Accepted Manuscript

Original article

Title: Percutaneous electrolysis and microelectrolysis for musculoskeletal pain management: milliamps or microamps? An evidence-based comparison through systematic review and meta-analysis

Authors: Hernán Andrés de la Barra Ortiz, Claudio Chamorro, Óscar Ronzio

Hernán Andrés de la Barra Ortiz - 0000-0002-3927-1743
Claudio Chamorro - 0000-0002-6703-8842
Óscar Ronzio - 0000-0002-0004-5992

DOI: https://doi.org/10.5114/areh.2024.141103

To appear in: Advances in Rehabilitation

Received date: 25 January 2024
Accepted date: 1 July 2024

Please cite this article as: de la Barra Ortiz HA, Chamorro C, Ronzio Ó. Percutaneous electrolysis and microelectrolysis for musculoskeletal pain management: milliamps or microamps? An evidence-based comparison through systematic review and meta-analysis. Adv Rehab. (2024), https://doi.org/10.5114/areh.2024.141103

Percutaneous electrolysis and microelectrolysis for musculoskeletal pain management: milliamps or microamps? An evidence-based comparison through systematic review and meta-analysis

Hernán Andrés de la Barra Ortiz[1,2,A-F], Claudio Chamorro[1,C-F], Óscar Ronzio[3,4,B,D-F]

[1]Exercise and Rehabilitation Sciences Institute, School of Physical Therapy, Faculty of Rehabilitation Sciences, Universidad Andres Bello, Santiago, 7591538, Chile
[2]Physiotherapeutic Resources Research Laboratory, Department of Physical Therapy, Federal University of São Carlos (UFSCar), São Paulo, Brazil
[3]Facultad de Ciencias de la Salud, Carrera de Kinesiología y Fisiatría, Capital Autónoma de Buenos Aires, Argentina
[4]Instituto de Ciencias de la Salud, Carrera de Licenciatura de Kinesiología y Fisiatría, Universidad Nacional Arturo Jauretche, Capital Autónoma de Buenos Aires, Argentina

Abstract

Introduction
Invasive techniques like percutaneous electrolysis have recently surged in popularity for treating musculoskeletal disorders. However, emerging techniques have sparked debates on optimal intensity current, highlighting the need for clarity in their efficacy.

Objective
To assess and compare the effects of electrolysis and microelectrolysis on pain intensity in individuals with musculoskeletal pain.

Methods
This study is a quantitative systematic review with an observational, retrospective, and secondary design. The search included databases such as PubMed, Scopus, Web of Science, EMBSCOhost, Embase, Cochrane Library, PEDro, and Google Scholar (updated on July 1, 2024). Independent reviewers selected eligible studies and assessed their quality using the Cochrane risk of bias 2 tool. Pain intensity was the primary outcome, while secondary outcomes included pain pressure threshold and disability. The meta-analysis calculated pooled effects using mean differences or standardized mean differences for these outcomes.

Results
Twenty-eight studies were included with an overall low risk of bias (21.4%). Randomization and outcome measurement (21.4%), intervention deviations (28.6%), and outcome measurement (53.6%) were all sources of bias. Post-treatment, pain intensity, and disability reduction were statistically significant ($p < 0.01$) for microelectrolysis (pain: SMD = -0.92; 95% CI: -1.3, -0.5 and disability: SMD = -0.92; 95% CI: -1.3, -0.5) and electrolysis (pain: SMD = -0.3; 95% CI: -0.6, -0.01 and disability: SMD = -1.8; 95% CI: -3.1, -0.6). For the pain pressure threshold, none of the modalities outperformed the controls.

Conclusions
This review highlights the effectiveness of electrolysis modalities in managing musculoskeletal pain and disability, especially microelectrolysis. Further research is needed to understand their analgesic mechanisms, and US-guided decisions should be based on comprehensive risk-benefit assessments.

Keywords: Musculoskeletal pain, Electrolysis, Pain Management, Direct current, Intratissue percutaneous electrolysis.

***Correspondence:** Hernán Andrés de la Barra Ortiz, Exercise and Rehabilitation Sciences Institute, School of Physical Therapy, Faculty of Rehabilitation Sciences, Universidad Andres Bello, Santiago, 7591538, Chile; email: handresdelabarra@yahoo.es

Introduction

Musculoskeletal pain (MSP) stands as a significant global health concern, affecting over 30% of the global population [1]. It encompasses a spectrum of acute and chronic discomforts arising from musculoskeletal disorders such as fractures, sprains, tendinopathies, and joint diseases [2]. Chronic MSP, which affects 20–33% of individuals globally, not only diminishes functionality and quality of life, but also contributes substantially to the global burden of disability [1]. Inadequate MSP management exacerbates healthcare costs, sick leave rates, and productivity losses, highlighting the urgent need for effective treatment approaches [1,2].

Myofascial pain syndrome is one of the most common types of chronic musculoskeletal pain [3]. It is characterized by specific tender spots known as myofascial trigger points (MTrPs) [3]. Palpation identifies MTrPs as muscle nodules within taut muscle bands. When stimulated, MTrPs can reproduce patterns of referred pain, causing motor and autonomic dysfunctions. Myofascial pain syndrome results from sarcomere contractures caused by excessive acetylcholine release, leading to local ischemia, pH changes, and nociceptor activation [3,4]. Direct factors like trauma, microtrauma, and overuse, as well as indirect ones like nutritional disturbances, sleep disorders, metabolic problems, or stress, can trigger the syndrome. These factors increase muscle tone by facilitating the formation of MTrPs, activating nociceptors, and releasing inflammatory mediators in the affected muscles [3]. Additionally, MFPS often accompanies other musculoskeletal conditions affecting the cervical, lumbar, and shoulder regions, resulting in regional pain [3,4].

Managing chronic MSP requires a multimodal therapeutic approach integrating pharmacological, non-pharmacological, and interventional pain management strategies [2]. Among these modalities, physical therapy emerges as a pivotal cornerstone, recognized for its clinical efficacy and cost-effectiveness [5] Evidence supports physiotherapy interventions as first-line treatments for a diverse spectrum of musculoskeletal conditions, encompassing therapeutic exercise, manual therapy, and electrophysical agents [4]. These interventions play a crucial role in alleviating MSP, promoting tissue healing, managing edema, and enhancing muscle strength, thereby facilitating patient recovery, and improving function [5]. Furthermore, electrotherapy modalities, as part of physical agents, play crucial roles as adjuncts in managing musculoskeletal disorders [4-6].

In recent years, there has been a growing interest in electrolysis techniques that use direct current (Galvanic) administered through percutaneous acupuncture-like needles to treat tendinopathies [7,8]. These techniques combine mechanical needle stimulation with current

stimulation, inducing controlled microtrauma in affected musculoskeletal tissues to stimulate healing processes [7,9]. Electrolysis distinguishes itself from microelectrolysis by employing direct currents ranging from 1 to 5 mA [8,9], in contrast to microelectrolysis' lower currents between 100 and 990 mA [7,10]. Both approaches deliver the current percutaneously via an acupuncture needle linked to the cathode. The goal of electrolysis is to cause inflammation by starting a nonthermal electrolytic reaction in specific tissues through the polar effects of the cathode. This causes electrochemical changes like higher pH, vasodilation, and the melting of substances. This process aids tissue healing, reduces inflammation, and alleviates pain, making it beneficial for treating tendinopathies, sprains, and myofascial trigger points (MTrPs) [7,9,11].

These techniques, commercialized under various names such as EPI®, EPTE®, MEP®, or Physio Invasiva®, collectively termed percutaneous electrolysis, are often conducted with ultrasound guidance but occasionally reported without, especially for MEP procedures [7,10]. Based on the reciprocity law (Bunsen-Roscoe law), these methods cause tissue electrolysis, though the rate of response varies due to differences in current densities, which are usually between 2.5 and 13.15 mA/cm^2 depending on the needle size [10,11]. While the therapeutic effects of electrolysis modalities may be similar, disparities in current density could result in either more comfortable or uncomfortable clinical responses for patients [12,13].

Although both electrolysis and microelectrolysis show promise in reducing pain in musculoskeletal disorders, there is a need for studies that support and compare the effects of both modalities as relatively recent techniques. Therefore, the objective of this systematic review (SR) is to evaluate the analgesic effects of electrolysis modalities in individuals with MSP conditions and explore their effects on disability and function, contributing to the growing body of evidence on the effectiveness of electrolysis for MSP and shedding light on its potential as a therapeutic approach.

Materials and methods

Design

The type of study is a quantitative-systematic review. The design is observational, retrospective, and secondary. This research was guided by the PICOS approach (population, intervention, comparison, outcome, and study type), which focused on individuals with musculoskeletal disorders who underwent electrolysis or microelectrolysis intervention and compared them with other physical therapy modalities, conservative interventions, or a placebo. The primary outcome was pain intensity using validated instruments such as the Visual Analog

Scale (VAS) and the Numeric Pain Rating Scale (NPRS), among others. Secondary outcomes included pain pressure threshold (PPT) measured with algometry, disability, or function using validated scales or indexes, such as the Neck Disability Index (NDI), the Northwick Park Neck Questionnaire (NPQ), the Victorian Institute of Sport Assessment-Achilles (VISA-A), the Victorian Institute of Sport Assessment Patella (VISA-P), the Shoulder Pain and Disability Index (SPADI), and functional tests. The included studies were RCTs or non-RCTs.

This review followed the PRISMA guidelines for preferred reports of systematic reviews and meta-analyses [14]. The National Institute for Health Research (NIHR) registered this review in the international prospective systematic review database (PROSPERO) on April 9, 2024 (CRD CRD42024530324).

Selection criteria

The following criteria were used to include studies in this review: (i) RCTs or non-RCTs with people with a diagnosis of any kind of musculoskeletal disorder; (ii) treatment with EL or MEL, either alone or in combination with other therapies; (iii) comparison with other physical therapy treatments or placebo EL or MEL; (iv) main outcome was changes in pain intensity; (v) secondary outcome was changes in function or disability. This review excluded literature reviews, other systematic reviews on electrolysis, studies on musculoskeletal conditions accompanied by neurological disorders, studies in languages other than English, Spanish, or Portuguese, and studies with incomplete or unavailable full texts.

Search strategy

An electronic search was conducted to identify randomized controlled trials (RCTs) examining the effects of electrolysis or microeletrolysis on patients with MSP. Databases including PubMed, Web of Science, Scopus, EBSCOhost, Embase, the Evidence-Based Physiotherapy (PEDro) database, Cochrane Library, and Google Scholar were systematically searched (updated on July 1, 2024).

The search was conducted using a comprehensive set of keywords: "*Electrolysis," "Electroacupuncture," "Direct current," "Intratissue percutaneous electrolysis," "Microelectrolysis," "Pain Management," "Tendinopathy," "Myofascial pain syndromes,"* and *"Trigger points."* The search strategy combined these keywords using 'OR' and 'AND' as boolean connectors. The search algortimh was structured as follows: *("electrolysis" OR*

"electroacupuncture" OR "direct current" OR "intratissue percutaneous electrolysis" OR "microelectrolysis") AND ("musculoskeletal pain" OR "pain management" OR "tendinopathy" OR "myofascial pain syndromes" OR "trigger points").

Three researchers (HDB, CCH, and OR) conducted the literature review using the Rayyan web tool to evaluate the titles and abstracts of the articles for relevance [15]. Relevant full-text articles were then thoroughly analyzed, with discrepancies resolved through collaborative discussion. Data extraction focused on participant demographics, study selection criteria, interventions, assessment methods, and outcomes of interest.

Quality of studies and risk of bias

The quality of the studies and risk of bias were evaluated using the PEDro scale and the Cochrane Collaboration RoB 2 tool (RoB2), respectively [16]. RCTs scoring 5 or lower on the PEDro scale and exhibiting two or more criteria of high RoB were classified as low-quality studies. The kappa statistic was employed to gauge the inter-rater agreement for the RoB assessment among the researchers [17].

Statistical analysis

A meta-analysis was conducted for continuous variables related to pain intensity, PPT, and disability, assessed in a minimum of two studies. Following Cochrane guidelines, the analysis was stratified by group in studies with three arms, comparing the electrolysis or microelectrolysis group with a combined group to create a single pairwise comparison [18]. Mean differences (MDs) or standardized mean differences (SMDs) with their respective 95% CI were calculated to assess relevant outcomes in terms of weighted mean difference (WMD) or pooled effect size. The Chi-squared ($\chi 2$) test and the I^2 statistic were used to evaluate heterogeneity between RCTs. Heterogeneity was rated as either not significant (0–40%), moderate (30–60%), substantial (50–90%), or significant (75–100%). According to the observed level of heterogeneity, the DerSimonian and Laird random-effects or Mantel-Haenszel fixed-effects methods were selected for the analysis based on the observed level of heterogeneity (95% CI). Statistical analyses were performed using Review Manager 5.4 software.

Quality of evidence (QoE)

The QoE regarding electrolysis techniques for statistically significant outcomes was assessed using the GRADE approach, considering the following criteria [20,21]: (a) Study limitations: arising from blinding, allocation deficiencies, or overestimation of treatment effects; (b) Inconsistency: determined by heterogeneity (> 50%) in main outcomes; (c) Indirectness: stems from significant deviations in treated individuals or when compared to less common interventions; (d) Imprecision: involves uncertainty due to broad confidence intervals crossing the line of no effect in the meta-analysis and an optimal sample size necessary for relevance (> 400); (e) Publication bias: when there are fewer than three relevant studies, potentially biasing the results. Evidence levels ranging from high to very low certainty were assigned, with associated levels of importance: not important, important, or critical. The synthesis of evidence for both electrolysis techniques was summarized using the GRADEpro GDT tool to construct a summary table (www.gradepro.org).

Results

Search results

The preliminary search comprised the exploration of six electronic databases (PubMed, Scopus, Web of Science, EBSCOhost, Embase, Cochrane Library, and PEDro database), resulting in the retrieval of 3,236 articles from databases and registries. Additionally, 32 articles were identified through alternative methods, principally via manual search on Google Scholar. Following the removal of 1,702 duplicate articles, detailed analysis of 1,534 studies led to the inclusion of 41 for comprehensive examination. Fifteen studies were excluded due to their nature as case series (n=3), case report studies (n = 7), RCT protocols (n = 2), incomplete studies (n = 2), and electrolysis studies in healthy subjects (n = 1). After examining alternative methods, 30 studies were excluded due to their duplication with formal database articles (n = 27), RCTs in healthy subjects (n=1), a critical review study (n = 1), and a case series study (n = 1). Appendix 1 provides a comprehensive overview of the excluded studies. A compilation of twenty-eight studies was included in this review [7,11,22–44]. Figure 1 outlines the search strategy via the PRISMA flowchart [14]. Appendix 2 summarizes the search strategy for the selected databases.

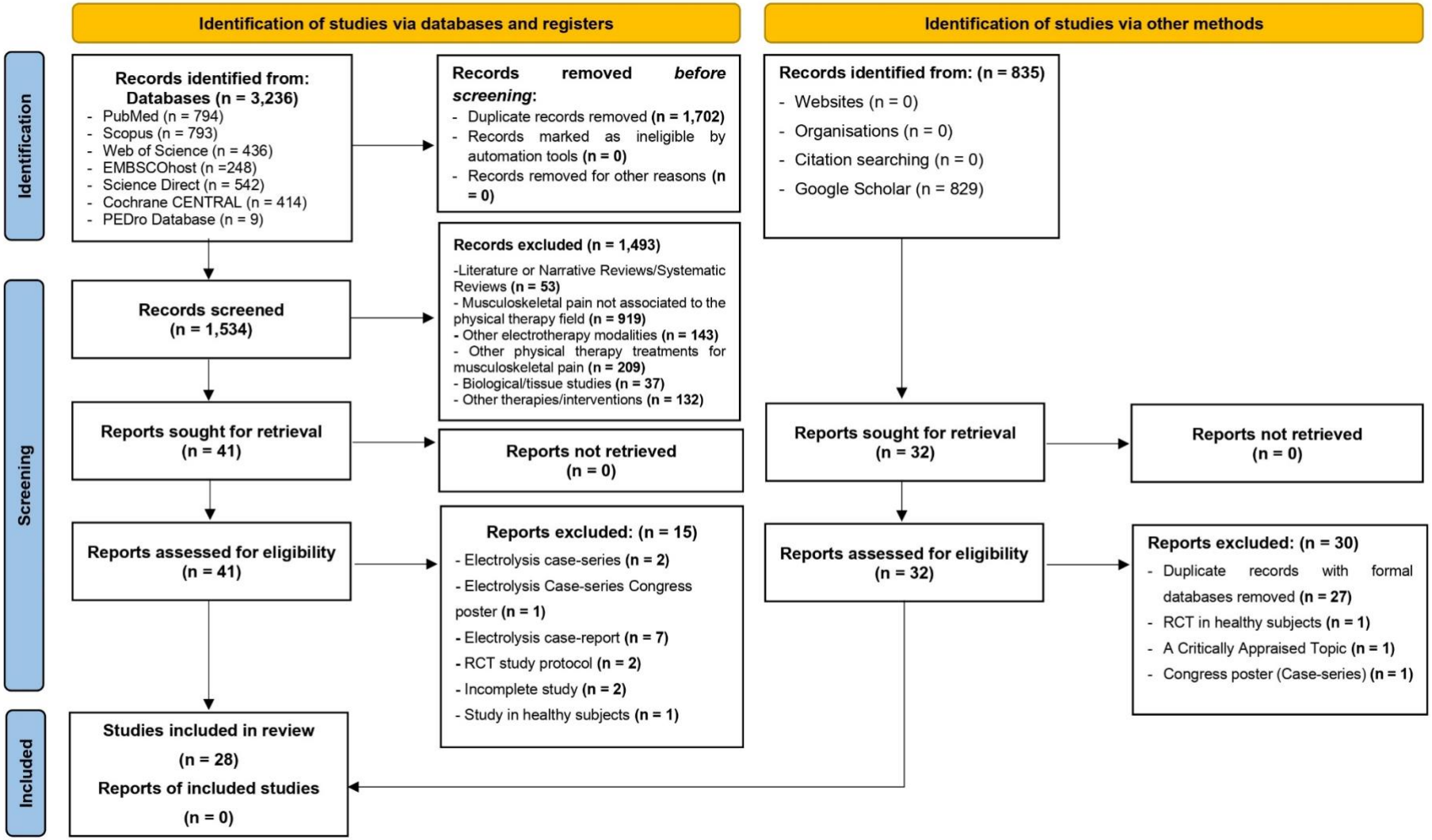


Fig. 1. PRISMA flow chart

Methodological quality and Risk of Bias

The methodological quality of the included studies with the PEDro scale resulted in an average score of 6.6 points (± 2.0) (Tab. 1) [16]. Criteria of highest quality included random allocation (82.2%), comparability of baseline groups (82.2%), and detailed reporting of outcome measures and variability (100%). Conversely, criteria with lower scores included concealed allocation (46.4%), subject blinding (50%), and assessor blinding (57.2%). The RoB assessment, conducted by researchers (HDB, CCH, and OR) for the 27 included studies, is depicted in Figure 2 [17]. Inter-rater agreement indicates good concordance (Fleiss kappa = 0.74) [18]. Sources of bias included bias arising from the randomization process and bias in outcome measurement (both 21.4%). Some concerns revolved around bias due to deviations from intended interventions (28.6%) and bias in outcome measurement (53.6%). Conversely, RoB was lower for bias due to missing outcome data (criterion 3) and selective outcome reporting (criterion 5). The overall RoB was assessed as 21.4%.

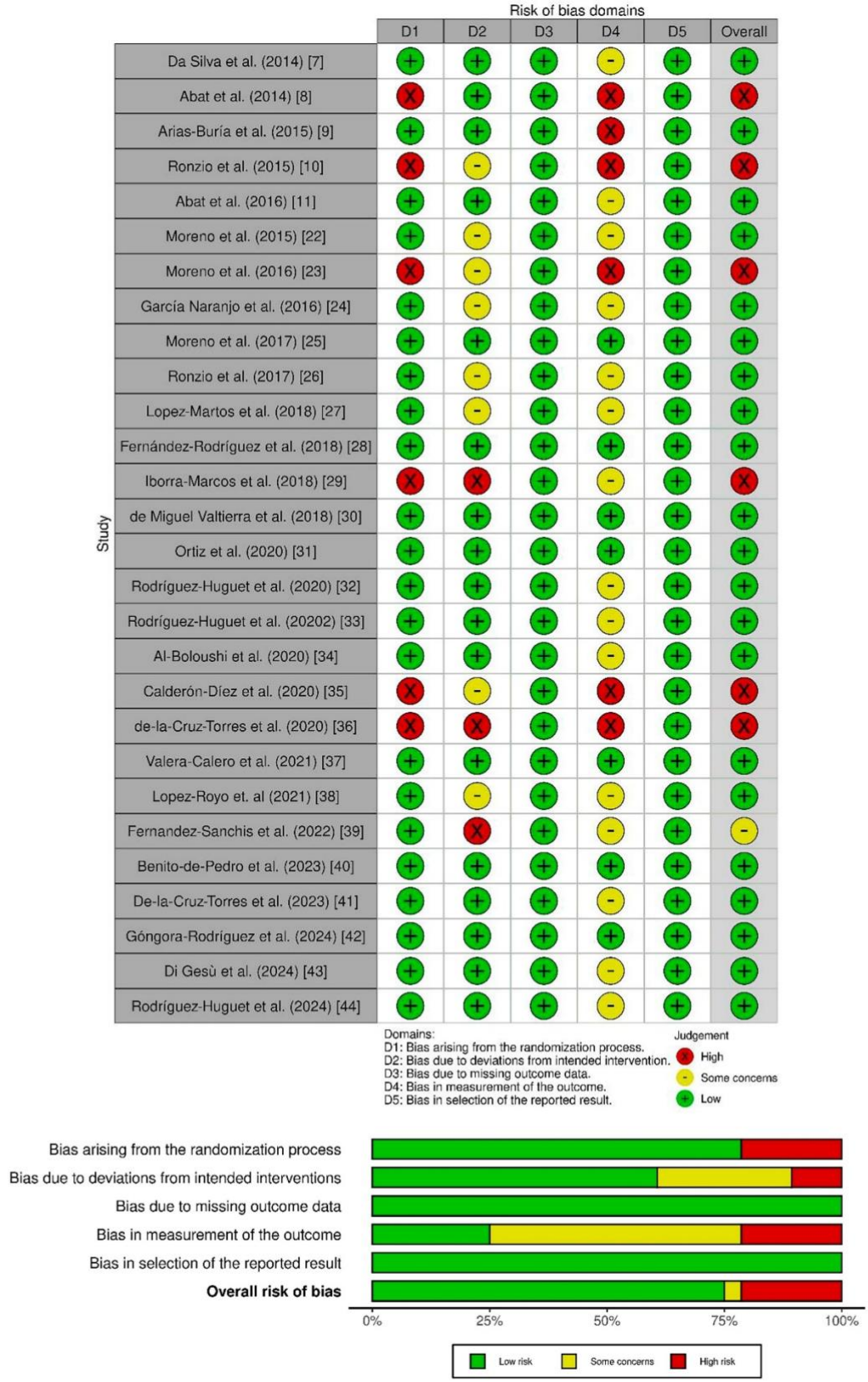


Fig. 2. RoB Graph: Review authors' assessments of each risk of bias item presented as percentages across all included studies

Study characteristics

Table 1 summarizes key aspects of the included studies, including author, country, number of participants, study groups, interventions, treatment sessions, outcomes, and assessment instances. Studies were developed between 2014 and 2024 in Brazil [7], Spain [8,9,11,22,24,27–29,32–42], Argentina [10,26], Italy [23,25,43], and Chile [31]. Prevalent conditions treated included patellar tendinopathy [8,11,37–39], calcaneal tendinopathy [7,11,37,38,42], subacromial impingement syndrome [9,22,30,32,42], and MTrPs [10,27,31,40], along with heel pain [28,29,34], lateral epicondylalgia [33,44], pubalgia [23,25], soleus injury [36,41], and whiplash [24]. The study included a total of 1,207 participants with a mean age of 33.2 years [± 2.6). The sample consisted of 439 men, 442 women, and 326 participants from ten studies where gender was unspecified [7,10,22,26,29,37,39,40].

A total of 617 participants received electrolysis treatments. Ten studies reported microelectrolysis. Four of them used MEP® [7,10,26,31] and seven used EPTE® [28,30,32,33,37,42,44]. Seventeen reported electrolysis with EPI® [8,9,11,22–25,27,29,34–36,38–41,43]. No studies used FISIOINVASIVA® electrolysis. Four studies used electrolysis alone [10,23,29,36], while the others combined it with therapeutic exercise (such as stretching, strength, or eccentric exercise) (n=17) [7–9,11,25,26,28,30,32,34–36,38,39,41,43,44], deep transverse massage [8,26], or therapeutic ultrasound (US) [31]. In the control groups, 570 participants received therapeutic exercise [7,9,11,24–26,28,30,32–34,36,39,41–43], US [11,24,31,42,44], low-level laser therapy [11], dry needling [32,34,38,40], or corticosteroid injections [29]. Three studies including placebo groups [26,28,41]. Six studies conducted only one post-treatment session [7,11,24,35,36,39], while twenty-two included follow-up assessments ranging from 2 weeks to 12 months.

Outcomes

Pain intensity was evaluated using instruments such as VAS [22,24,26,27,29,31,34,35,38,43], NPRS [9,25,28,30,32,33,36,42], VISA-A [7], VISA-P [8], and verbal rating scale (VRS) [23,40]. In eight studies, pressure algometry was used to measure the PPT [10,24,30–33,40,44]. Disability was assessed with various instruments, including DASH [9,30,42], NPQ [24], SPADI [30,42] limited range of movement [22] and patient-specific functional scale (PSFS) [44]. Function was evaluated using questionnaires such as the Tegner

Lysholm scale (TLS) [8], VISA-A [26,35,43], VISA-P [11,38], patient-specific functional scale (PSFS) [23,25], the temporomandibular joint functional test [27], the Foot and Ankle Ability Measure (FAAM) [28], the Foot and Ankle Disability Index (FADI) [29,35], and the Foot Health Status Questionnaire (FHSQ) [34]. Furthermore, four studies reported quality of life measured with the SF-36 [38,39], SF-12 [33], and the 5-level EQ-5D health questionnaire [34].

Electrolysis dosage

Table 2 summarizes the electrolysis application parameters used in the studies. For microelectrolysis, the dose ranged from 6.6 to 31.5 millicoulombs (mC), and for electrolysis, it ranged from 13.5 to 45 mC. The average dose for both techniques was 31.5 mC. Treatment durations for microelectrolysis were between 20 and 180 seconds, while for electrolysis, they ranged from 3 to 10 seconds, with average intensities of 0.45 mA and 3 mA, respectively.

Ultrasound guidance was used for all electrolysis procedures and for some microelectrolysis applications (EPTE®), while non-ultrasound-guided applications were reported for microelectrolysis (MEP® and EPTE®) [7,10,12,26,27,37]. The average number of sessions was 4, conducted over 2 to 3 weeks. The maximum number of sessions was 12 [35] and the minimum was 1 [10,31,37,40].

Meta-analysis

Pain Intensity

Twenty-five studies, eleven on microelectrolysis and fourteeen on electrolysis, were included in the meta-analysis examining the effects of HILT compared to other treatments (Fig. 3). Due to the observed heterogeneity, the Dersimonian-Laird random-effects method was used to determine the effect size in terms of SMD. A statistically significant difference was observed in favor of the groups treated with microelectrolysis (SMD = -0.92; 95% CI: -1.30, -0.53; $p < 0.01$; EG [n] = 276, CG [n] = 262), electrolysis (SMD = -0.30; 95% CI: -0.59, -0.01; $p = 0.04$; EG [n] = 449, CG [n] = 457), and when both techniques were combined (SMD = -0.59; 95% CI:-0.85,-0.32; $p = 0.01$), with large, small, and moderate effect sizes, respectively. The authors deemed the evidence on microelectrolysis critical and the evidence on electrolysis important, both with low certainty (Tab. 3) [20].

Tab 1. Characteristics of the included studies in the meta-analyses

N°	Author (year) Country	Musculoskeletal disorder	PEDro score	Location of research implementation	Sample Groups (n) Mean age (SD)	Electrolysis Technique	Interventions	Sessions	Outcomes	Assessment	Results after treatment	Sources of funding
1	Da Silva et al. (2014) [7] Brazil	Calcaneal tendinopathy	7/10+	Physiotherapy Department of Integrated Clinics of the Centro Universitário do Rio Grande do Norte (UNI-RN)	n = 20 EG = 10 (♂ NS; ♀ NS) CG = 10 (♂ NS; ♀ NS) 45 (NS)	Microelectrolysis (MEP®)	EG: MEP + TE + DTM CG: TE + DTM	4s (1s per week) (4 weeks)	(A) PI (VISA-A)	T0: baseline T1: post-treatment	EG: ↓PI* CG: ↓PI* EG < CG: ↓PI	Not reported
2	Abat et al. (2014) [8] Spain	Patellar tendinopathy	4/10+	Department of Orthopedic Surgery, Hospital de la Santa Creu i Sant Pau, Autonomous University of Barcelona ICATME-Hospital Universitari Quirón Dexeus, Autonomous University of Barcelona	n = 40 EG1 = 21 (♂ = 17; ♀ = 4) EG2 = 19 (♂ = 18; ♀ = 1) 26 (± 8.3) Participants were divided according to the Blazina score	Electrolysis (EPI®)	EG1: TE + EPI EG2: TE + EPI No CG	10s (2 weeks)	(A) PI (VISA-P) (B) Function (VISA-P) (C) Function (TLS)	T0: baseline T1: 3-month follow-up T2: 2-year follow-up T3: 5-year follow-up T4: 10-year follow-up	EG1: ↓PI* and ↑function* EG2: ↓PI* and ↑function*	Not reported
3	Arias-Buría et al. (2015) [9] Spain	SAIS	7/10**	Physical therapy clinic in Madrid	n = 36 EG = 17 (♂ = 4; ♀ = 13) CG = 19 (♂ = 5; ♀ = 14) 57 (± 6.5)	Microelectrolysis (EPTE®)	EG: EPTE + TE CG: TE	4s (1s per week) (4 weeks)	(A) PI (NPRS) (B) Disability (DASH)	T0: baseline T1: during treatment (session 2) T2: post-treatment	EG: ↓PI* and ↓disability* CG: ↓PI* and ↓disability* EG < CG: ↓PI* and ↓disability*	Not funded
4	Ronzio et al. (2015) [10] Argentina	MFPS - MTrPs	4/10+	Department of Physiotherapy, Maimónides University, Buenos Aires	n = 16 EG = 8 (♂ NS; ♀ NS) CG = 8 (♂ NS; ♀ NS) 24 (NS)	Microelectrolysis (MEP®)	EG: MEP CG: Placebo	1s	(A) PPT (ALG)	T0: baseline T1: post-treatment (1 min) T2: post-treatment (10 min)	EG: ↑PPT* CG: ↑PPT EG > CG: ↑PPT*	Not reported

5	Abat et al. (2016) [11] Spain	Patellar tendinopathy	7/10**	Outpatient clinics in the city of Barcelona	n = 64 EG = 32 (♂ = 24; ♀ = 8) CG = 32 (♂ = 27; ♀ = 5) 39 (± 6.2) Participants of each group were divided according to the VISA-P score (< o > 90 points)	Electrolysis (EPI®)	EG: EPI + TE CG: US + LLLT + ITFC + TE	4s (8 weeks)	(A) Function (VISA-P)	T0: baseline T1: post-treatment	EG: ↑function* CG: ↑function* EG > CG: ↑function*	Not funded
6	Kazemi et al. (2015) [22] Spain	SAIS	5/10⁺	Institute of Physiotherapy and Sports, University of Alcalá, Madrid	n = 40 EG 1 = 10 (♂ NS; ♀ NS) EG 2 = 10 (♂ NS; ♀ NS) EG 3 = 10 (♂ NS; ♀ NS) CG = 10 (♂ NS; ♀ NS) 39.9 (± 3.9)	Electrolysis (EPI®)	EG 1 = EPI (MTsPs) EG 2 = EPI (Infraspinatus tendon) EG 3 = EPI (MTrPs and infraspinatus tendon) CG: No treatment	2s (2 weeks)	(A) PI (VAS) (B) Limited ROM (GNM)	T0: baseline T1: during treatment (1 week) T2: during treatment (2 weeks) T3: post-treatment	EG 1: ↓PI* and ↓ limited ROM* EG 2: ↓PI* and ↓ limited ROM* EG 3: ↓PI* and ↓ limited ROM* CG: ↓PI and ↓ limited ROM EG3 < EG2 = EG1 < CG: ↓PI* and ↓ limited ROM*	Not reported
7	Moreno et al. (2016) [23] Italy	Pubalgia	4/10⁺	Udinese Football Club	n = 8 EG = 8 (♂ = 8; ♀ = 0) 27 (± 4.4)	Electrolysis (EPI®)	EG: EPI CG: No CG	4-6s (4 weeks)	(A) PI (VRS) (B) Function (PSFS)	T0: baseline T1: during treatment (24 hours) T2: during treatment (1 week) T3: post-treatment T4: 6-month follow-up	EG: ↓PI*and ↑function*	Not reported
8	García Naranjo et al. (2016) [24] Spain	Whiplash	5/10⁺	Vecindario Rehabilitation Centre, Santa Lucía, Gran Canaria Island	n = 100 EG = 50 (♂ = 16; ♀ = 34) CG = 50 (♂ = 20; ♀ = 30) 38 (± 8.7)	Electrolysis (EPI®)	EG: EPI CG: MWT + TENS + US + massage + TE	3s (1s per week) (3 weeks)	(A) PI (VAS) (B) PPT (ALG) (C) Disability (NPQ)	T0: baseline T1: post-treatment	EG: ↓PI*, ↓disability* and ↑PPT* CG: ↓PI*, ↓disability* and ↑PPT* EG < CG: ↓PI* and ↓disability* EG > CG: ↑PPT*	Not funded
9	Moreno et al. (2017) [25] Italy	Adductor longus enthesopathy	9/10⁺	Udinese Football Club	n = 24 EG = 8 (♂ = 11; ♀ = 0) CG = 8 (♂ = 13; ♀ = 0) 26 (± 4.7)	Electrolysis (EPI®)	EG: EPI + TE CG: TE	2s (1 week)	(A) PI (NPRS) (B) Function (PSFS)	T0: baseline T1: post-treatment T2: 2-month follow-up T3: 4-month	EG: ↓PI*and↑function* CG: ↓PI* and ↑function* EG < CG: ↓PI* EG > CG: ↑function	Not funded

										follow-up T4: 6-month follow-up		
10	Ronzio et al. (2017) [26] Argentina	Calcaneal tendinopathy	6/10⁺	Integrated Clinics of Potiguar University, Rio Grande, Natal	n = 20 EG = 10 (♂ NS; ♀ NS) CG = 10 (♂ NS; ♀ NS) 24 (NS)	Microelectrolysis (MEP®)	EG: MEP + TE + DTM CG: TE + DTM	4s (1s per week) (4 weeks)	(A) PI (VAS) (B) ROM (GNM) (C) Function (VISA-A)	T0: baseline T1: during treatment (1 week) T2: during treatment (2 week) T3: during treatment (3 week) T4: post-treatment	EG: ↓PI*, ↑ROM* and↑function* CG: ↓PI*, ↑ROM* and↑function* EG < CG: ↓PI* EG > CG: ↑ROM* and↑function*	This work has been supported by Universidade Potiguar (Brazil)
11	Lopez-Martos et al. (2018) [27] Spain	MFPS - MTrPs	6/10**	Department of Oral and Maxillofacial Surgery, Virgen del Rocío University Hospital, Seville	n = 60 EG = 20 (♂ = 5; ♀ = 15) CG1 = 20 (♂ = 2; ♀ = 18) CG2 = 20 (♂ = 1; ♀ = 19) 38 (NS)	Electrolysis (EPI®)	EG: EPI CG1 : DDN CG2: Placebo	3s (1s per week) (3 weeks)	(A) PI (VAS) (B) MMO (Therabite® System ruler) (C) Function (TMJ functionality test)	T0: baseline T1: 28 days T2: 42 days T3: 70 days	EG 1: ↓PI*,↑MMO and ↑function* EG 2: ↓PI*,↑MMO and ↑function* CG ↓PI,↑MMO and ↑function EG 1 < EG 2 < CG: ↓PI* EG 1 > EG 2 > CG: ↑MMO and ↑function*	Carlos III Health Institute-Health Research Fund
12	Fernández-Rodríguez et al. (2018) [28] Spain	Heel pain	9/10⁺	University Clinic of the Ultrasound Department, San Francisco de Asís Hospital, Madrid	n = 67 EG = 38 (♂ = 15; ♀ = 23) CG = 29 (♂ = 10; ♀ = 19) 45 (± 11.3)	Microelectrolysis (EPTE®)	EG: EPTE + TE CG: Placebo + TE	5s (1s per week) (5 weeks)	(A) PI (NPRS) (B) Fascia thickness (USG) (C) Function (FAAM)	T0: baseline T1: 1-week follow-up T2: 3-month follow-up T3: 12-month follow-up	EG: ↓PI*,↓ fascia thickness* and ↑function* CG: ↓PI*,↓ fascia thickness* and ↑function* EG < CG: ↓PI* EG = CG: fascia thickness* EG > CG: ↑function*	Universidad Camilo Jose Cela provided financial support for the research, authorship, and/or publication.
13	Iborra-Marcos et al. (2018) [29] Spain	Plantar fasciitis	4/10⁺	Avanfi Institute, MadridVirgen de la Paloma Hospital, Madrid	n = 64 EG = 32 (♂ NS; ♀ NS) CG = 32 (♂ NS; ♀ NS) 46 (± NS)	Electrolysis (EPI®)	EG: EPI CG: Corticosteroid injections	10s (1s per week) (10 weeks)	(A) PI (VAS) (B) Fascia thickness (USG) (C) Function (FADI)	T0: baseline T1: 3-week follow-up T2: 6-month follow-up T3: 12-month follow-up	EG: ↓PI*,↓ fascia thickness* and ↑function* CG: ↓PI*,↓ fascia thickness* and ↑function* EG < CG: ↓PI* and fascia thickness* EG > CG: ↑function*	Not funded

14	de Miguel Valtierra et al. (2018) [30] Spain	SAIS	9/10⁺	Healthcare center in Madrid	n = 50 EG = 25 (♂ = 12; ♀ = 13) CG = 25 (♂ = 11; ♀ = 14) 55 (± 12.4)	Microelectrolysis (EPTE®)	EG: EPI + MT + TE CG: MT + TE	5s (1s per week) (5 weeks)	(A) PI (NPRS) (B) PPT (ALG) (C) Disability (DASH) (D) Disability (SPADI) (E) Self-reported improvement (GROC)	T0: baseline T1: post-treatment T2: 3-week follow-up T3: 6-month follow-up	EG: ↓PI*,↓ disability* and ↑PPT* CG: ↓PI*,↓ disability* and ↑PPT* EG < CG: ↓PI* and↓ disability* EG > CG: ↑PPT*	Not funded
15	Ortiz et al. (2020) [31] Chile	MFPS - MTrPs	9/10⁺	Laboratory of Electrophysical Agents, School of Physical Therapy, Andrés Bello University	n = 48 EG = 24 (♂ = 11; ♀ = 13) CG = 24 (♂ = 12; ♀ = 12) 22 (± 1.7)	Microelectrolysis (MEP®)	EG: MEP + US CG: US	1s	(A) PI (VAS) (B) PPT (ALG)	T0: baseline T1: post-treatment T2: 3-days follow-up T3. 7-days follow-up	EG: ↓PI* and ↑PPT* CG: ↓PI* and ↑PPT* EG < CG: ↓PI* EG > CG: ↑PPT*	Not funded
16	Rodríguez-Huguet et al. (2020) [32] Spain	SAIS	8/10⁺	Santa María Clinic, Cádiz	n = 36 EG = 18 (♂ = 16; ♀ = 2) CG = 18 (♂ = 11; ♀ = 7) 43 (± 9.9)	Microelectrolysis (EPTE®)	EG: EPTE + TE CG: TDN + TE	4s (1s per week) (4 weeks)	(A) PI (NPRS) (B) PPT (ALG) (C) ROM (GNM)	T0: baseline T1: post-treatment T2: 1-month follow-up T3: 12-month follow-up	EG: ↓PI*, ↑PPT* and ↑ROM* CG: ↓PI*, ↑PPT* and ↑ROM* EG < CG: ↓PI* EG > CG: ↑PPT* and ↑ROM* (flexion, Internal rotation and extension)	Not funded
17	Rodríguez-Huguet et al. (2020) [33] Spain	Epicondilalgya	8/10**	Santa María Clinic, Cádiz	n = 32 EG = 11 (♂ = 11; ♀ = 0) CG = 13 (♂ = 13; ♀ = 0) 39 (± 13.9)	Microelectrolysis (EPTE®)	EG: EPTE + TE CG: TDN + TE	4s (1s per week) (4 weeks)	(A) PI (NPRS) (B) PPT (ALG) (C) ROM (GNM) (D) QoL (SF-12)	T0: baseline T1: post-treatment T2: 1-month follow-up T3: 12-month follow-up	EG: ↓PI*, ↑PPT* and ↑ROM* CG: ↓PI*, ↑PPT* and ↑ROM* EG < CG: ↓PI* EG > CG: ↑PPT,↑ROM and ↑QoL	Not funded
18	Al-Boloushi et al. (2020) [34] Spain	Heel pain	7/10**	Physical Therapy Department, Physical Medicine and Rehabilitation Hospital, Kuwait City	n = 102 EG = 51 (♂ = 15; ♀ = 36) CG = 51 (♂ = 15; ♀ = 36) 48 (± 8.9)	Electrolysis (EPI®)	EG: EPI + TE CG: TDN + TE	4s (1s per week) (4 weeks)	(A) PI (VAS) (B) Foot function (FHSQ) (C) Footwear (FHSQ) (D) GFH (FHSQ) (E) QoL (EQ-5D-5L)	T0: baseline T1: post-treatment T2: 2-month follow-up T3: 3-month follow-up T4: 13-month follow-up	EG: ↓PI*, ↑Foot function*, ↑Footwear*, ↑GFH* and ↑QoL* CG: ↓PI*, ↑Foot function*, ↑Footwear*, ↑GFH* and ↑QoL* CG < EG: ↓PI* EG = CG: ↑Foot function*, ↑Footwear*, ↑GFH* and ↑QoL*	This research received funding from Ministry of Health Kuwait

19	Calderón-Díez et al. (2020) [35] Spain	Calcaneal tendinopathy	4/10+	Faculty of Nursing and Physiotherapy, University of Salamanca	n = 39 EG = 39 (♂ = 33; ♀ = 6) 42.6 (± NS)	Electrolysis (EPI®)	EG: EPI + TE No CG	12s (1s per week) (12 weeks)	(A) PI (VAS) (B) Function (FADI) (C) Function (VISA-A)	T0: baseline T1: post-treatment (12 weeks)	EG: ↓PI*and ↑function*	Not reported
20	de-la-Cruz-Torres et al. (2020) [36] Spain	Chronic soleus injury	4/10**	MVClinic Institute, Madrid	n = 30 EG 1 = 10 (♂ = 1; ♀ = 9) EG 2 = 10 (♂ = 1; ♀ = 9) CG = 10 (♂ = 1; ♀ = 9) 21.0 (± 2.7)	Electrolysis (EPI®)	EG1: EPI EG2: EPI + TE CG: TE	8s (2 per week) (4 weeks)	(A) PI (NPRS) (B) ROM (Lunge test) (C) Function (Endurance test) (D) Function (Heel raise test) (E) ADL (Likert-scale) (F) ADL (DFOS)	T0: baseline T1: post-treatment (4 weeks)	EG 1: ↓PI*, ↑ROM*, ↑Function* and ↑ADL* EG 2: ↓PI*, ↑ROM*, ↑Function* and ↑ADL* EG 1 = EG 2 < CG: ↓PI* EG 1 = EG 2 > CG: ↑ROM*, ↑Function* and ↑ADL*	Not funded
21	Valera-Calero et al. (2021) [37] Spain	Patellofemoral pain	9/10**	Camilo José Cela University, Madrid	n = 15 EG 1 = 5 (♂ = NS; ♀ = NS) EG 2 = 5 (♂ = NS; ♀ = NS) CG = 5 (♂ = NS; ♀ = NS) NS (± NS)	Microelectrolysis (EPTE®)	EG 1: High-intensity electrolysis EG 2: Low-intensity electrolysis CG: DDN	1s (1 week)	(A) PPT (ALG) (B) PI (VAS-SAKPP)	T0: baseline T1: post-treatment T2: follow-up (1 week)	EG 1: ↑PPT* and ↓PI* EG 2: ↑PPT* and ↓PI* CG: ↑PPT* and ↓PI* EG 1 = EG 2 < CG: ↓PI* EG 1 = EG 2 > CG: ↑PPT*	Not reported
22	Lopez-Royo et. al (2021) [38] Spain	Patellar tendinopathy	5/10**	Laboratory of San Jorge University, Zaragoza	n = 48 EG 1 = 16 (♂ = 13; ♀ = 3) CG 1 = 16 (♂ = 14; ♀ = 2) CG 2 = 16 (♂ = 15; ♀ = 1) 32.3 (± 7.1)	Electrolysis (EPI®)	EG: EPI + TE CG 1: DDN + TE CG 2: Sham DDN	4s (1s every 2 weeks) (8 weeks)	(A) PI (VAS) (B) Function (VISA-P) (C) QoL (SF-36)	T0: baseline T1: post-treatment (10 weeks) T2: follow-up (22 weeks)	EG 1: ↓PI*, ↑Function* and ↑QoL* CG 1: ↓PI*, ↑Function* and ↑QoL* CG 2: ↓PI*, ↑Function* and ↑QoL* EG > CG 1 > CG 2: ↓PI* EG > CG 1 > CG 2: ↑Function* and ↑QoL*	Not reported

23	Fernandez-Sanchis et al. (2022) [39] Spain	Patellar tendinopathy	4/10**	Faculty of Health Sciences, Universidad San Jorge, Villanueva de Gállego	n = 42 EG 1 = 14 (♂ = NS; ♀ = NS) CG 1 = 13 (♂ = NS; ♀ = NS) CG 2 = 15 (♂ = NS; ♀ = NS) 32.5 ± (7.1)	Electrolysis (EPI®)	EG: EPI + TE CG 1: DDN + TE CG 2: Sham DDN + TE	4s (8 weeks)	(A) QoL (SF-36) (B) QALY (SF-6D)	T0: baseline T1: post-treatment (8 weeks)	EG: ↑QALY (SF-6D)* CG 1: ↑QALY (SF-6D)* CG 2: ↑QALY (SF-6D) EG > CG 1 > CG 2: ↑QALY (SF-6D)*	Not funded
24	Benito-de-Pedro et al. (2023) [40] Spain	MFPS - MTrPs	9/10⁺	The Physiotherapy and Podiatry Clinic FISIOFUENLA	n = 52 EG = 26 (♂ NS; ♀ NS) CG = 26 (♂ NS; ♀ NS) 39 (± 9.4)	Electrolysis (EPI®)	EG: EPI CG: DDN	1s	(A) PI (VNPS) (B) PPT (ALG) (C) ROM (GNM) (D) Disability (NPQ)	T0: baseline T1: post-treatment T2: 3-day follow-up T3: 14-day follow-up	EG: ↓PI*, ↑PPT*, ↑ROM* and ↓disability* CG: ↓PI*, ↑PPT*, ↑ROM* and ↓disability* EG = CG: ↓PI*, ↑PPT* and ↓disability* EG > CG: ↑ROM*	Not funded
25	De-la-Cruz-Torres et al. (2023) [41] Spain	Chronic soleus injury	6/10⁺	Department of Physiotherapy, University of Seville	n = 20 EG = 10 (♂ NS; ♀ = 10) CG = 10 (♂ NS; ♀ = 10) 22.4 (± 4.9)	Electrolysis (EPI®)	EG: EPI + TE CG: Placebo + TE	2s (2 weeks)	(A) PI (NPRS) (B) ROM (Lunge test) (C) Function (Heel raise test) (D) Disability (CS) (E) Self-improvement (GRCS)	T0: baseline T1: post-treatment (4 weeks)	EG: ↓PI*, ↑ROM*, ↑function* and ↓disability* CG: ↓PI*, ↑ROM*, ↑function* and ↓disability* EG = CG: ↓PI, ↑ROM, ↑function and ↓disability	Not reported
26	Góngora-Rodríguez et al. (2024) [42] Spain	SAIS	9/10⁺	Department of Nursing and Physiotherapy, University of Cádiz	n = 50 EG = 25 (♂ 19; ♀ 6) CG = 25 (♂ 17; ♀ 8) 44.2 (± 11.8)	Microelectrolysis (EPTE®)	EG: EPTE + PNS + TE CG: TENS + US + TE	4s (1s per week) (4 weeks)	(A) PI (NPRS) (B) Shoulder strength (DNM) (C) Tendon thickness (USG) (D) Disability (DASH) (E) Disability (SPADI) (F) Muscle activity (EMG)	T0: baseline T1: post-treatment T2:follow-up (12 weeks) T3: follow-up (24 weeks)	EG: ↓PI*, ↓Tendon thickness*, ↓disability*,↑Shoulder strength* and ↑muscle activity* CG: ↓PI*, ↓Tendon thickness*, ↓disability*,↑Shoulder strength* and ↑muscle activity* EG < CG: ↓PI*, ↓Tendon thickness* and ↓disability* EG > CG: ↑Shoulder strength* and ↑muscle activity*	Not funded

27	Di Gesù et al. (2024) [43] Italy	Calcaneal tendinopathy	7/10⁺	Health Center Mya Salute, Palermo	n = 50 EG = 25 (♂ 15; ♀ 10) CG = 25 (♂ 17; ♀ 8) 40.9 (± 12.5)	Electrolysis (EPI®)	EG: EPI + TE CG: TE	3s (1s per week) (3 weeks)	(A) PI (VAS) (B) Function (VISA-A)	T0: baseline T1: post-treatment (6 weeks) T2:follow-up (4 weeks) T3: follow-up (8 weeks)	EG: ↓PI* and ↑function* CG: ↓PI* and ↑function* CG < EG: ↓PI CG > EG: ↑function	Not funded
28	Rodríguez-Huguet (2024) [44] Spain	Epicondilalgya	9/10⁺	Santa María Clinic, Cádiz	n = 40 EG = 20 (♂ 13; ♀ 7) CG = 20 (♂ 12; ♀ 8) 40.2 (± 12.7)	Microelectrolysis (EPTE®)	EG: EPTE + VT + TE CG: MT + US + TE	4s (1s per week) (4 weeks)	(A) PI (NPRS) (B) PPT (ALG) (C) ROM (GNM) (B) Disability (PRTEE)	T0: baseline T1: post-treatment T2: 1-month follow-up T3: 3-month follow-up	EG: ↓PI*, ↑PPT*, ↑ROM* and ↓disability* CG: ↓PI*, ↑PPT*, ↑ROM* and ↓disability* CG < EG: ↓PI* and ↓disability* CG > EG: ↑PPT* and ↑ROM*	Not funded

Abbreviations: ♂- men, ♀- women, ADL- activities of daily living, ALG- algometry, CG- control group, CS, curve sprint test, DASH- Disability Arm, Shoulder, and Hand Questionnaire, DDN- deep dry needling, DNM- dynamometry, DFOS- Dance Functional Outcome Survey, DTM- deep transverse massage, EG- experimental group, EMG- surface electromyography, EPI- percutaneous intratisular electrolysis (mA), EPTE- percutaneous therapeutic electrolysis (µA), EQ-5D-5L- the 5-level EQ-5D health questionnaire by EuroQol, FAAM- The Foot and Ankle Ability Measure, FADI- Foot and Ankle Disability Index, FHSQ- Foot Health Status Questionnaire, GFH- General Foot Health, GNM- goniometry; GRCS- Global Rating of Change Scale, GROC- Global Rating of Change, MEP- percutaneous electrolysis (µA), MFPS- myofascial pain syndrome, MT- manual therapy, MTrPs- myofascial trigger points, MWT- microwave therapy, NPQ- Northwick Park Neck Questionnaire, NPRS- numeric pain rating scale, NS- not specified, PI- pain intensity, PNS- percutaneous peripheral nerve stimulation, PPT- pain pressure threshold, PRTEE- patient-rated tennis elbow evaluation questionnaire, PSFS- patient-specific functional scale, QoL- quality of life, QALY- quality-adjusted life years, ROM- range of movement, SAIS- subacromial impingement syndrome, SAKPP- subjective anterior knee pain perception, SF-3D- The short-form 6-dimension, SPADI- shoulder and pain disability index, SR- systematic review, TE- therapeutic exercises, TDN- trigger point dry needling, TENS- transcutaneous electrical nerve stimulation, TLS- Tegner Lysholm scale, TMJ- temporomandibular joint, US- therapeutic ultrasound, USG- ultrasonography, VISA-A- the Victorian Institute of Sports Assessment self-administered Achilles questionnaire, VISA-P- the Victorian Institute of Sport Assessment Patella Questionnaire, VAS- visual anolog scale, VNPS- visual numeric pain scale, VRS- verbal rating scale, , VT- vacuum therapy. *$p < 0.05$, **Score confirmed in PEDro database, ⁺Score determined by researchers (Not available in PEDro database).

Tab. 2. Electrolysis and microelectrolysis parameters

N°	Electrolysis parameters	Technique	Musculoskeletal disorder	Ecoguided	Intensity	Time application (sec)	Needle	Series	Dose
1	Da Silva et al. (2014) [7]	MEP®***	Calcaneal tendinopathy	No	450 µA (0.45 mA)	20 sec	0.22 x 13mm	3 x 3 points	27 mC
2	Abat et al. (2014) [8]	EPI®*	Patellar tendinopathy	Yes	3 mA	NS	NS	3	NS
3	Arias-Buría et al. (2015) [9]	EPTE®**	SAIS	Yes	350 µA (0.35 mA)	80 sec	0.3 x 25 mm	NS	28 mC
4	Ronzio et al. (2015) [10]	MEP®***	MFPS - MTrPs	No	500 µA (0.5 mA)	180 sec	0.3 x 25 mm	1	90 mC
5	Abat et al. (2016) [11]	EPI®*	Patellar tendinopathy	Yes	2 mA	NS	0.25 x 25 mm	3	NS
6	Kazemi et al. (2015) [22]	EPI®*	SAIS	Yes	6 mA	4 sec	NS	3	72 mC
7	Moreno et al. (2016) [23]	EPI®*	Pubalgia	Yes	3 mA	5 sec	0.33 x 50 mm	3	45 mC
8	García Naranjo et al. (2016) [24]	EPI®*	Whiplash	Yes	4 mA	NS	0.16 x 25 mm	3	NS
9	Moreno et al. (2017) [25]	EPI®*	Adductor longus enthesopathy	Yes	3 mA	5 sec	0.33 x 50 mm	3 bilaterally	45 mC
10	Ronzio et al. (2017) [26]	MEP®***	Calcaneal tendinopathy	No	450 µA (0.45 mA)	20 sec	0.22 x 13 mm	3	27 mC
11	Lopez-Martos et al. (2018) [27]	EPI®*	MFPS - MTrPs	No	2 mA	3 sec	0.25 x 40 mm	3	18 mC
12	Fernández-Rodríguez et al. (2018) [28]	EPTE®**	Heel pain	Yes	NS	NS	0.35 x 40 mm	NS	28 mC
13	Iborra-Marcos et al. (2018) [29]	EPI®*	Plantar fasciitis	Yes	3 mA	5 sec	0.30 x 25 mm	3	45 mC
14	de Miguel Valtierra et al. (2018) [30]	EPTE®**	SAIS	Yes	350 µA (0.35 mA)	90 sec	0.30 x 25 mm	1	31.5 mC

15	Ortiz et al. (2020) [31]	MEP®***	MFPS - MTrPs	No	600 µA (0.6 mA)	180 sec	0.30 x 25 mm	3	10.8
16	Rodríguez-Huguet et al. (2020) [32]	EPTE®**	SAIS	Yes	350 µA (0.35 mA)	80 sec	0.30 x 25 mm	1	28 mC
17	Rodríguez-Huguet et al. (2020) [33]	EPTE®**	Epicondylalgia	Yes	350 µA (0.35 mA)	80 sec	0.30 x 25 mm	1	28 mC
18	Al-Boloushi et al. (2020) [34]	EPI®*	Heel pain	Yes	1.5 mA	5 sec	0.30 x 25 mm	5	37.5 mC
19	Calderón-Díez et al. (2020) [35]	EPI®*	Calcaneal tendinopathy	Yes	3 mA	10 sec	0.30 x 25 mm	1	30 mC
20	de-la-Cruz-Torres et al. (2020) [36]	EPI®*	Chronic soleus injury	Yes	2.5 mA	3 sec	0.30 × 40mm	3	22.5 mC
21	Valera-Calero et al. (2021) [37]	EPTE®**	Patellofemoral pain	No	EG 1: 660 µA (0.66 mA) EG 2: 220 µA (0.22 mA)	EG 1: 10 sec EG 2: 30 sec	0.30 × 40 mm	1	6.6 mC
22	Lopez-Royo et. al (2021) [38]	EPI®*	Patellar tendinopathy	Yes	3 mA	3 sec	0.25 x 25 mm	3	27 mC
23	Fernandez-Sanchis et al. (2022) [39]	EPI®*	Patellar tendinopathy	Yes	3 mA	3 sec	0.25 × 25 mm	3	27 mC
24	Benito-de-Pedro et al. (2023) [40]	EPI®*	MFPS - MTrPs	Yes	1.5 mA	5 sec	0.30 x 30 mm or 0.30 x 40 mm	3 to 5	22.5 to 37.5 mC
25	De-la-Cruz-Torres et al. (2023) [41]	EPI®*	Chronic soleus injury	Yes	1.5 mA	3 sec	0.30 x 40 mm	3	13.5 mC
26	Góngora-Rodríguez et al. (2024) [42]	EPTE®**	SAIS	Yes	350 µA (0.35 mA)	72 sec	0.30 x 40 mm	1	25.2 mC
27	Di Gesù et al. (2024) [43]	EPI®*	Calcaneal tendinopathy	Yes	2 mA	10 sec	0.25 x 25 mm	2	40 mC
28	Rodríguez-Huguet (2024) [44]	EPTE®**	Epicondylalgia	Yes	350 µA (0.35 mA)	80 sec	0.30 x 25 mm	1	28 mC

Abbreviations: EPI*- percutaneous intratissue electrolysis, EPTE**- percutaneous therapeutic electrolysis, mA- milliamps, mC- millicoulombs, MEP***- percutaneous microelectrolysis, MFPS- myofascial pain syndrome; mm, millimeters, MTrPs- myofascial trigger points, NS- not specified, µA- microamps, SAIS- subacromial impingement syndrome, sec- seconds.

Tab. 3. Summary of findings and quality of evidence (GRADE) for interesting outcomes

Certainty assessment							№ of patients		Effect	Certainty	Importance[f]
№ of studies	**Study design**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Publication bias**	**electrolysis or microelectrolysis**	**other physical therapy interventions**	**Absolute (95% CI)**		
Pain intensity for microelectrolysis (assessed with: VAS, NPRS, VISA-A, VISA-P and VRS)											
11	randomised trials	serious[a]	serious[b]	not serious[c]	not serious[d]	none	276	262	SMD **-0.92 fewer** (-1.30 to -0.50)	⊕⊕◯◯ Low	CRITICAL
Pain intensity for electrolysis (assessed with: VAS, NPRS, VISA-A, VISA-P and VRS)											
14	randomised trials	serious[a]	serious[b]	not serious[c]	not serious[d]	none	449	457	SMD **-0.30** fewer (-0.59 to -0.01)	⊕⊕◯◯ Low	IMPORTANT
Disability for microelectrolysis (assessed with: DASH and SPADI)											
3	randomised trials	serious[a]	not serious[b]	not serious[c]	serious[d]	none	95	95	SMD -0.92 fewer (-1.30 to 0.54)	⊕⊕◯◯ Low	IMPORTANT
Disability for electrolysis (assessed with: DASH, NPQ, SPADI, limited ROM)											
5	randomised trials	serious[a]	very serious[b]	not serious[c]	serious[d]	none	173	135	SMD **1.84 fewer** (3.11 to 0.56)	⊕◯◯◯ Very low	IMPORTANT
Function for microelectrolysis (assessed with: VISA-A and FAAM)											
2		serious[a]	very serious[b]	not serious[c]	serious[d]		48	39			IMPORTANT

	randomised trials					publication bias strongly suspected[e]			SMD **2.38 more** (0.88 to 3.89)	⊕◯◯◯ Very low	

Abbreviations: CI- confidence interval, DASH- Disability Arm, Shoulder, and Hand Questionnaire, FAAM- The Foot and Ankle Ability Measure, NPQ- Northwick Park Neck Questionnaire, NPRS- numeric pain rating scale, ROM- range of movement, SMD- standardized mean difference, SPADI- shoulder and pain disability index, VAS- visual anolog scale, VISA-A- the Victorian Institute of Sports Assessment self-administered Achilles questionnaire, VISA-P- the Victorian Institute of Sport Assessment Patella Questionnaire, VRS- verbal rating scale.

Explanations: (a) The overall risk of bias was generally low (22.2%). Sources of bias included randomization and outcome measurement (22.2%), with concerns about intervention deviations (30%) and outcome measurement (52.0%); (b) The heterogeneity determines the inconsistency, depending on the I2 statistic (≥ 50%); (c) Considering a direct comparison of interventions and outcomes relevant to the study, with applicability to the clinical context, it was found that the indirect evidence held little significance; (d) Imprecision was assessed by examining the width of the confidence interval (CI) for the pooled mean difference, the crossing of the no-effect line in the meta-analysis, and the sample size ($n < 400$); (e) Insufficient studies in the meta-analysis; (f) The SMD determined the effect size, which served as the basis for gauging importance.

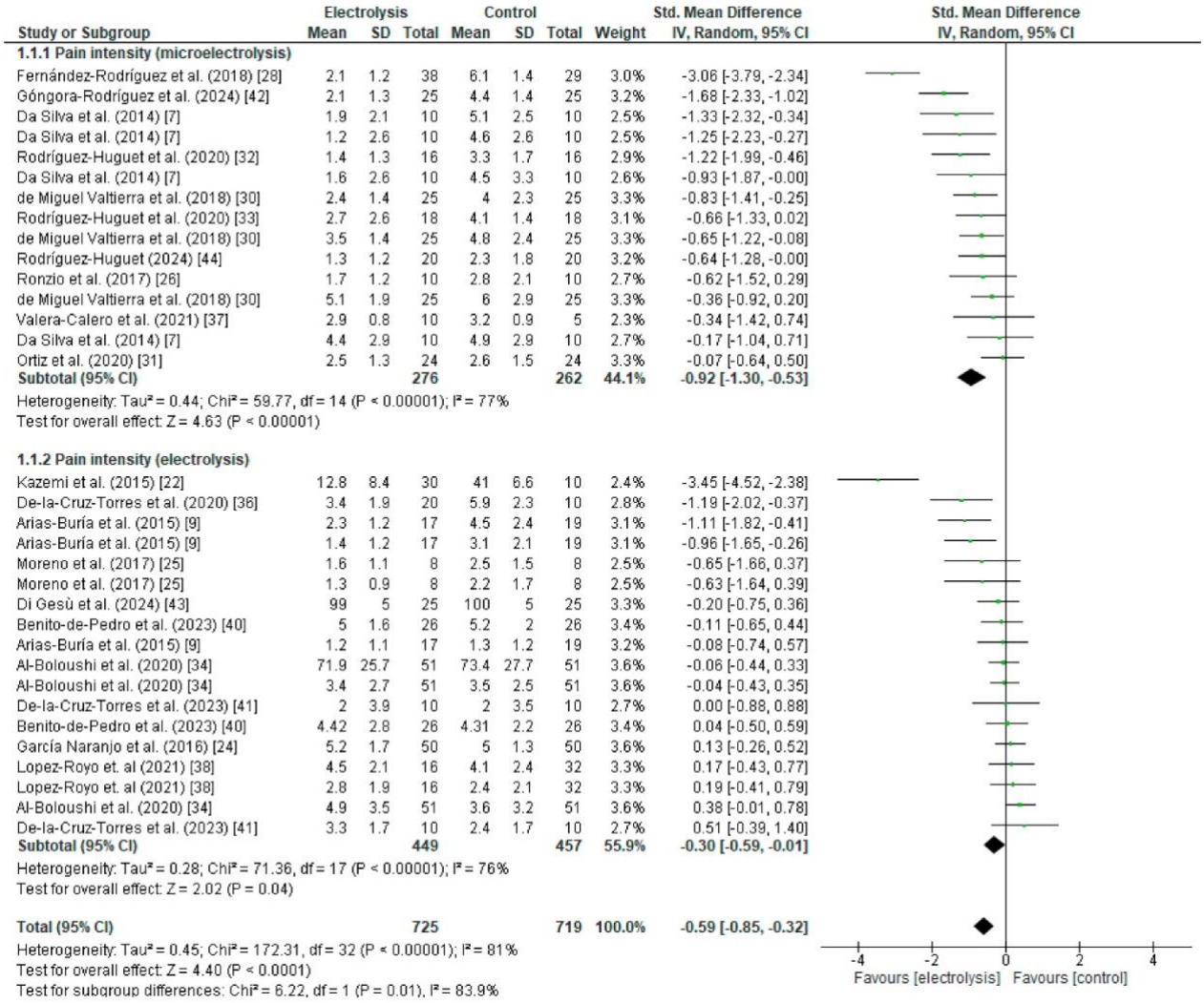
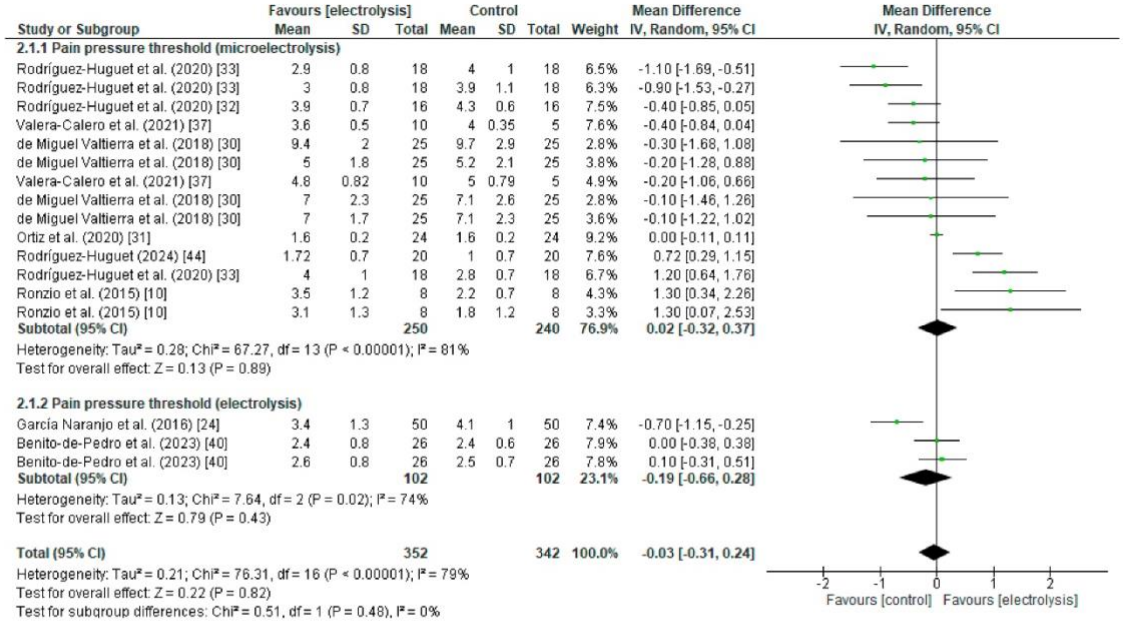


Fig. 3. Forest plots for pain intensity at rest at the end of treatment for both electrolysis modalities

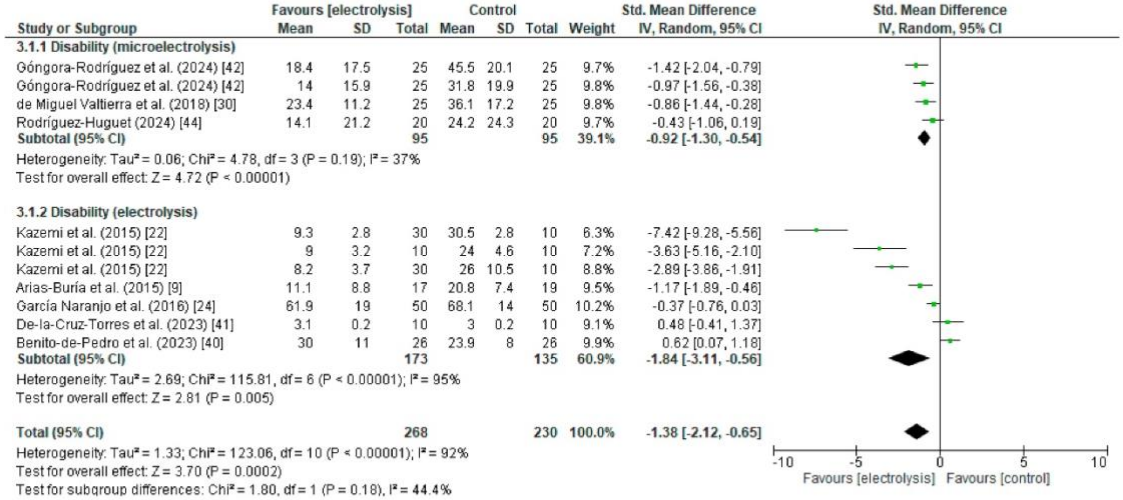
Pain pressure threshold

Ten studies, seven on electrolysis and three on microelectrolysis, were included in the meta-analysis (Fig. 4a) to evaluate the effects of electrolysis on PPT. The Dersimonian-Laird random-effects method was used to determine the WMD. No statistically significant differences were observed for microelectrolysis (WMD = -0.05; 95% CI: -0.41, 0.31; p = 0.78; EG [n] = 230, CG [n] = 220), electrolysis (WMD = -0.19; 95% CI: -0.66, 0.28; p = 0.43; EG [n] = 102, CG [n] = 102), or when both techniques were combined (WMD = -0.19; 95% CI: -0.37, 0.18). Heterogeneity was rated as substantial. As no statistically significant differences existed between groups, an assessment of the evidence's quality was not conducted.

4a



4b



4c

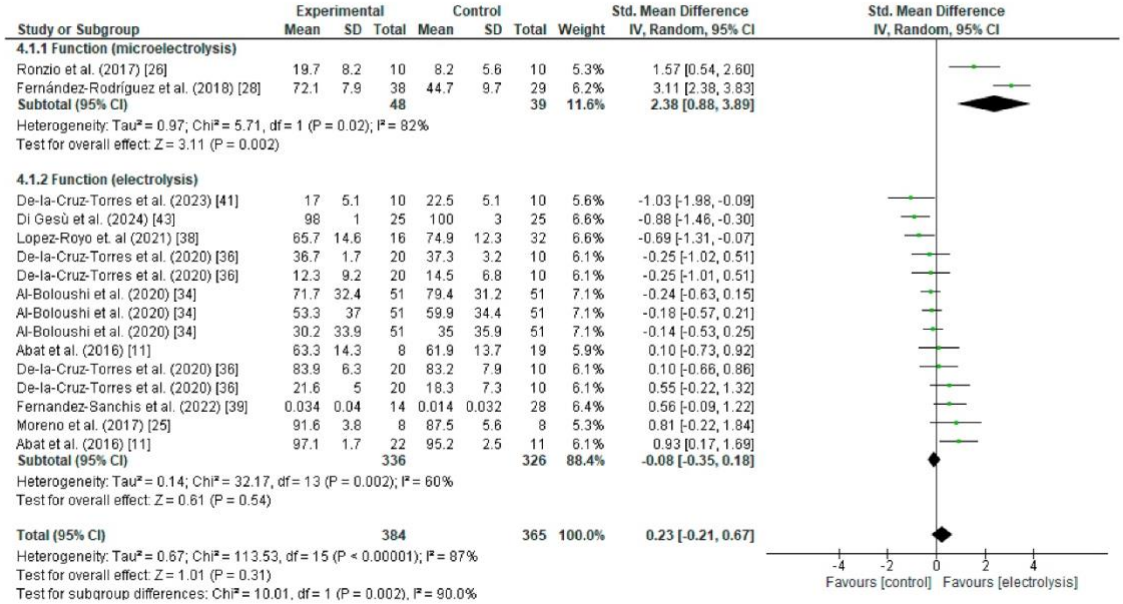


Fig. 4. Forest plots for secondary outcomes for both electrolysis modalities: pain pressure threshold (4a), disability (4b), and function (4c)

Disability

The meta-analysis included eight studies, three on microelectrolysis and five on electrolysis (Fig. 4b). The Dersimonian-Laird random-effects method was used to determine the SMD. A statistically significant reduction was observed in favor of microelectrolysis (SMD = -0.92; 95% CI: -1.30, -0.54; $p < 0.01$; EG [n] = 95, CG [n] = 95), electrolysis (SMD = -1.84; 95% CI: -3.11, -0.56; $p < 0.05$; EG [n] = 173, CG [n] = 135), and both techniques combined (SMD = -1.38; 95% CI: -2.12, -0.65; $p < 0.01$), with large effect sizes for all three comparisons. No heterogeneity was observed in microelectrolysis, while electrolysis showed significant heterogeneity. The authors deemed the evidence on microelectrolysis and electrolysis for disability as important, but with low certainty (Tab. 3) [20,21].

Function

Eleven studies, two on microelectrolysis and nine on electrolysis, were included to evaluate the effects of electrolysis on function (Fig. 4c). Due to the observed heterogeneity, the Dersimonian-Laird random-effects method was used to determine the effect size from SMD. Microelectrolysis showed a statistically significant increase with a large effect size on function (SMD = 2.38; 95% CI: 0.88, 3.89; $p < 0.01$; EG [n] = 48, CG [n] = 39) in contrast to electrolysis (SMD = -0.08; 95% CI: -0.35, 0.18; $p = 0.54$; EG [n] = 336, CG [n] = 326), which was not significant than controls. The evidence on microelectrolysis for function was assessed as important, but with very low certainty [20,21]. The quality of evidence for electrolysis was not rated due to the lack of statistically significant differences between groups (Tab. 3).

Discussion

The objective of this study was to assess and contrast the analgesic efficacy of two electrolysis modalities in the management of musculoskeletal pain disorders. The principal findings indicate that both interventions elicit pain reduction post-treatment, albeit with microelectrolysis demonstrating the best effects. Furthermore, both modalities diminish disability, with only functional enhancement observed in microelectrolysis. Nevertheless, neither

intervention surpasses controls concerning PPT. However, these results require consideration of the observed heterogeneity, albeit moderate, across certain analyses.

Electrolysis and pain reduction

This review reveals that tendon pathologies have been the primary target for electrolysis modalities, while MTrPs and muscle injuries have received relatively less application. Both electrolysis types have been shown to be effective in reducing pain in these conditions, whether used alone [10,23,29,36], or in combination with therapeutic exercise, such as stretching and eccentric training [7–9,11,25,26,28,30,32,34–36,38,39,41,43,44], deep transverse massage (8,26), or US (31). However, microelectrolysis appears to exert a more pronounced impact, as evidenced by a larger effect size (SMD = 0.92; 95% CI: 0.5,1.3) compared to electrolysis (SMD = 0.30; 95% CI: 0.01,0.6).

This suggests that microelectrolysis leads to a significant and clinically meaningful reduction in pain intensity, with a notable difference observed between treatment groups. To strengthen these findings, further meta-analyses should incorporate additional RCTs assessing pain intensity using common and validated instruments, such as VAS, to determine if the observed effect surpasses the minimally clinically important difference (MCID) reported for the selected tool [45].

The precise therapeutic mechanism underlying the analgesic effects of electrolysis techniques remains to be understood, although both mechanical and biochemical pathways have been proposed. Upon contact with tissue, the galvanic current initiates a chemical reaction, resulting in the dissociation of water molecules (H_2O) and salt (NaCl), thereby forming sodium hydroxide (NaOH) [4-6]. This compound induces tissue destruction, aligning with the etymology of 'electrolysis,' which signifies 'breakdown' or 'degradation' [7].

In tendons, it is hypothesized that electrolysis provokes tenocyte disruption and local inflammatory processes. The destruction of fibrous tissue occurs through a caustic reaction, which promotes new tissue formation by eliciting a controlled inflammatory response conducive to tissue regeneration [8–10]. Studies in animal models support this hypothesis by demonstrating that direct current enhances anti-inflammatory and angiogenic molecular mechanisms in a collagenase-induced tendon injury, as evidenced by significant increases in cytochrome C and vascular endothelial growth factor [7,47]. Studies have also shown that low-intensity galvanic current can ease the pain of chronic tendinopathies. Degeneration of the tendon tissue and a failure of the repair response characterize these conditions [48]. Pathological neovascularization, fibroblast

hyperplasia, and free nerve ending arborization are thought to be the hallmarks of chronic tendinopathies. Electrolysis is suggested to enhance collagen synthesis rates, increase fibroblast migration and collagen alignment in chronic tendons, and destroy free nerve endings surrounding the pathological tendon [7,11,48,49].

The hypothesis for MTrPs suggests that electrolysis disrupts the energy crisis-induced muscle spasm cycle [50]. This theory describes a vicious cycle where sustained muscle contraction causes ischemia and an energy deficit (ATP), preventing the disengagement of actin-myosin cross-bridges (due to failure in calcium reuptake by the Ca-Mg ATPase pump). This leads to metabolite accumulation and nerve-ending sensitization, which perpetuates pain and muscle dysfunction while maintaining the active trigger point [50,51]. Electrolysis is hypothesized to break this cycle through a vascular response produced by controlled inflammation, providing local blood flow [10].

Algometry acknowledges PPT as a key measure in MTrP evaluation [52]. Despite the noted rise in PPT following treatment, electrolysis modalities were not superior to control interventions like therapeutic exercise, deep transverse massage, deep dry needling, and ultrasound. These results offer patients alternative modalities for pain management, emphasizing their less invasive nature and greater acceptance, particularly in instances of needle phobia (belonephobia) [53].

Although the hypotheses regarding tendinopathies and MTrPs are plausible, additional studies are imperative to elucidate the precise etiology of pain in these conditions and to further delineate the analgesic effects of electrolysis on these specific tissues.

Electrolysis and disability

The findings indicate positive effects on disability for both electrolysis techniques, with a large effect size ($d > 0.8$), while only microelectrolysis demonstrates effectiveness in improving function. There is a close relationship between disability or function and pain, particularly in chronic pain conditions [54,55]. Pain can limit an individual's functional capacity, which in turn can exacerbate the perception of pain due to physical inactivity and reduced mobility. However, the duration, intensity, scope, and significance of pain are key factors in this relationship, and a linear correlation is not always present [54]. Despite the complexity of disability as a construct, we recognize functional outcomes as patient-reported outcome measures (PROMs), and we highly recommend the use of PROMs in RCTs and clinical practice as a strategic priority [56].

Recommendations

The authors recommend the use of microelectrolysis for managing the reported conditions, employing intensities between 0.35 and 0.6 μA to achieve an average therapeutic dose of 31.5 mC. They suggest that electrolysis modalities, akin to other physical agents, may operate following the Arndt-Schultz law, where the biological response varies with stimulus intensity: low intensities stimulate, moderate ones enhance, high ones inhibit, and very high ones can be toxic. The high current densities of electrolysis compared to microelectrolysis, provide a very high energy load, which might account for microelectrolysis's superior therapeutic response and potential patient discomfort.

Conservative treatment is frequently the initial approach for managing tendinopathies. Alongside electrolysis, other therapies can complement it, including activity modification, cold and heat compression, transverse friction massage, stretching, and eccentric exercise [7,11]. Eccentric contractions stretch the muscle-tendon complex, leading to specific adaptations, pain-relieving effects, and increased tendon resilience, hence their common inclusion in the included RCTs. Furthermore, eccentric exercise improves neuromuscular control, aiding in pain prevention and reducing the risk of reinjury in a way that concentric exercise does not.

The discussion regarding the essentiality of ultrasound guidance in electrolysis therapies revolves around two main viewpoints [12]. Advocates argue that it offers greater precision in targeting, thereby enhancing treatment safety and effectiveness [8,9,11]. Conversely, some authors highlight the financial implications, specialized training requirements, and the notion that, in certain instances, meticulous clinical assessment and familiarity with anatomical landmarks may suffice for safe and effective procedure guidance [12]. Ultimately, the decision to use ultrasound should be based on a thorough assessment of the risks and benefits, as well as the available expertise and resources in the clinical setting.

Limitations

In this SR, the authors emphasize adherence to PRISMA guidelines [14], PROSPERO protocol registration for evaluating and presenting evidence [57], and a comprehensive search across eight different sources. However, limitations have been identified: First, the RoB associated with randomization and outcome measurement, coupled with concerns regarding intervention deviations and outcome measurement, may introduce biases in the results due to the potential influence of treatment knowledge and outcome assessment. Such circumstances can compromise the study's internal validity and the interpretation of its findings. Second, despite statistically and clinically significant improvements in pain intensity and disability, the heterogeneity observed

among RCTs poses a constraint on the quality and recommendation of the evidence. This variability is likely attributable to the limited number of RCTs addressing this specific topic, particularly those concerning microelectrolysis. It is noteworthy that no complications arose regarding articles in languages outside those specified (an exclusion criterion stipulated by the authors), facilitating the analysis of studies on this basis.

Conclusion

In summary, this SR emphasizes the analgesic effectiveness of electrolysis modalities in treating musculoskeletal pain disorders. While both techniques led to pain reduction and improved disability post-treatment, microelectrolysis exhibited superior effects compared to electrolysis. However, neither intervention outperformed controls in terms of PPT. These findings suggest promising opportunities for electrolysis modalities, particularly microelectrolysis, in pain management. Nevertheless, further research is required to better understand their analgesic mechanisms. Moreover, decisions regarding the adoption of ultrasound guidance should be made after careful consideration of the risks, benefits, and available clinical resources.

Funding

This research received no external funding.

Conflicts of interest

The authors declare no conflict of interest.

Appendix 1. Summary of excluded articles via databases, registries, and other methods.

N°	Source	Reason of exclusion	Author	Year	Reference
1	Studies via database and registers	Case series	Valera-Garrido et al.	2014	Valera-Garrido F, Minaya-Muñoz F, Medina-Mirapeix F. Ultrasound-guided percutaneous needle electrolysis in chronic lateral epicondylitis: Short-term and long-term results. Acupunct Med. 2014;32(6):446–54.
2	Studies via database and registers	Case series	Abat et al.	2014	Abat F, Diesel W-J, Gelber P-E, Polidori F, Monllau J-C, Sanchez-Ibañez J-M. Effectiveness of the Intratissue Percutaneous Electrolysis (EPI®) technique and isoinertial eccentric exercise in the treatment of patellar tendinopathy at two years follow-up. Muscles Ligaments Tendons J. 2014;4(2):188–93.
3	Studies via database and registers	Case report	Abat	2014	Abat. Large tear of the pectoralis major muscle in an athlete. Results after treatment with intratissue percutaneous electrolysis (EPI®). J Sports Med Doping Stud. 2014;04(02).
4	Studies via database and registers	Case series (Congress poster)	González-Pérez et al.	2015	González-Pérez LM, Lopez-Martos R, Montes-Carmona JF, Urresti-Lopez FJ, Ruiz-Canela P, Infante-Cossio P, et al. Effectiveness of Percutaneous Intratissue Electrolysis (PIE) technique in the temporomandibular myofascial pain syndrome. Int J Oral Maxillofac Surg. 2015;44:e214.
5	Studies via database and registers	Case report	Mattiussi et al.	2016	Mattiussi G, Moreno C. Treatment of proximal hamstring tendinopathy-related sciatic nerve entrapment: presentation of an ultrasound-guided “Intratissue Percutaneous Electrolysis” application. Muscles Ligaments Tendons J. 2016;6(2):248–52.
6	Studies via database and registers	Case report	Muñoz-Fernández t al.	2018	Muñoz Fernández AC, Vera DM. C0077 Ultrasound-guided invasive treatment with microcurrent in the lateral epicondyle tendinopathy. a case report. In: Abstracts. BMJ Publishing Group Ltd and British Association of Sport and Exercise Medicine; 2018.
7	Studies via database and registers	Case report	López et al.	2018	López JT, Llopis MM, Lado SI, Ruiz de Lara Osácar A, Iglesias JG, Gonzalez CF. C0073 Ultrasound-guided percutaneous terapeutic electrolisis (EPTE) for supraspinatus tendinosis pain: a case report. In: Abstracts. BMJ Publishing Group Ltd and British Association of Sport and Exercise Medicine; 2018.
8	Studies via database and registers	Incomplete study	González-Pérez et al.	2017	Gonzalez-Perez LM, Infante-Cossio P, Montes-Latorre E, Torres-Carranza E, Ruiz-Canela P, Urresti-Lopez FJ, et al. Clinical results after deep dry needling versus intratissue percutaneous electrolysis technique for the treatment of temporomandibular myofascial pain. Int J Oral Maxillofac Surg. 2017;46:358.

9	Studies via database and registers	Incomplete study	González-Pérez et al.	2019	Gonzalez-Perez LM, Canivell-Zabaleta M, Rodriguez-Posada F, Caro-Jimenez MJ, Lopez-Martos R, Infante-Cossio P, et al. Study comparing intratissue percutaneous electrolysis, deep dry needling and botulinum toxin for the management of temporomandibular myofascial pain. Int J Oral Maxillofac Surg. 2019;48:280.
10	Studies via database and registers	Study protocol	López-Royo et al.	2020	López-Royo MP, Gómez-Trullén EM, Ortiz-Lucas M, Galán-Díaz RM, Bataller-Cervero AV, Al-Boloushi Z, et al. Comparative study of treatment interventions for patellar tendinopathy: a protocol for a randomised controlled trial. BMJ Open. 2020;10(2):e034304.
11	Studies via database and registers	Study protocol Healthy subjects	Varela-Rodríguez et al.	2021	Varela-Rodríguez S, Sánchez-González JL, Sánchez-Sánchez JL, Delicado-Miralles M, Velasco E, Fernández-de-Las-Peñas C, et al. Effects of percutaneous electrolysis on endogenous pain modulation: A randomized controlled trial study protocol. Brain Sci. 2021;11(6):801.
12	Studies via database and registers	Case reports	Muñoz-Fernández et al.	2022	Muñoz-Fernández AC, Barragán-Carballar C, Villafañe JH, Martin-Pérez S, Alonso-Pérez JL, Díaz-Meco R, et al. Correction: Muñoz-Fernández et al. A new ultrasound-guided percutaneous electrolysis and exercise treatment in patellar tendinopathy: three case reports. Frontiers in Bioscience-Landmark. 2021; 26: 1166-1175. Front Biosci (Landmark Ed). 2022;27(3):109.
13	Studies via database and registers	Healthy subjects	Varela-Rodríguez et al.	2022	Varela-Rodríguez S, Sánchez-Sánchez JL, Velasco E, Delicado-Miralles M, Sánchez-González JL. Endogenous pain modulation in response to a single session of percutaneous electrolysis in healthy population: A double-blinded randomized clinical trial. J Clin Med. 2022;11(10):2889.
14	Studies via database and registers	Case report	Carrasco-Uribarren et al.	2022	Carrasco-Uribarren A , Palacio-Albertin JC, Pascual-Lanuza N, PT, Pérez-Guillén S, Ciuffreda G, Cabanillas-Barea S. Ultrasound-Guided Percutaneous Needle Electrolysis in a Patient With Cervicogenic Headache After a Chronic Whiplash: A Case Report. JOSPT Cases 2022;2(2):88–92.
15	Studies via database and registers	Study protocol	López-Royo et al.	2020	López-Royo MP, Gómez-Trullén EM, Ortiz-Lucas M, Galán-Díaz RM, Bataller-Cervero AV, Al-Boloushi Z, et al. Comparative study of treatment interventions for patellar tendinopathy: a protocol for a randomised controlled trial. BMJ Open. 2020;10(2):e034304.
16	Studies via other methods	Healthy subjects	Sánchez-González et al.	2023	Sánchez-González JL, Navarro-López V, Calderón-Díez L, Varela-Rodríguez S, Fernández-de-Las-Peñas C, Sánchez-Sánchez JL. Effectiveness of different percutaneous electrolysis protocols in the endogenous modulation of pain: A Double-Blinded Randomized Clinical Trial. Musculoskelet Sci Pract. 2023;68(102872):102872.

17	Studies via other methods	A critically appraised topic	Lumpkin et al.	2023	Lumpkin KJ, Fuchs EJ, Lowes JN. The efficacy of dry needling in combination with electrical stimulation on pain reduction and improved function in chronic plantar heel pain: A critically appraised topic. Athletic Ther Today. 2023;28(6):281–90.
18	Studies via other methods	Case series (Congress poster)	Calderón-Díez et al.	2023	Calderón-Díez L, Sánchez-Sánchez JL, Sánchez-Ibáñez JM, Belón-Pérez P. Percutaneous electrolysis (EPI®), a promising technology in the treatment of insertional patellar tendinopathy in soccer players. In: Lecture Notes in Networks and Systems. Cham: Springer International Publishing; 2023. p. 24–31.

Appendix 2. Search strategy (last updated July 1, 2024).

	KEYWORDS	PUBMED*	SCOPUS*	WOS*	EBSCOhost*	Embase*	COCHRANE*	PEDro	**TOTAL**	Google Scholar**
1	*"Electrolysis"*	10.816	93.875	53.348	200	14.723	124		173.086	
2	*"Electroacupuncture"*	7.892	11.631	7.035	2.619	11.395	3.700		44.272	
3	*"Direct current"*	16.029	72.525	48.786	2.535	23.304	6.911		170.090	
4	*"Intratissue percutaneous electrolysis"*	10	16	9	10	12	6		63	
5	*"Microelectrolysis"*	195	244	188	3	222	9		861	
6	*S1 OR S2 OR S3 OR S4 OR S5*	34.613	177.051	108.784	5.335	49.143	10.794		385.720	
7	*"Musculoskeletal Pain"*	11.714	20.084	14.975	4.925	22.549	3.154		77.401	
8	*"Pain Management"*	82.124	64.006	54.862	37.210	76.020	15.761		329.983	
9	*"Tendinopathy"*	10.172	9.825	7.797	5.159	7.437	1.639		42.029	
10	*"Myofascial pain syndromes"*	2.203	3.163	340	1.741	393	1.737		9.577	
11	*"Trigger points"*	2.279	5.634	2.817	1.758	2.962	2.233		17.683	
12	*S7 OR S8 OR S9 OR S10 OR S11*	105.342	98.406	78.685	49.115	107.021	23.047		461.616	
13	*S7 OR S12*	794	793	436	248	542	414	9	3.236	835

***Search algorithm used for formal databases:** ("electrolysis" OR "electroacupuncture" OR "direct current" OR "intratissue percutaneous electrolysis" OR "microelectrolysis") AND ("musculoskeletal pain" OR "pain Management" OR "tendinopathy" OR "myofascial pain syndromes" OR "trigger points")

****Search algorithm used for studies obtained vía ther methoids: ("electrolysis" OR "intratissue percutaneous electrolysis" OR "microelectrolysis") AND ("musculoskeletal pain" OR "pain management")**

References

1. Blyth FM, Briggs AM, Schneider CH, Hoy DG, March LM. The Global Burden of musculoskeletal pain-where to from here? Am J Public Health. 2019; 109(1): 35–40.
2. El-Tallawy SN, Nalamasu R, Salem GI, LeQuang JAK, Pergolizzi JV, Christo PJ. Management of musculoskeletal pain: An update with emphasis on chronic musculoskeletal pain. Pain Ther. 2021; 10(1): 181–209.
3. Urits I, Charipova K, Gress K, Schaaf AL, Gupta S, Kiernan HC, et al. Treatment and management of myofascial pain syndrome. Best Pract Res Clin Anaesthesiol. 2020; 34(3): 427–48.
4. Perreault T, Ball A, Dommerholt J, Theiss R, Fernández-de-Las-Peñas C, Butts R. Intramuscular electrical stimulation to trigger points: Insights into mechanisms and clinical applications-A scoping review. J Clin Med. 2022; 11(20): 6039.
5. Fullen BM, Wittink H, De Groef A, Hoegh M, McVeigh JG, Martin D, et al. Musculoskeletal pain: Current and future directions of physical therapy practice. Arch Rehabil Res Clin Transl. 2023; 5(1): 100258.
6. Rodriguez Lagos L, Arribas-Romano A, Fernández-Carnero J, González-Zamorano Y, Laguarta Val S. Effects of percutaneous and transcutaneous electrical nerve stimulation on endogenous pain mechanisms in patients with musculoskeletal pain: A systematic review and meta-analysis. Pain Med. 2023; 24(4): 397–414.
7. Abat F, Gelber PE, Polidori F, Monllau JC, Sanchez-Ibañez JM. Clinical results after ultrasound-guided intratissue percutaneous electrolysis (EPI®) and eccentric exercise in the treatment of patellar tendinopathy. Knee Surg Sports Traumatol Arthrosc. 2015; 23(4): 1046–52.
8. Arias-Buría JL, Truyols-Domínguez S, Valero-Alcaide R, Salom-Moreno J, Atín-Arratibel MA, Fernández-de-Las-Peñas C. Ultrasound-guided percutaneous electrolysis and eccentric exercises for subacromial pain syndrome: A randomized clinical trial. Evid Based Complement Alternat Med. 2015; 2015: 315219.
9. Ronzio OA, Villa CA, Gómez D, Valentim da Silva RM, Gill JP, d'Almeida S, et al. Effects in pressure-pain threshold of percutaneous galvanic microcurrent in the trapezius trigger points. Physiotherapy. 2015; 101: e1297–8.
10. Abat F, Sánchez-Sánchez JL, Martín-Nogueras AM, Calvo-Arenillas JI, Yajeya J, Méndez-Sánchez R, et al. Randomized controlled trial comparing the effectiveness of the ultrasound-

guided galvanic electrolysis technique (USGET) versus conventional electro-physiotherapeutic treatment on patellar tendinopathy. J Exp Orthop. 2016; 3(1): 34.

11. de la Barra Ortiz HA, Castillo RC, Zarraonandia MD, Cáceres IR, Ramírez VR. Comparison of the effectiveness of electrolysis and microelectrolysis in the treatment of musculoskeletal pain: a systematic review. Physiother Q. 2023; 31(1): 73–89.
12. d'Almeida SM, da Silva RMV, Ronzio OA. Surveillance on safety and complications four years after the introduction of Percutaneous Microelectrolisis (MEP®) Sport technique as a physical therapy practice. Fisioter Pesqui. 2019; 26(2): 213–18.
13. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. Syst Rev. 2021; 10(1): 89.
14. Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan—a web and mobile app for systematic reviews. Syst Rev. 2016; 5, 210.
15. Cashin AG, McAuley JH. Clinimetrics: Physiotherapy evidence database (PEDro) scale. J Physiother. 2020; 66(1): 59.
16. Flemyng E, Moore TH, Boutron I, Higgins JP, Hróbjartsson A, Nejstgaard CH, et al. Using Risk of Bias 2 to assess results from randomised controlled trials: guidance from Cochrane. BMJ Evid Based Med. 2023; 28(4): 260–6.
17. McHugh ML. Interrater reliability: the kappa statistic. Biochem Med (Zagreb). 2012; 22(3): 276–82.
18. Cumpston M, Li T, Page MJ, Chandler J, Welch VA, Higgins JP, et al. Updated guidance for trusted systematic reviews: a new edition of the Cochrane Handbook for Systematic Reviews of Interventions. Cochrane Database Syst Rev. 2019; 10: ED000142.
19. Austin TM, Richter RR, Sebelski CA. Introduction to the GRADE approach for guideline development: considerations for physical therapist practice. Phys Ther. 2014; 94(11): 1652–9.
20. Caplan AM, Caplan L. The GRADE method. Rheum Dis Clin North Am. 2022; 48(3): 589–99.
21. Kazemi A, R-Moreno M. Results of the Electrolysis Percutaneous Intratissue in the shoulder pain: infraspinatus, A Randomized Controlled Trial. Revista Cubana de Ortopedia y Traumatología. 2016; 30(1).
22. Moreno C, Mattiussi G, Núñez FJ. Therapeutic results after ultrasound-guided intratissue percutaneous electrolysis (EPI®) in the treatment of rectus abdominis-related groin pain in professional footballers: a pilot study. J Sports Med Phys Fitness. 2016; 56(10): 1171–8.

23. García Naranjo J, Barroso Rosa S, Loro Ferrer JF, Limiñana Cañal JM, Suarez Hernández E. A novel approach in the treatment of acute whiplash syndrome: Ultrasound-guided needle percutaneous electrolysis. A randomized controlled trial. Orthop Traumatol Surg Res. 2017; 103(8): 1229–34.
24. Moreno C, Mattiussi G, Núñez FJ, Messina G, Rejc E. Intratissue percutaneous electolysis combined with active physical therapy for the treatment of adductor longus enthesopathy-related groin pain: a randomized trial. J Sports Med Phys Fitness. 2017; 57(10): 1318–29.
25. Ronzio OA, da Silva Coldibeli E, Soares Fernandes MDR, Froes Meyer P, da Silva RMV. Effects of percutaneous microelectrolysis (MEP®) on pain, rom and morning stiffness in patients with achilles tendinopathy. Eur J Physiother. 2017; 19: 62–3.
26. Lopez-Martos R, Gonzalez-Perez L-M, Ruiz-Canela-Mendez P, Urresti-Lopez F-J, Gutierrez-Perez J-L, Infante-Cossio P. Randomized, double-blind study comparing percutaneous electrolysis and dry needling for the management of temporomandibular myofascial pain. Med Oral Patol Oral Cir Bucal. 2018; 23(4): e454–62.
27. Fernández-Rodríguez T, Fernández-Rolle Á, Truyols-Domínguez S, Benítez-Martínez JC, Casaña-Granell J. Prospective randomized trial of electrolysis for chronic plantar heel pain. Foot Ankle Int. 2018; 39(9): 1039–46.
28. Iborra-Marcos Á, Ramos-Álvarez JJ, Rodriguez-Fabián G, Del Castillo-González F, López-Román A, Polo-Portes C, et al. Intratissue percutaneous electrolysis vs corticosteroid infiltration for the treatment of plantar fasciosis. Foot Ankle Int. 2018; 39(6): 704–11.
29. de Miguel Valtierra L, Salom Moreno J, Fernández-de-Las-Peñas C, Cleland JA, Arias-Buría JL. Ultrasound-guided application of percutaneous electrolysis as an adjunct to exercise and manual therapy for subacromial pain syndrome: A randomized clinical trial. J Pain. 2018; 19(10): 1201–10.
30. Ortiz H, Cancino J, Peña FS, León FS, Donoso EM, Gaete VT. Effectiveness of percutaneous microelectrolysis and ultrasound in the decrease of pain in myofascial trigger points: evaluation through algometry and visual analog scale. Physiother Q. 2020; 28(3): 1–8.
31. Rodríguez-Huguet M, Góngora-Rodríguez J, Rodríguez-Huguet P, Ibañez-Vera AJ, Rodríguez-Almagro D, Martín-Valero R, et al. Effectiveness of percutaneous electrolysis in supraspinatus tendinopathy: A single-blinded randomized controlled trial. J Clin Med. 2020; 9(6): 1837.
32. Rodríguez-Huguet M, Góngora-Rodríguez J, Lomas-Vega R, Martín-Valero R, Díaz-Fernández Á, Obrero-Gaitán E, et al. Percutaneous electrolysis in the treatment of lateral epicondylalgia: A single-blind randomized controlled trial. J Clin Med. 2020; 9(7): 2068.

33. Al-Boloushi Z, Gómez-Trullén EM, Bellosta-López P, López-Royo MP, Fernández D, Herrero P. Comparing two dry needling interventions for plantar heel pain: a protocol for a randomized controlled trial. J Orthop Surg Res. 2019; 14(1): 31.
34. Calderón-Díez L, Sánchez-Sánchez JL, Belón-Pérez P, Sánchez-Ibáñez JM. Prospective Analysis of the Beneficial Effects of Intratissue Percutaneous Electrolysis (EPI) Combined with Eccentric Exercise in the Treatment of Chronic Achilles Tendinopathy. J Orthop Res Ther 2020; 5: 1173.
35. De-la-Cruz-Torres B, Barrera-García-Martín I, Valera-Garrido F, Minaya-Muñoz F, Romero-Morales C. Ultrasound-guided percutaneous needle electrolysis in dancers with chronic soleus injury: A randomized clinical trial. Evid Based Complement Alternat Med. 2020; 2020: 1–8.
36. Valera-Calero JA, Sánchez-Mayoral-Martín A, Varol U. Short-term effectiveness of high- and low-intensity percutaneous electrolysis in patients with patellofemoral pain syndrome: A pilot study. World J Orthop. 2021; 12(10): 781–90.
37. López-Royo MP, Gómez-Trullén EM, Ortiz-Lucas M, Galán-Díaz RM, Bataller-Cervero AV, Al-Boloushi Z, et al. Comparative study of treatment interventions for patellar tendinopathy: a protocol for a randomised controlled trial. BMJ Open. 2020; 10(2): e034304.
38. Fernández-Sanchis D, López-Royo MP, Jiménez-Sánchez C, Herrero P, Gómez-Barrera M, Calvo S. A comparative study of treatment interventions for patellar tendinopathy: a secondary cost-effectiveness analysis. Acupunct Med. 2022; 40(6): 516–23.
39. Benito-de-Pedro AI, Becerro-de-Bengoa-Vallejo R, Losa-Iglesias ME, Rodríguez-Sanz D, Calvo-Lobo C, Benito-de-Pedro M. Efficacy of deep dry needling versus percutaneous electrolysis in ultrasound-guided treatment of active myofascial trigger points of the levator scapulae in short-term: A randomized controlled trial. Life (Basel). 2023; 13(4): 939.
40. De-la-Cruz-Torres B, Romero-Rodríguez B, Romero-Morales C. Ultrasound-guided percutaneous needle electrolysis combined with therapeutic exercise may add benefit in the management of soleus injury in female soccer players: A pilot study. J Sport Rehabil. 2023; 32(3): 265–71.
41. Góngora-Rodríguez J, Rosety-Rodríguez MÁ, Rodríguez-Almagro D, Martín-Valero R, Góngora-Rodríguez P, Rodríguez-Huguet M. Structural and functional changes in supraspinatus tendinopathy through Percutaneous electrolysis, Percutaneous peripheral Nerve Stimulation and eccentric exercise combined therapy: A single-blinded randomized clinical trial. Biomedicines. 2024; 12(4): 771.
42. Di Gesù M, Alito A, Borzelli D, Romeo D, Bonomolo F, Calafiore D, et al. Efficacy of ultrasound-guided galvanic electrolysis technique and physical therapy in patients with

Achilles' tendinopathy: A pilot randomised controlled trial. J Back Musculoskelet Rehabil. 2024.

43. Rodríguez-Huguet M, Rodríguez-Almagro D, Rosety-Rodríguez MA, Vinolo-Gil MJ, Molina-Jiménez J, Góngora-Rodríguez J. Pulsed negative pressure myofascial vacuum therapy and percutaneous electrolysis in the treatment of lateral epicondylalgia: A single-blind randomized controlled trial. J Hand Ther. 2024: S0894-1130(24)00004-8.
44. Salas Apaza JA, Franco JVA, Meza N, Madrid E, Loézar C, Garegnani L. Minimal clinically important difference: The basics. Medwave. 2021; 21(3): e8149.
45. Robertson GS, Wemyss-Holden SA, Dennison AR, Hall PM, Baxter P, Maddern GJ. Experimental study of electrolysis-induced hepatic necrosis. Br J Surg. 1998; 85(9): 1212–6.
46. Abat F, Valles SL, Gelber PE, Polidori F, Stitik TP, García-Herreros S, et al. Mecanismos moleculares de reparación mediante la técnica Electrólisis Percutánea Intratisular en la tendinosis rotuliana. Rev Esp Cir Ortop Traumatol. 2014; 58(4): 201–5.
47. Cook JL, Purdam CR. Is tendon pathology a continuum? A pathology model to explain the clinical presentation of load-induced tendinopathy. Br J Sports Med. 2009; 43(6): 409–16.
48. Alfredson H, Ohberg L, Forsgren S. Is vasculo-neural ingrowth the cause of pain in chronic Achilles tendinosis? An investigation using ultrasonography and colour Doppler, immunohistochemistry, and diagnostic injections. Knee Surg Sports Traumatol Arthrosc. 2003; 11(5): 334–8.
49. Shah JP, Thaker N, Heimur J, Aredo JV, Sikdar S, Gerber L. Myofascial trigger points then and now: A historical and scientific perspective. PM R. 2015; 7(7): 746–61.
50. Bron C, Dommerholt JD. Etiology of myofascial trigger points. Curr Pain Headache Rep. 2012; 16(5): 439–44.
51. Geri T, Botticchio A, Rossettini G, Pournajaf S, Pellicciari L, Di Antonio S, et al. Pressure pain threshold of the upper trapezius trigger point: A systematic review with meta-analysis of baseline values and their modification after physical therapy. J Clin Med. 2022; 11(23): 7243.
52. McLenon J, Rogers MAM. The fear of needles: A systematic review and meta-analysis. J Adv Nurs. 2019; 75(1): 30–42.
53. Moore A, Tumin D. Overlap of pain-related and general measures of disability among adults with chronic pain. Pain Pract. 2024; 24(1): 62–71.
54. Zale EL, Lange KL, Fields SA, Ditre JW. The relation between pain-related fear and disability: a meta-analysis. J Pain. 2013; 14(10): 1019–30.
55. Makhni EC, Hennekes ME. The use of patient-reported outcome measures in clinical practice and clinical decision making. J Am Acad Orthop Surg. 2023; 31(20): 1059–66.

56. Schiavo JH. PROSPERO: An international register of systematic review protocols. Med Ref Serv Q. 2019; 38(2): 171–80.