times to outcome represent-Immediately
§Times to outcome represent-<3 wk
¶Times to outcome represent->3 wk
**Yes or No values were reported when MCID was available for the relevant outcome measure*
Abbreviations:
DDN, Deep Dry Needling; MCID, Minimally Clinically Important Difference; PPT, Pain Pressure Threshold; TDN, Trigger Point Dry Needling; VAS, Visual Analog Scale;

multiple muscle groups. Again, caution should be taken when comparing the results of these studies due to differences in protocol. A systematic review of the findings included here seems to indicate that TDN offers the possibility of allowing therapists to treat soft tissue restrictions more effectively and with faster results than either traditional or no intervention. If further research substantiates this trend, TDN treatment may allow for improved tolerance to other interventions, such as manual therapy and therapeutic exercise, with potential for overall accelerated progression and more lasting positive results. Future studies should determine whether or not a treatment effect exists when TDN is combined with joint mobilisations and therapeutic exercise.

Eight studies in this review compared TDN to another form of treatment (see Table 3).[8,21–24,30,31,38] The results of these studies indicate that TDN may be the treatment of choice over some traditional interventions, but it does not appear to be superior to other needling techniques for pain reduction. Specifically, Edwards and Knowles[22] and Perez-Palomares *et al.*[8] found TDN to be superior to stretching and PENS for at least one outcome measure. Llamas-Ramos *et al.*[30] compared TDN to manual MTrP release and found equal benefit for pain reduction post treatment and at 2-week follow up, with improved PPT scores greater in the TDN group as compared to the manual release group.[30]

In regards to other forms of needling, Itoh *et al.*[23] and Irnich *et al.*[21] reported conflicting results when comparing TDN to standard acupuncture. Itoh *et al.*[23] found TDN to be superior to acupuncture for pain and disability, as evidenced by both statistically significant difference and clinically meaningful improvement. Irnich *et al.*[21] reported statistically significant improvement in VAS scores for acupuncture over TDN, but MCID between groups for this measure was not achieved. While both groups improved equally in ROM, the acupuncture group reported greater overall change. The data reported in these two studies indicate general similarities in outcomes for TDN and acupuncture, with conflicting results possibly being attributable to differences in study conditions. Zheng *et al.*[31] compared TDN to miniscalpel needling under ultrasound guidance and found that, while both groups demonstrated decreased pain from baseline, the miniscalpal technique

provided statistically significant greater reduction in pain than the TDN group. When comparing TDN to lidocaine injection, Ay *et al.*[24] and Eroglu *et al.*[38] found statistically significant benefit from baseline for all groups, with no difference between the groups, for at least one outcome measure. These results suggest the need for a cost/benefit analysis of TDN compared to other needling treatments, particularly pharmaceutical injection, which likely incurs greater monetary expense and presents greater health-related risks than TDN.

Heterogeneity of study patients, methods and outcome measures in the data presented here complicates comparisons among studies and analyses of results. While certain trends are identified in this review, caution should be taken when extrapolating these results to the clinical setting because comparisons are not exact, and limitations in methodological rigour exist.

Based on the search results conducted for this review, one prior meta-analysis focussed specifically on the effectiveness of TDN has been published.[18] This meta-analysis included studies of upper-quarter myofascial pain published up through 2012 and looked exclusively at the effectiveness of TDN for pain reduction.[18] The systematic review presented here builds upon the prior study by including the most recent evidence from 2013 to 2014. It also strives to expand upon the discussion of TDN effectiveness by representing the broader scope of impairments and body regions targetted with TDN treatment.

Limitations

Results were limited by the inclusion of only English-speaking articles. Access to new, unpublished data were not available by the time this review was submitted; therefore, the results presented here may be influenced by publication bias.

A wide variety of TDN protocols were used in the RCT's reviewed, which complicates comparison of study outcomes and possibly jeopardises the external validity of this review. Heterogeneity of study protocol contributed to the author's decision to forego conducting a meta-analysis of the data. While the PEDro score effectively judges internal validity, use of other clinical appraisal tools may have enhanced the analysis of study design and methods.

Conclusion

The majority of the highest-quality studies of TDN in the literature to date seem to indicate that TDN is effective for reducing pain and tenderness in multiple body regions, including the head, trunk, upper extremity and lower extremity. Lack of consistency among the articles in this review in regards to patient recruitment, protocol, methodology and outcome measures precludes the formation of any strong conclusions from the available data. Nevertheless, an emerging body of evidence exists to suggest that multiple body regions may benefit from TDN for pain reduction, improved function and improved ROM. More high-quality studies and replication of current studies are needed to further substantiate this trend. Future studies should follow specific, sequenced protocols designed to isolate variables of interest. Multiple outcome measures should be explored per study, with measures over time, in order to better understand the potential benefits of TDN and guide clinical decision-making.

Key points

Findings

Trigger point dry needling appears to reduce myofascial pain, regardless of body region, at various points in time.

Implications

Physical therapists may choose to use TDN as an adjunctive treatment to reduce pain related to MTrPs. Future research should focus on isolating potentially key variables, developing a standardise protocol and performing a cost-benefit analysis.

Caution

Heterogeneity among patient characteristics and protocols limits comparisons between studies. There is limited evidence for TDN to the distal upper extremity, lumbar spine and distal lower extremity.

Disclaimer Statements

Contributors All authors were involved in the design, gathering of information, data analysis, write up and final edits.

Funding There is no funding for this article.

Conflicts of interest There are no conflicts of interest.

Ethics approval None required for this review as there were no subjects involved in the study.

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