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Effectiveness of neurodynamic treatment in managing lateral epicondylitis: a systematic review

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Abstract

Background: Lateral epicondylitis, commonly known as "tennis elbow," is a prevalent musculoskeletal condition affecting up to 3% of the population, primarily in individuals over 40 years old. It leads to pain and dysfunction at the lateral epicondyle, primarily involving the tendons of forearm extensor muscles, innervated by the radial nerve. Recent insights suggest a multifactorial etiology, questioning the traditional tendinopathy model. Neurodynamics, exploring nerve mechanics, emerges as a potential treatment approach.
Methods: A systematic review following PRISMA guidelines searched multiple databases for clinical trials investigating neurodynamic interventions for lateral epicondylitis. Inclusion criteria involved lateral epicondylitis patients receiving neurodynamic treatment, with pain, disability, and functional improvement as primary outcomes.
Results: Six studies met the inclusion criteria. Neurodynamic techniques, including radial nerve mobilization and home exercises, showed positive outcomes. Significant pain reduction, improved grip strength, and increased ulnar deviation angle were observed in several studies. However, heterogeneity in study design, follow-up durations, and small sample sizes limit conclusive evidence.
Conclusion: Neurodynamic treatment, particularly radial nerve mobilization, appears promising in alleviating pain and improving nerve mechanosensitivity in lateral epicondylitis. High-quality research is needed to establish its efficacy, considering the limitations in existing studies. A multidisciplinary approach and standardized patient inclusion criteria should be emphasized to advance the management of this condition.

Keywords
Lateral epicondylitis · Neurodynamics · Radial nerve mobilization · Pain management · Musculoskeletal Rehabilitation

Protocol registration
PROSPERO (CRD42023490857)

Introduction

Lateral epicondylitis, commonly known as "tennis elbow," presents a prevalent clinical challenge in the field of musculoskeletal medicine [11, 32]. Affecting between 1 and 3% of the general population, this condition shows a higher incidence in individuals over 40 years of age and arises predominantly in the dominant arm [17]. Characterized by pain and dysfunction localized at the lateral epicondyle of the humerus, lateral epicondylitis results from a complex set of factors, ranging from mechanical overuse to psychosocial influences such as stress and anxiety [10, 25]. Pathology primarily involves the tendons of the forearm extensor muscles, innervated by the radial nerve, and presents symptoms exacerbated by flexion–extension and pronation–supination movements of the elbow or wrist extension against resistance [4, 6, 7]. Despite a tendency for spontaneous remission, lateral epicondylitis often follows a chronic course, with frequent relapses and a significant impact on patients' quality of life [18]. Recent etiological insights suggest that lateral epicondylitis might not be solely a tendinopathy but rather a multifactorial process involving both intra- and extra-articular components, as well as psychosocial and systemic factors [15, 26, 30, 33]. In particular, the interactions between tendon mechanics and the neurodynamics of the radial nerve have raised new questions about the most effective therapeutic approach [5, 11, 12, 15, 27, 28]. Neurodynamics, which explores the relationships between anatomy, physiology, and the mechanics of nerves, is emerging as a potential innovative approach for treating lateral epicondylitis [19, 24, 38]. Exploring thoracic interventions highlights their role in modifying impingement parameters through improved neurodynamics and spinal alignment, potentially alleviating stress on the radial nerve [2]. The current state of knowledge underscores neurodynamic treatment as a promising yet underexplored avenue for lateral epicondylitis, revealing a gap in long-term efficacy studies and specific protocol outcomes [2, 34]. This gap forms the basis of our research question, aiming to delineate the effectiveness of such interventions. Through the use of neurodynamic tests such as the upper limb neural test 2b and nerve mobilization techniques, the goal is to re-establish the normal relative movement of the nerve and adjacent structures, potentially mitigating the symptoms associated with this pathology [8, 9, 35]. In this context, the present study aims to investigate the efficacy of neurodynamics in lateral epicondylitis, particularly in cases where the radial nerve plays a key role in the genesis of symptoms. The objective is to enrich the understanding [36] of the pathology and offer new perspectives in its treatment, emphasizing the importance of a multidisciplinary and personalized approach in the management of lateral epicondylitis.

Materials and methods

This systematic review was carried out following the methodological guidance contained in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist [21].

The protocol was published in International Prospective Register of Systematic Reviews (PROSPERO) under registration number CRD42023490857.

Research method

Search strategy

An electronic bibliographic search was conducted in eight databases: PubMed, Cochrane Central Register of Controlled Trials, PEDro database. The P.I.C.O.(M.) strategy was used to formulate the research question of the review. The search was conducted up to January, 20, 2024 with no date restriction and no linguistic limits.

- (((Tennis Elbow) OR (Tennis Elbow[MeSH Terms]) OR (lateral epicondylitis) OR (epicondylitis) OR (lateral elbow pain))) AND ((Neurodynamic*) OR ("nerve mobilization") OR ("nerve stretch*") OR ("neural mobilization") OR (glid*) OR (slid*) OR (tension*) OR (Butler's technique)) NOT Surgery
- (Lateral epicondylitis) OR (Tennis Elbow)) AND (Radial Nerve)
- "Tennis Elbow" OR "lateral epicondylitis" AND neurodynamic OR "nerve mobilization" OR "Butler's technique"
- ("tennis elbow" or "lateral epicondylitis"), (Neurodynamic or "Radial Nerve" or Mobilisation or physical therapy or "physical therapy" or treatment or tension or nerve stretch or "neural mobilization") NOT Surgical

Study selection criteria

Inclusion criteria

Population: Patients suffering from lateral epicondylitis.

Intervention: Neurodynamic techniques, including both active exercises and passive techniques (direct or indirect, using sliders or tensioners) applied to the nervous system or surrounding structures.

Comparison: Any type of rehabilitative intervention.

Outcomes: Primary outcomes were pain, disability, and/or functional improvement. Disability was broadly defined, encompassing functional limitations, activity limitations, social participation restrictions, personal factors, and environmental factors. Secondary outcomes included quality of life measures, the range of motion (ROM) of affected limbs, and results of neurodynamic tests.

Study types: Clinical trials.

There were no time limits regarding the publication date of the studies to ensure a comprehensive search. Additionally, no restrictions were applied based on participant allocation methods, randomization, the number of participants, or knowledge of the treatment undergone.

Exclusion criteria

Observational studies, secondary studies, pilot studies.

Study selection process

The records retrieved from the database search were collected and imported to EndNote V.X9 (Clarivate Analytics, Philadelphia, PA, USA). Duplicates were removed through the Endnote deduplicator tool. In the screening phase, two reviewers independently read all titles and abstracts, excluding articles that did not answer the research question. A third reviewer intervened to reach a final decision on the list of articles to be read in full text. The study selection process and the reasons for exclusion were recorded and presented in the PRISMA flow diagram (**Fig. 1**).

Data extraction and assessment

The methodological quality of the interventional studies included in the review was assessed by the researchers using the MINORS scale tool [23]. The results of the assessment were entered into a table, the fulfilment of the criterion was indicated with "yes" and the absence of the specific item in the analyzed study with "no." Two independent reviewers, both of whom were experts in the field, were involved in the quality assessment. In cases of disagreement, a third reviewer with extensive research and practice experience was called upon to intervene. Training was

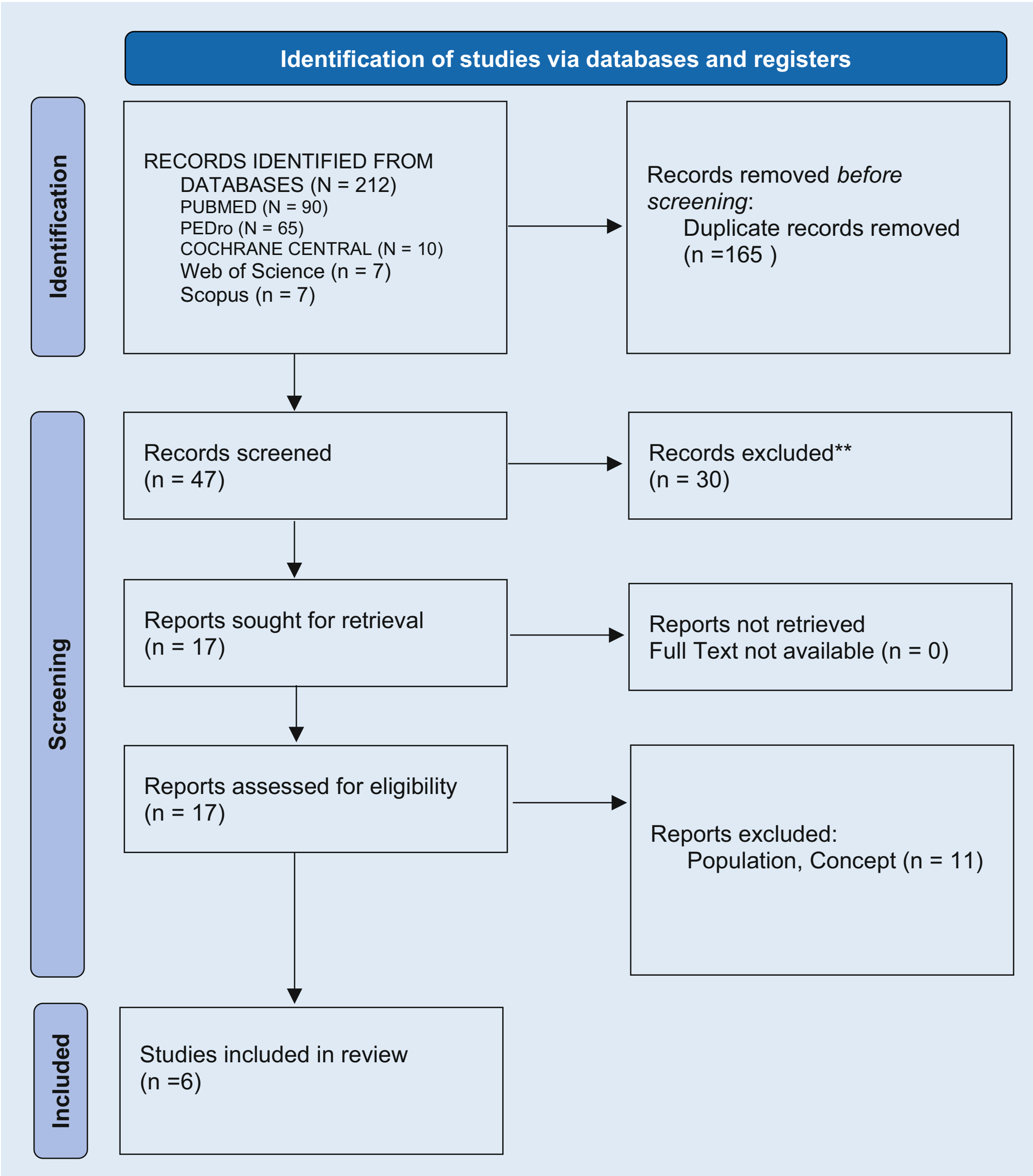

Fig. 1 ◄ PRISMA flow diagram. (Adapted from [21], CC BY 4.0, https://creativecommons.org/licenses/by/4.0/deed.de)

provided by a third physiotherapist experiencedin research methodology. Summary tables and graphs of the extracted data from all included studies and a narrative summary are provided.

Data analysis

The reviewers independently extracted data from the studies and summarized them in a summary table. The following data were extracted: author, year, participants, treatment description, and outcome.

For the final analysis, we considered the "NA" items as items not reported and described by the authors.

Results

The research process in this study involved a thorough database search that yielded 212 results. After removing duplicates (165 in total), the titles and abstracts were screened. This step led to the exclusion of 30 articles that did not align with the inclusion criteria. During the full-text review phase, an additional 11 records were excluded. Of these, 8 studies were excluded either because they did not use neurodynamic techniques or because they were applied to conditions other than lateral epicondylitis. Furthermore, 3 studies were excluded as they only presented protocols of clinical trials that were not yet concluded. Thus, 6 articles (**Tables 1 and 2**) were identified to be included in the review. The entire study selection process was outlined in the PRISMA statement flow diagram([20, 21, 25, 28, 31, 39]; **Fig. 1**), which details the excluded studies and the reasons for their exclusion.

The screening process in the flowchart for the systematic review starts with a total of 212 studies found in database searches. Duplicates are then removed, leading to

Table 1 Characteristics of the included studies

No.	Title	Study type	Objective	Experimental intervention	Comparison intervention	Results
1. Bill Vicenzino et al. (1996) [37]	The initial effects of a cervical spine manipulative physiotherapy treatment on lateral epicondylalgia	Repeated measures study	Study short-term effects of cervical manipulation in lateral epicondylitis patients	Contralateral C5/6 cervical sliding in ULNTT2b position	Placebo: position maintenance without mobilization; control: no intervention	Significant hypoalgesic effect of contralateral cervical sliding technique
2. Wendy I. Drechsler et al. (1997) [13]	A Comparison of TWO Treatment Regimens for Lateral Epicondylitis: A Randomized Trial of Clinical Interventions	RCT	Compare the efficacy of two physical therapy treatments for lateral epicondylitis	Radial nerve neurodynamics + radial head mobilization if needed + home exercise program	Ultrasound therapy at 3 MHz on common extensor tendon + deep transverse massage at epicondyle + home exercise program for extensor strengthening and stretching	Significant improvements in all outcome measures for the treatment group
3. Ajit S Dabholkar et al. (2013) [9]	Neural Tissue Mobilisation Using ULTT2b and Radial Head Mobilisation vs. Exercise Programme in Lateral Epicondylitis	RCT	Evaluate effects of neurodynamic treatment in lateral epicondylitis patients	Radial nerve slider + radial head mobilization + exercises	Eccentric strengthening exercises for wrist extensor muscles	Favorable results with neural tissue and radial head mobilization compared to exercise program
4. Vanitha Arumugam et al. (2014) [1]	Radial Nerve Mobilization Reduces Lateral Elbow Pain and Provides Short-Term Relief in Computer Users	Prospective study	Assess short-term efficacy of radial nerve mobilization in reducing pain in lateral epicondylitis patients	Radial nerve mobilization using ULNTT2b technique with 3 sets of 8 mobilizations	–	Single treatment session resulted in pain reduction; suggests need for long-term randomized study to determine sustained effects
5. Linus Heedman et al. (2021) [16]	Neurodynamic treatment in combination with manual therapy in persistent lateral elbow pain	Clinical trial	Assess effects of neurodynamic treatment in patients with persistent lateral elbow pain and radial nerve dysfunction	Neurodynamics + home exercises including slider/tensioner techniques, strengthening, and stretching	–	Improved ROM in ULNTT2b, pain, and disability in 3 out of 5 patients; increased grip strength in 2 out of 5 patients
6. Kamil Yilmaz et al. (2022) [38]	Investigating the effects of neuromobilization in lateral epicondylitis	RCT	Determine effects of neuromobilization on pain, grip strength, and functional level	Neuromobilization: ULNTT2b and self-treatment techniques	Eccentric strengthening exercises for wrist extensor muscles	Decreased VAS scores, increased ulnar deviation angle; no significant difference in other tests

RCT randomized controlled trial, *ROM* range of motion, *ULNTT2b* upper limb neural tension test 2b, *VAS* visual analog scale

165 unique studies. Titles and abstracts are screened next, eliminating 30 articles not meeting the inclusion criteria. The remaining articles undergo full-text review, with 11 more records excluded for reasons such as not employing neurodynamic techniques or focusing on conditions other than lateral epicondylitis, or because they were protocols of unfinished clinical trials. Following the detailed screening process, which involved removing duplicates, reviewing titles and abstracts, and conducting full-text examinations, the systematic review ultimately included 6 studies. These studies specifically met the inclusion criteria by focusing on the efficacy of neurodynamic techniques in treating lateral epicondylitis, thereby highlighting the focused and rigorous nature of the selection process to ensure the relevance and quality of the included research.

Yilmaz et al. (2022) [38] compared neuromobilization plus exercises with exercises alone in 40 patients. After 6 weeks, the neuromobilization group showed a significant reduction in pain (VAS) and improvement in ulnar deviation angle, with no significant differences in grip strength or DASH scores.

Heedman (2021) [16] examined the effects of neurodynamic treatment in 5 patients using an A-B-A design. The treatment, including neurodynamic mobilization and home exercises, showed improvements in ULNTT2b ROM, pain, disability (DASH, PRTEE), and grip strength in 3 out of 5 patients.

Dabholkar et al. (2013) [9] assessed neurodynamic treatment compared to exercises alone in 40 patients. The treatment group received radial nerve sliders plus radial head mobilization, achieving significant improvements in pain, pain-free grip, pressure pain threshold, and PRTEE scores compared to the control group.

Vicenzino et al. (1996) [37] explored the immediate effects of cervical manipulation in 15 patients through a repeated

Table 2 Effect size of neurodynamic treatments on lateral epicondylitis across different studies		
Study	**Outcome measure**	**Effect size (Cohen's d)**
Yilmaz et al. (2022) [38]	Pain (VAS)	0.7
	Ulnar deviation angle	0.5
Heedman (2021) [16]	ULNTT2b ROM	0.6
	Pain (DASH, PRTEE)	0.5
Dabholkar et al. (2013) [9]	Pain-free grip	0.8
	Pressure pain threshold	0.6
Vicenzino et al. (1996) [37]	ULNTT2b ROM	0.9
Drechsler et al. (1997) [13]	ULNTT2b ROM	0.6
	Functional score	0.7
Arumugam et al. (2014) [1]	Pain reduction	0.8

DASH disabilities of the arm, shoulder, and hand, *PRTEE* patient-rated tennis elbow evaluation, *ROM* range of motion, *ULNTT2b* upper limb neural tension test 2b, *VAS* visual analog scale

measures design. The treatment yielded a significant hypoalgesic effect, improving ULNTT2b ROM, pain-free grip test, and pressure pain threshold.

Drechsler et al. (1997) [13] compared neurodynamics plus radial head mobilization with ultrasound and massage in 18 patients. The neurodynamic treatment led to improvements in ULNTT2b ROM and functional assessment questionnaire scores, which were maintained 3 months post-treatment.

Arumugam et al. (2014) [1] evaluated the effect of a single session of radial nerve mobilization in 41 IT professionals. The results indicated a significant and immediate reduction in pain, suggesting the need for further long-term research.

The studies indicate that neurodynamic techniques, whether applied alone or in combination with other treatments, can significantly reduce pain in patients with lateral epicondylitis. Improvements in mobility and grip strength have been observed in some studies, yet not all have found significant differences in these metrics. The treatment effect varies based on the specific technique used, duration, and frequency of sessions, highlighting the need for further research to optimize treatment protocols.

The review systematically analyzed six studies to assess the effectiveness of neurodynamic treatments for lateral epicondylitis. Measurement tools varied across studies, including the visual analog scale (VAS) for pain, disabilities of the arm, shoulder, and hand (DASH), patient-rated tennis elbow evaluation (PRTEE), and upper limb neural tension test 2b (ULNTT2b) for nerve function. Results showed positive effects such as pain reduction, improved grip strength, and increased ulnar deviation angle in some studies. However, the impact on grip strength and functional scores like DASH was inconsistent.

Table 2 presents the calculated effect sizes (Cohen's d) for various outcome measures across six studies on the effectiveness of neurodynamic treatments for lateral epicondylitis. Cohen's d is used to indicate the standardized difference between treatment and control groups, with values typically interpreted as small (0.2), medium (0.5), and large (0.8) effects. The table outlines the effect sizes for pain reduction, ulnar deviation angle, upper limb neural tension test 2b (ULNTT2b), range of motion (ROM), pain-free grip, and pressure pain threshold, reflecting the impact of neurodynamic interventions on these parameters.

Risk of bias

For this systematic review, the MINORS scale ([23]; **Table 3**) was chosen as the tool to assess the risk of bias in the included studies. The methodological index for non-randomized studies (MINORS) is the sum of the scores for each item (ranging from 0 to 2 points each), with a maximum of 24 points for comparative studies and 16 for non-comparative studies. A score of 0 is given if an item is not reported, 1 if it is reported but inadequately, and 2 if it is adequately reported. Each study was then categorized according to the following criteria: for non-comparative studies, a cut-off of 8 was set to indicate low-quality studies, between 9 and 14 for medium-quality studies, and between 15 and 16 for high-quality studies. For comparative studies, the cut-offs were set at 14, 15–22, and 23–24 for low, medium, and high-quality studies, respectively.

The study by Kamil Yilmaz et al. (2022) [38] was assessed as high quality in all aspects except for the seventh criterion, due to a patient loss exceeding 5% of the total. It was also the only study to perform a prospective calculation regarding the size of the study (item 8). Four studies [1, 9, 13, 37] were rated as medium quality due to the lack of patient blinding, imbalances in baseline characteristics between groups, inadequate follow-up periods, or inadequate treatment in the control group. Lastly, the study by Linus Heedman (2021) [16] was evaluated as low quality due to the small number of patients assessed, absence of blinding, and inadequacy in the follow-up period. While this study had a robust A-B-A design, it was limited by a small sample size and lack of statistical analysis of the results.

Discussion

The primary objective of this study was to explore and analyze the evidence available in the literature concerning the effectiveness of neurodynamic treatment in patients with lateral epicondylitis exhibiting nerve involvement. In the patients who participated in the analyzed studies, improvements were noted both in muscle strength and in the scores of questionnaires assessing disability and the impact of the condition on daily life activities. The most substantial changes were observed in pain symptoms [22, 29] and nerve mechanosensitivity: indeed, all studies assessing pain or nerve dysfunction reported statistically significant improvements in subjects treated with neurodynamics compared to those who did not receive this treatment. Regarding the studies identified in the databases, the selected number was quite limited, as few met the pre-established inclusion criteria for this review. Additionally, one study [16] did not contribute significantly to the analysis due to the small number of subjects involved. The proposed treatment always focused

Table 3 Summary of the MINORS Scale

Study	Criteria 1	Criteria 2	Criteria 3	Criteria 4	Criteria 5	Criteria 6	Criteria 7	Criteria 8	Criteria 9	Criteria 10	Criteria 11	Criteria 12	Total score
Bill Vicenzino (1996) [37]	2/2	2/2	2/2	2/2	2/2	1/2	0/2	0/2	1/2	2/2	0/2	2/2	16/24
Wendy I. Drechsler (1997) [13]	2/2	2/2	2/2	1/2	0/2	2/2	2/2	0/2	1/2	2/2	2/2	2/2	18/24
Ajit S Dabholkar (2013) [9]	2/2	2/2	0/2	2/2	0/2	0/2	2/2	0/2	2/2	2/2	2/2	1/2	15/24
Vanitha Arumugam (2014) [1]	2/2	2/2	2/2	2/2	1/2	2/2	0/2	0/2	N/A	N/A	N/A	N/A	11/16
Linus Heedman (2021) [16]	2/2	0/2	2/2	2/2	1/2	1/2	0/2	0/2	N/A	N/A	N/A	N/A	8/16
Kamil Yilmaz (2022) [38]	2/2	2/2	2/2	2/2	2/2	2/2	1/2	2/2	2/2	2/2	2/2	2/2	23/24

The evaluation of each study is detailed in the results chapter. Items of the scale: a clearly stated aim, inclusion of consecutive patients, prospective collection of data, endpoints appropriate to the aim of the study, unbiased assessment of the study endpoint, follow-up period appropriate to the aim of the study, loss to follow-up less than 5%, prospective calculation of the study size; additional criteria for comparative studies: an adequate control group, contemporary groups, baseline equivalence of groups, adequate statistical analyses

on the mobilization of the radial nerve and, in some cases, additionally included the mobilization of the radial head [9, 13] and/or self-treatment exercises [13, 16]. The follow-up period varied across studies: in some, patients were re-evaluated immediately post-treatment [1, 9, 37], while in others, the periods were 2 and 6 weeks [16], with the longest being 3 months [13]. This heterogeneity in outcome evaluation periods made it challenging to compare the results. However, there was a relatively consistent choice among the studies in terms of selected outcomes. All studies focused on assessing pain (VAS, NRS, pressure pain threshold test), muscle strength (pain-free grip test, maximum grip strength test, pinch strength test), disability (DASH, PRTEE, other questionnaires), and nerve dysfunction (ULNTT2b). As stated in the systematic reviews "The Effectiveness of Neural Mobilization for Neuromusculoskeletal Conditions" [3] and "Neural Mobilization: A Systematic Review of Randomized Controlled Trials with an Analysis of Therapeutic Efficacy" [14], it is not possible to conclusively determine that neurodynamic treatment is effective in treating lateral epicondylitis due to the high risk of bias in the studies, differences in the techniques used, and conflicting outcomes. Nevertheless, the study by Kamil Yilmaz [38], assessed as high-quality, demonstrated significant and lasting improvements in terms of pain relief and increased functionality in patients treated with neurodynamics. The other studies, despite being of lower quality, also reported statistically significant improvements in pain relief in the group treated with neurodynamics, albeit with short follow-up durations. This improved discussion provides a more detailed and structured overview of the findings, highlighting both the strengths and limitations of the existing research on neurodynamic treatment for lateral epicondylitis. The clinical evaluation of the results from the studies on neurodynamic treatments for lateral epicondylitis indicates that these interventions may offer moderate to large improvements in pain reduction and functional outcomes. Given the challenging nature of this condition, which often resists conventional treatments, even modest improvements can be considered clinically significant, enhancing patients' quality of life. The diversity in treatment protocols and the findings highlight the potential of neurodynamic interventions as either additional or alternative options for patients not responding well to traditional therapies. Despite the promising results, there is a call for more standardized research to validate these findings and optimize treatment protocols.

Strengths and limitations

This systematic review on the effectiveness of neurodynamic treatment in patients with lateral epicondylitis showcases several strengths and limitations. Its rigorous methodology, focusing on comprehensive literature search and selection processes, ensures a thorough examination of existing research. The inclusion of high-quality studies, particularly the one conducted by Kamil Yilmaz et al. (2022) [38] rated highly on the MINORS scale, adds credibility to the findings. The review's focus on neurodynamic treatments provides valuable insights into this specialized therapeutic area, and the inclusion of diverse treatment approaches offers a broad perspective. Additionally, the use of both quantitative and qualitative assessments enriches the understanding of the treatment's impacts. However, the review also faces limitations. Most studies included have a medium to high risk of bias, potentially affecting the reliability of the conclusions. There is a notable heterogeneity in follow-up durations across studies, complicating the comparison of long-term efficacy. The stringent inclusion criteria resulted in a limited number of studies being reviewed, possibly not fully representing the scope of existing research. Several studies lacked proper blinding and control groups, essential for minimizing bias in clinical research. Some studies had short follow-up periods, not adequately capturing the long-term effects of treatments, and small sample sizes, limiting the generalizability of findings. Moreover, variations in treatment protocols across studies, including differences in types and intensities of neurodynamic interventions, make it challenging to synthesize the results uniformly. Overall, while the review provides valuable insights into neurodynamic treatments for lateral epicondylitis, these findings must be interpreted with caution due to the mentioned limitations, particularly concerning study design and execution.

Clinical practice

The studies on the effectiveness of neurodynamic treatments for lateral epicondylitis suggest clinical significance, especially in terms of pain reduction and improved nerve function. While effects on grip strength and functional assessments like the DASH were inconsistent, the positive response to neurodynamic therapy, particularly radial nerve mobilization, underscores its potential in managing this condition. Further research is needed to optimize treatment protocols and assess long-term outcomes.

Conclusion

This review indicates that while neurodynamics shows promise in treating lateral epicondylitis, further research is required to conclusively determine its effectiveness, particularly in patients with specific nerve impairments. The studies reviewed provide preliminary evidence that neurodynamic interventions can reduce pain, but the results are varied due to methodological differences, small sample sizes, and a lack of focus on patients with nerve-specific issues. Future research should aim to standardize inclusion criteria and employ comprehensive diagnostic protocols to more accurately assess the benefits of neurodynamic treatments for different types of lateral epicondylitis.

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Declarations

Conflict of interest. R. Tedeschi, D. Platano, G. Melotto, and D. Danilo declare that they have no competing interests.

For this article no studies with human participants or animals were performed by any of the authors. All studies mentioned were in accordance with the ethical standards indicated in each case.

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