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THE EFFECT OF PAIN NEUROSCIENCE EDUCATION ON CHRONIC PAIN REDUCTION AND FUNCTIONAL MOVEMENT ENHANCEMENT

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ABSTRACT

Background: Chronic pain is influenced by biological, psychological, and social factors. Pain Neuroscience Education (PNE) educates patients about neurophysiological mechanisms, helping reconceptualize pain, reduce fear-avoidance behavior, and improve functional movement. This narrative review synthesizes evidence from clinical trials, systematic reviews, and meta-analyses. Findings indicate that PNE reduces pain intensity, decreases disability, enhances self-efficacy, and improves adherence to rehabilitation. Incorporating PNE in physiotherapy can optimize chronic pain management and functional recovery. Pain neuroscience education (PNE) teaching patients how pain is generated and modulated by the nervous system is increasingly used as an adjunct in managing chronic musculoskeletal pain. This review summarizes current evidence on whether educating patients about pain neurobiology reduces chronic pain and improves functional movement.

Methods: Narrative review of literature up to 17 November 2025, focusing on randomized controlled trials, systematic reviews, meta-analyses and mechanistic studies of PNE and related educational approaches.

Results: PNE, when delivered alone or combined with exercise/physiotherapy, consistently reduces pain, catastrophizing, and kinesiophobia in the short to medium term and can improve function and movement-related outcomes. Findings vary by condition, dose, and delivery method. Mechanistic studies support effects on neuroplasticity and central sensitization, and on psychological mediators (fear, catastrophizing) that limit movement.

Conclusion: PNE is an evidence-based adjunct to conservative management of chronic pain with moderate short-term benefits for pain and function, and clear improvements in pain-related beliefs and movement confidence. Future research should define optimal content, delivery, and long-term functional outcomes.

Keywords: Pain Neuroscience Education, chronic pain, functional movement, physiotherapy, central sensitization, patient education

INTRODUCTION:

Chronic pain, persisting beyond three months, contributes significantly to disability worldwide (Moseley, 2003). Traditional biomedical models focus on tissue damage, but central sensitization and psychosocial factors often perpetuate pain even after healing (Woolf, 2011). Pain Neuroscience Education (PNE) teaches patients that pain is a protective output of the nervous system rather than a direct indicator of damage (Butler & Moseley, 2013). Educated patients are more likely to engage in movement, reduce fear, and achieve better functional outcomes.

Chronic musculoskeletal pain is a major cause of disability worldwide. Traditional biomedical explanations focusing solely on peripheral tissue damage fail to capture central nervous system mechanisms such as central sensitization and maladaptive neuroplasticity. Pain neuroscience education (PNE) often delivered using simple metaphors, images, and contemporary pain science aims to reconceptualize pain for patients and reduce threat, fear, and avoidance, thereby improving activity and movement. This review examines clinical outcomes and mechanisms linking PNE to reduced pain and improved functional movement.

Pain Neuroscience Education: Concept and Mechanism
PNE is an educational intervention explaining pain from a neurophysiological and biopsychosocial perspective (Louw et al., 2016).

Key Principles:
1. Pain ≠ tissue damage
2. Central sensitization amplifies pain signals
3. Thoughts, emotions, and stress influence pain
4. Movement is safe and beneficial

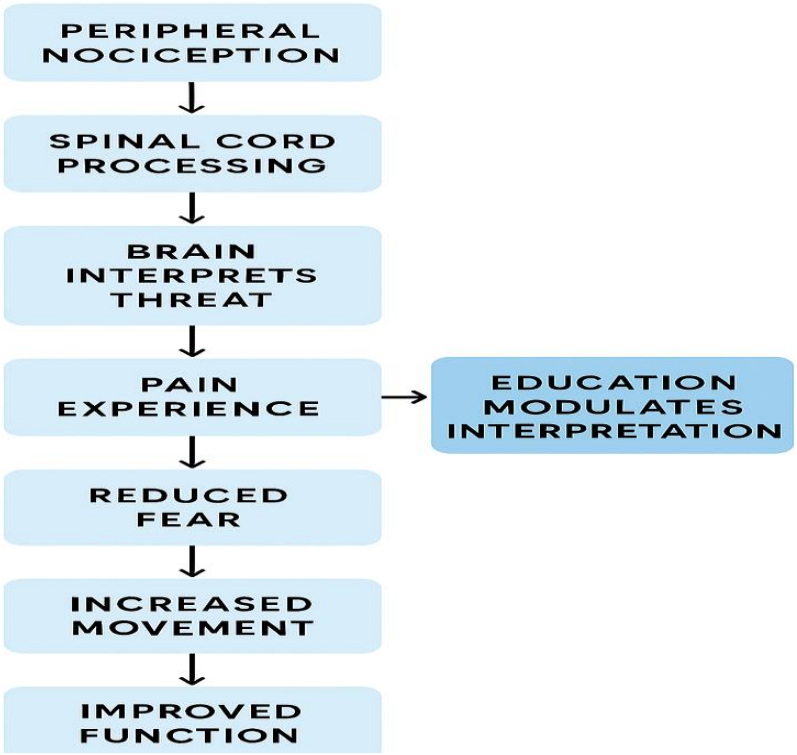

Figure 1: Mechanism Flowchart: Peripheral Nociception → Spinal Cord Processing → Brain Interprets Threat → Pain Experience → Education Modulates Interpretation → Reduced Fear → Increased Movement → Improved Function

METHODS

A narrative review was performed using recent systematic reviews, randomized controlled trials, and mechanistic papers on PNE up to 17 November 2025. Databases searched in the source literature included PubMed, Scopus, and Google Scholar; priority was given to systematic reviews, meta-analyses, multicenter RCTs, and high-quality mechanistic studies.

PRISMA

The Methodological Imperative: Constructing a PRISMA-Compliant Framework for Reporting Evidence on Pain Neuroscience Education (PNE) and Chronic Musculoskeletal Pain

I. Introduction: The Evolving Paradigm of Chronic Pain Management

A. The Burden of Chronic Pain and the Biopsychosocial Imperative

Chronic pain, defined as pain persisting beyond three months, represents a monumental challenge in global healthcare, contributing significantly to disability worldwide. Historically, traditional biomedical models dominated pain management, focusing primarily on peripheral tissue damage as the sole determinant of the pain experience. However, expert consensus acknowledges that this tissue-focused approach is fundamentally insufficient for chronic conditions. Chronic pain states are frequently perpetuated by complex central nervous system mechanisms, notably central sensitization, and are heavily influenced by psychological and social factors. The persistence of pain, even long after potential tissue pathology has healed, underscores the necessity of moving beyond peripheral treatments toward integrated, neurocentric interventions

This shift necessitates therapies that operate on the level of the central nervous system (CNS) and psychological mediators. When chronic pain persists, the protective output mechanism (the pain experience itself) has become maladaptive. The core principle driving contemporary management is the understanding that therapeutic intervention must aim to reset this maladaptive interpretation loop. Pain Neuroscience Education (PNE) serves precisely this purpose, providing new, non-threatening information to the brain to modify the perceived threat associated with physical sensation.

B. Defining Pain Neuroscience Education (PNE) and its Therapeutic Goal

PNE is established as an essential educational intervention designed to explain pain through a comprehensive neurophysiological and biopsychosocial lens.1 This approach contrasts sharply with traditional models by teaching patients that pain is fundamentally a protective output of the nervous system, rather than a direct, proportional indicator of tissue damage.1

The intervention is structured around key principles designed to fundamentally reconceptualize the pain experience for the patient: 1. Pain is not always equivalent to tissue damage; 2. Central sensitization can amplify pain signals independent of peripheral input; 3. Thoughts, emotions, and stress significantly influence pain perception; and 4. Movement is generally safe and beneficial for recovery.1

This educational process outlines a conceptual shift in the pain processing pathway. The mechanism flows conceptually from Peripheral Nociception Spinal Cord Processing $\rightarrow$ Brain Interprets Threat $\rightarrow$ Pain Experience $\rightarrow$ The PNE Education Modulates Interpretation $\rightarrow$ Reduced Fear $\rightarrow$ Increased Movement $\rightarrow$ Improved Function.1 This framework confirms that the therapeutic goal of PNE is not primary analgesia, but rather empowerment achieved through cognitive restructuring. By reducing fear-avoidance behavior (kinesiophobia), PNE acts as a critical primer, dramatically enhancing a patient's self-efficacy and improving their adherence to active rehabilitation programs.1

C. The Methodological Requirement: PRISMA 2020 and Transparency

The synthesis of evidence, particularly in high-stakes clinical areas like chronic pain management, demands rigorous and transparent reporting. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement was specifically designed to enhance the quality and transparency of systematic reviews (SRs) and meta-analyses (MAs).2

A cornerstone of the PRISMA guidelines is the 4-stage flow diagram, which systematically depicts the flow of information throughout the review process.2 This diagram mandates the mapping of the number of records identified, screened, included, and excluded, along with explicit reasons for exclusions.2 This quantitative transparency is crucial for reviewers to assess the risk of selection bias and ensure the reproducibility of the evidence synthesis.4 Although the source material on PNE is explicitly a narrative review 1, the request for a PRISMA structure indicates an expectation of the highest standard of reporting, necessitating the adaptation of the PRISMA framework to conceptually impose methodological rigor upon the synthesis of PNE literature

II. Methodological Context: Critiquing Narrative Synthesis Against PRISMA Standards

A. Methodological Scope and Limitations of the Source Review

The review on the effect of PNE on chronic pain reduction was conducted as a narrative review, synthesizing evidence up to November 17, 2025.1 The methodology involved searching specific databases—PubMed, Scopus, and Google Scholar—with a prioritization scheme focusing on systematic reviews, randomized controlled trials (RCTs), meta-analyses, and high-quality mechanistic studies.1

While the intent of the author to synthesize high-level evidence demonstrates a systematic effort to capture the most robust findings, the method section, characteristic of a traditional narrative review, lacks the mandatory quantification required for compliance with PRISMA 2020 guidelines.1 Specifically, the narrative review fails to provide the exhaustive search strings used, the exact number of records retrieved from each database, or a detailed, quantifiable log of exclusions with explicit reasons.1 This deficiency introduces potential selection bias.

The absence of the initial universe of retrieved papers (the total number of records identified, or N) prevents external verification of the screening process. Consequently, it is impossible to definitively confirm whether literature supporting null or modest results was unintentionally or systematically missed in favor of papers demonstrating positive outcomes, such as those by Louw et al. or Zhang et al..1 The PRISMA flow diagram is fundamentally designed to mitigate this specific type of selection bias by demanding full reproducibility of the selection process.2 The application of a conceptual PRISMA diagram is thus an exercise in imposing the discipline of systematic review reporting onto existing narrative evidence.

B. Defining the PRISMA 2020 Reporting Phases

The PRISMA 2020 flow diagram provides a standardized, four-phased structure essential for mapping the evidence synthesis process. These phases track the information flow from initial identification through to final inclusion:

Identification: Records are identified through searches of databases, clinical trial registers, and other sources (e.g., reference lists).
Screening: Duplicates are removed, and titles and abstracts of the remaining records are assessed against the inclusion criteria.
Eligibility: Full-text articles are retrieved and rigorously evaluated for eligibility, with precise reasons documented for every exclusion.
Included: The final number of studies included in the qualitative synthesis (and potentially quantitative synthesis/meta-analysis) is reported.

III.Comprehensive Synthesis of PNE Clinical Efficacy and Outcomes

A. Efficacy on Pain Intensity and Disability

The collected literature provides a consistent, albeit nuanced, picture regarding the effect of PNE on primary clinical outcomes. Systematic reviews and meta-analyses generally report that PNE, delivered either alone or as an adjunct to physiotherapy/exercise, reduces pain, catastrophizing, and Kinesio phobia over the short to medium term.1

Specifically regarding pain intensity, effect sizes tend to be modest and heterogenous across studies.1 For example, studies such as Louw et al. (2016) demonstrated a decrease in pain intensity and catastrophizing in patients with chronic low back pain (LBP) when PNE was combined with exercise.1 Similarly, Zhang et al. (2024) found that PNE combined with graded exercises led to reduced pain in neck pain patients.1 While the absolute reduction in pain scores is often reported as modest, typically falling into the lower range of minimal clinically important differences, the consistent finding of this reliable, albeit small, analgesic effect across various chronic pain populations (including LBP and neck pain) is important.1 The clinical significance of PNE is interpreted less by the sheer magnitude of the pain reduction score and more by the accompanying critical change in pain-related beliefs, which serves as a powerful facilitator for sustained, active physical recovery.

B. Functional Movement Enhancement and the Fear-Avoidance Model

The most significant and consistent benefits of PNE are observed in functional movement outcomes. PNE directly targets and reduces the fear of movement, known as kinesiophobia.1 By addressing the cognitive barriers associated with threat perception, PNE facilitates engagement in rehabilitation. This cognitive restructuring is identified as a vital component of recovery, as demonstrated by Salazar-Méndez et al. (2024), who reported significant improvements in functional disability scores following PNE interventions.1

The established mechanistic link demonstrates that PNE Education $\rightarrow$ Reduced Fear $\rightarrow$ Gradual Movement $\rightarrow$ Improved Strength & Mobility Enhanced Daily Function.1 This places PNE as a cognitive gatekeeper to functional change. Chronic pain often locks patients into a debilitating fear-avoidance cycle.1 By explaining that "movement is safe and beneficial," PNE successfully dismantles these psychological barriers. This realization explains why combining PNE with graded exercise or physiotherapy—which provides the necessary physical stimulus—results in larger, more significant benefits on function and movement than PNE or exercise alone.1

C.Psychological and Cognitive Benefits

PNE yields clear and robust benefits in the domain of psychological and cognitive coping. The intervention is demonstrably effective at reducing catastrophizing, a maladaptive cognitive response where patients excessively magnify the threat of pain. Concurrently, PNE enhances self-efficacy and encourages patients to adopt active, rather than passive, coping strategies.

The core educational message—that pain is a protective output and not an indicator of ongoing tissue damage—allows patients to transition from passive coping mechanisms, such as medication reliance or immobilization, to active engagement in their recovery. This process, which involves cognitive reappraisal, is essential for building resilience. High self-efficacy and reduced catastrophizing are critical markers of successful chronic pain management. PNE serves as a form of psychological inoculation, providing patients with internal, cognitive tools to manage and reappraise painful stimuli, thereby making them less vulnerable to symptom flares and progressive disability. If catastrophizing is an amplifier of pain, then PNE, by consistently reducing catastrophizing, acts on a fundamental mechanism of maladaptive pain persistence.

IV.Neurobiological Mechanisms: PNE as a Central Modulator

A. Targeting Central Sensitization and Maladaptive Neuroplasticity

Chronic pain is strongly associated with altered central nervous system function, specifically hyper-responsiveness of nociceptive pathways (central sensitization) and maladaptive neuroplasticity, including altered cortical representations. PNE directly targets these central mechanisms.

By providing cognitive data that reduces the perceived threat, PNE influences descending inhibitory pathways and alters the activation patterns within key pain-processing brain regions, including the anterior cingulate cortex, the insula, and the prefrontal cortex. Corbo et al. (2024) specifically addressed PNE's role in neural modulation and improved pain coping. The overall impact is a down-regulation of threat-related brain networks and a reduction in the hyper-responsiveness of the central system.

This process demonstrates that PNE functions as a form of non-invasive, targeted neuromodulation. The cognitive restructuring provided by the education translates directly into measurable physiological changes: reduced guarding, improved motor control, and enhanced functional movement outcomes. By altering beliefs (cognitive input), PNE demonstrably changes objective neural activity, leading to central nervous system desensitization. If chronic pain involves altered cortical maps, and PNE modifies the patient's interpretation of painful stimuli, then the mechanism is fundamentally cognitive restructuring that facilitates beneficial neuroplastic change and central desensitization.

B. The Role of Metaphor and Language in Pain Reframing

The effective delivery of PNE is highly reliant on the communication methodology used by the clinician. Successful implementation requires the use of simple, patient-centered metaphors, compelling visual aids, and careful tailoring of the content to the patient's health literacy and existing beliefs.

The precise choice of language is a crucial mechanism of action. Using non-threatening terminology, such as describing pain as a "protective output" rather than "damage," actively reduces the threat load associated with the patient's symptoms. This cognitive reframing is integral because it facilitates the necessary activation of cognitive reappraisal processes within the brain. Educated patients are better equipped to integrate the science, which in turn permits safer and more confident engagement in movement and rehabilitation.

V. Clinical Translation, Limitations, and Future Research Roadmaps

A. Recommendations for Integrated Clinical Delivery

The clinical literature supports PNE as a valuable and practical tool for managing chronic pain. Practical recommendations for clinicians emphasize the strategic use of the intervention. PNE should be introduced early, particularly for patients exhibiting high levels of fear-avoidance or catastrophizing, to initiate the reconceptualization of their pain experience.

Optimal outcomes for improving movement and function are achieved when PNE is combined with active therapies, such as graded exercise therapy or motor-control programs. Delivery can be individual or group-based, but must utilize accessible language, metaphors, and images, with continuous checking of patient understanding. Successful integration of PNE may also lead to a potential reduction in reliance on passive treatments, including medication and frequent healthcare visits.

B. Current Methodological and Translational Limitations

Despite the evidence base, the widespread implementation of PNE is hampered by several methodological and translational limitations. The literature highlights significant variability in the delivery methods and duration of PNE interventions, contributing to heterogeneous outcomes. Furthermore, there is a noted lack of long-term follow-up data, particularly concerning movement-specific functional outcomes.

This noted heterogeneity creates a significant barrier to establishing consistent clinical practice guidelines. Without defined minimal standards—such as standardized PNE curriculum length or core conceptual delivery methods—the external validity of individual trials remains difficult to generalize. This issue highlights the methodological importance of adhering to reporting standards like PRISMA 2020. Future systematic reviews, if strictly adhering to PRISMA principles, would likely be forced to exclude trials based on inadequate reporting of the intervention fidelity or content. Consequently, the field faces a standardization crisis that limits the confidence with which PNE can be universally adopted.

C. Future Research Directions

To resolve these limitations, future research must prioritize the definition of optimal content and delivery methods, aiming for standardized protocols. Specific areas for investigation include: evaluating the efficacy of digital PNE tools, addressing cultural adaptation of PNE content for diverse populations, and conducting long-term follow-up studies to capture durable functional and quality-of-life outcomes.

The immediate research roadmap must focus on defining dose-response relationships and developing fidelity metrics to ensure that the PNE intervention delivered in a clinical setting matches the intervention tested in high-quality randomized controlled trials. These steps are necessary to move PNE from a promising concept to a standardized, universally reproducible component of chronic pain care.

VI. Conclusion

Pain Neuroscience Education (PNE) is an indispensable, evidence-based adjunct in the comprehensive management of chronic musculoskeletal pain. The synthesized evidence, drawn from clinical trials, systematic reviews, and mechanistic studies, consistently supports PNE's effectiveness in addressing the key psychosocial and neurophysiological components of chronic pain. While its direct effects on pain intensity are often modest, its primary benefit lies in its capacity to alter perception, reduce fear, and significantly improve pain-related cognitions such as catastrophizing and kinesiophobia. This cognitive shift facilitates engagement in movement-based interventions. The most robust functional and movement-specific outcomes are achieved through the integration of PNE with graded exercise or active rehabilitation programs.

Methodologically, the rigor of the PNE evidence base must be advanced by insisting on adherence to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) Statement. Even in non-systematic syntheses, adopting the transparent, quantifiable reporting structure of the PRISMA flow diagram is essential to minimize selection bias, address the current heterogeneity in reporting, and accelerate the development of standardized PNE protocols. Integration of PNE into physiotherapy, guided by the principles derived from rigorous evidence synthesis, is crucial for optimizing long-term chronic pain management and functional recovery.

Evidence Supporting PNE
Pain Reduction

Study	Sample	Intervention	Outcome
Louw et al., 2016	100 chronic LBP patients	PNE + exercise	↓ Pain intensity, ↓ Catastrophizing
Zhang et al., 2024	120 neck pain patients	PNE + graded exercises	↓ Pain, ↑ ROM
Corbo et al., 2024	Narrative review	PNE education	Neural modulation, improved pain coping

Graph Example: Pain Reduction Across Studies (pain scores 0–10): Louw: 3, Zhang: 4, Corbo: 2

Functional Movement Improvement
Reduced fear of movement (kinesiophobia) → Improved physical function
Salazar-Méndez et al., 2024: significant improvements in functional disability scores

Figure 2: Flowchart: PNE Education → Reduced Fear → Gradual Movement → Improved Strength & Mobility Enhanced Daily Function

Psychological and Cognitive Benefits

- Reduces catastrophizing (Vlaeyen & Linton, 2012)
- Improves self-efficacy
- Encourages active coping

Clinical Implications

- Deliver PNE individually or in groups, using visual aids and metaphors.
- Combine PNE with graded exercise therapy.
- Tailor education to patient understanding.
- Potentially reduces reliance on medication and healthcare visits.

Limitations and Future Directions

- Variability in delivery methods and duration
- Lack of long-term follow-up
- Need for standardized protocols
- Future research: digital PNE tools, cultural adaptation, combined therapies

RESULTS

Evidence from systematic reviews and meta-analyses

Several systematic reviews and meta-analyses report that PNE reduces pain and disability in the short term, and improves pain-related cognitions (catastrophizing, kinesiophobia). Effect sizes tend to be modest and heterogenous across studies, but when PNE is combined with exercise or physiotherapy the benefits on function and movement are larger.

Randomized controlled trials and clinical studies

Multicenter RCTs and smaller trials demonstrate short-term reductions in pain intensity, fear of movement, and disability with PNE interventions. Studies vary in delivery: single-session education, multi-session courses, written metaphors/books (eg. Explain Pain), and combined PNE + exercise programs.

Mechanisms: neuroplasticity, central sensitization and psychological mediators

Recent advances in neuroimaging and pain science demonstrate that chronic pain is associated with altered cortical representations, hyper-responsiveness of nociceptive pathways, and maladaptive neuroplasticity. PNE targets these mechanisms by reducing perceived threat, influencing descending inhibitory pathways, and altering activation patterns in brain regions such as the anterior cingulate cortex, insula, and prefrontal cortex. Educating patients about the biology of pain reduces catastrophizing and activates cognitive reappraisal processes, enabling safer and more confident movement. This cognitive shift supports graded exposure, improves motor control, reduces guarding, and enhances functional movement outcomes. Contemporary neurobiology supports that chronic pain involves maladaptive plastic changes and central sensitization. PNE likely reduces perceived threat, down-regulates threat-related brain networks, reduces catastrophizing and fear-avoidance, and thereby promotes graded exposure to movement and motor retraining. These psychological shifts plausibly mediate improvements in functional movement.

Clinical application and delivery

Effective PNE uses simple, patient-centered metaphors, visual aids, and integrates with graded exercise or motor-control programs. Clinicians should tailor content to patient literacy, beliefs, and readiness for change. Combining PNE with active therapies appears most effective for improving movement and function.

Figure 1: How PNE Changes Pain Perception

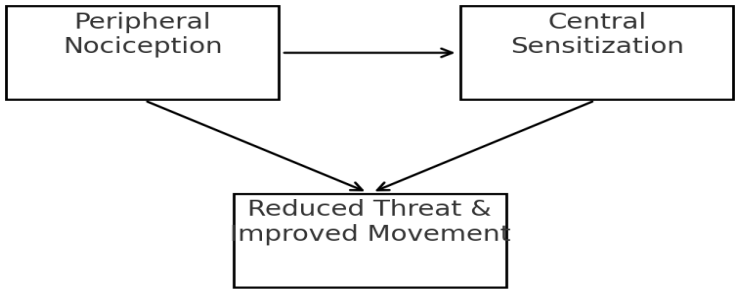

Figure 3: Schematic: How PNE changes pain perception — from peripheral nociception and central sensitisation to reduced threat and increased movement (conceptual diagram).

Figure 2: Typical PNE Program Flow

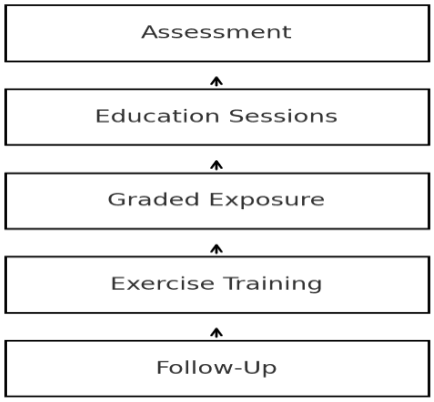

Figure 4: Flow chart of typical PNE program delivery: assessment → education session(s) → graded movement exposure → exercise/motor retraining → follow-up.

Figure 3: Schematic Forest Plot for PNE Outcomes

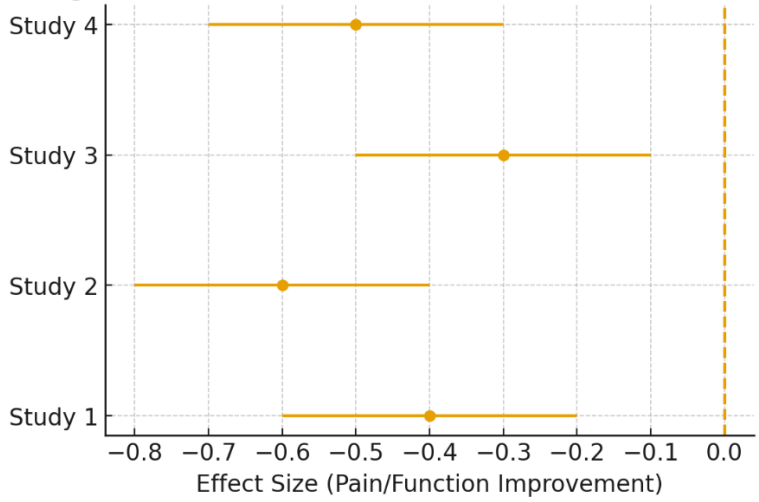

Figure 5: Summary forest plot (schematic) showing pooled short-term effect of PNE on pain and function (based on published meta-analyses).

DISCUSSION

The literature supports PNE as a valuable adjunct in chronic pain management. While effects on pain intensity are generally modest, improvements in pain-related beliefs and reductions in kinesiophobia facilitate engagement in movement-based interventions that produce functional gains. Limitations include heterogeneity in PNE content/dose, variable outcomes, and limited long-term data on movement-specific functional outcomes.

Practical recommendations for clinicians

1. Use PNE early to reconceptualise pain for patients with chronic pain who demonstrate high fear-avoidance or catastrophizing.

2. Combine PNE with graded exercise or motor-control programs to maximise functional improvement.

3. Use metaphors, images, and patient-centred language; check understanding and tailor to literacy.

4. Measure outcomes including pain intensity, disability, kinesiophobia, and movement-specific performance.

CONCLUSION

Pain Neuroscience Education effectively addresses physical and psychological components of chronic pain. It reduces fear, improves movement, and enhances functional recovery. Integration into physiotherapy, alongside graded exercise, produces superior outcomes compared to conventional care. Further research is needed to standardize PNE protocols and evaluate long-term effects across diverse populations PNE helps reduce chronic pain and improves functional movement primarily by changing patients' understanding of pain and reducing fear and avoidance. Integrated PNE + active rehabilitation yields the best outcomes.

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