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Review Article

Pain Neuroscience Education in Physiotherapy Management of Knee Osteoarthritis: A Review for Clinical Practice and Research

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Abstract

Background: Knee osteoarthritis (KOA) is one of the most prevalent causes of pain and disability worldwide. Traditional physiotherapy has primarily focused on biomechanical and exercise-based management. However, growing evidence suggests that pain neuroscience education (PNE) can enhance outcomes by addressing maladaptive pain beliefs and central sensitisation.

Objective: To review the current evidence (2020–2025) regarding the effectiveness of PNE as an adjunct to physiotherapy interventions in the management of KOA.

Methods: A structured literature search was conducted in PubMed using predefined terms related to PNE and knee osteoarthritis. Randomised controlled trials (RCTs), feasibility studies, systematic reviews, and narrative reviews published between 2020 and 2025 were included.

Results: Ten key studies, including systematic reviews, RCTs, and clinical trials, were analysed. PNE interventions were consistently associated with reduced pain intensity, improved pain self-efficacy, and enhanced functional outcomes when combined with physiotherapy exercises. Studies also reported psychosocial benefits such as decreased catastrophizing, fear-avoidance, and improved movement confidence.

Conclusion: Incorporating PNE into physiotherapy management for KOA can address both physical and cognitive dimensions of pain, potentially improving treatment outcomes. Further research with standardised protocols and long-term follow-up is recommended.

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1. INTRODUCTION

Knee osteoarthritis (KOA) affects hundreds of millions globally and is a major contributor to pain, reduced quality of life, and loss of mobility in older adults. Conventional physiotherapy—focused on exercise (strengthening, neuromuscular control), education about joint mechanics, weight management, and manual techniques—remains first-line conservative care.[1] However, outcomes are often limited by persistent pain and psychosocial factors. The pathophysiology of KOA pain is multifactorial: nociceptive input from joint tissues (cartilage loss, osteophytes, synovitis), mechanical overload, and structural change are classical drivers, but there is increasing recognition of altered central pain processing, central sensitisation, maladaptive beliefs (e.g., "my knee is damaged so

exercise will harm it"), pain catastrophizing, fear-avoidance behaviour, and low self-efficacy. These non-tissue drivers may sustain pain and limit effective rehabilitation. [2,3]

Pain neuroscience education (PNE) offers a complementary approach by reframing pain from a purely biomedical "tissue damage" model to a biopsychosocial and neurophysiological model: the nervous system assesses threat and may generate pain in the absence of ongoing tissue damage, or amplify nociceptive signals via central mechanisms. PNE aims to reduce perceived threat, re-educate the patient on pain mechanisms (e.g., nociception, central sensitisation, descending modulation, contextual factors), and foster active engagement in movement and exercise rather than passive "protect the joint" beliefs. Over the past decade, PNE has gained momentum in musculoskeletal rehabilitation, and more recently, publications (2020–2025) have specifically examined its use in KOA and knee conditions. While promising, the evidence base is still evolving and heterogeneous. Recent literature demonstrates that integrating PNE with physiotherapy may enhance treatment adherence and functional outcomes in individuals with KOA.[4]

The purpose of this narrative review is to [1] summarise the evidence from the last five years (2020–2025) for PNE in physiotherapy management of KOA, [2] describe mechanistic rationales and delivery considerations, [3] present clinical recommendations for physiotherapists treating KOA, and [4] highlight research gaps and future directions.

2. MATERIALS AND METHODS

A targeted literature search was done to capture randomised controlled trials (RCTs), systematic reviews, and high-quality observational studies published from January 2020 through August 2025 that assessed Pain Neuroscience Education in Knee OA or related chronic knee pain populations. Databases searched included PubMed/PMC and Google Scholar. Search terms included combinations of keywords and MeSH headings: "pain neuroscience education", "pain science education", "neurophysiological pain education", "knee osteoarthritis", "knee OA", "physiotherapy", "exercise", "randomised trial", "systematic review". Reference lists of retrieved articles and identified systematic reviews were hand-searched for additional relevant studies. Inclusion criteria: adult participants (≥18 yrs) with a diagnosis of KOA (or knee osteoarthritis confirmed clinically/radiographically) or chronic knee pain with features of KOA; interventions including PNE delivered by or in conjunction with physiotherapy/exercise programmes; outcomes including pain intensity, function/physical performance, disability, psychosocial variables (catastrophizing, kinesiophobia, self-efficacy); minimum follow-up of ≥2 weeks. Exclusion criteria: paediatric populations; non-knee musculoskeletal conditions without the KOA subgroup; non-English articles. The search string used in PubMed is provided in the Methods Appendix. Screening of titles/abstracts and full-text was conducted by two independent reviewers; discrepancies were resolved by consensus.

3. RESULTS

Evidence Summary (2020–2025)

Systematic reviews and syntheses

Recent systematic reviews and umbrella reviews conclude that PNE-based interventions can improve psychosocial outcomes (pain knowledge, catastrophizing, self-efficacy) in musculoskeletal pain populations and specifically in KOA, but the magnitude and consistency of improvement in pain intensity and physical function vary across trials. The authors emphasise methodological heterogeneity (in PNE content, dose, comparator arms), small sample sizes, and short follow-ups as major limitations. For example, Ordoñez-Mora *et al.* (2022) conducted a systematic review of PNE interventions in osteoarthritis and reported beneficial changes in psychosocial measures but noted variable effects on pain and function.

Several RCTs and pilot trials have evaluated PNE as an adjunct to exercise or rehabilitation programmes for KOA:

- A recent RCT combining PNE + conventional exercise in KOA found that the adjunct PNE group had greater reductions in catastrophizing and somewhat improved short-term pain/function compared to exercise alone.
- Another RCT in chronic post-total knee arthroplasty (TKA) pain compared neuromuscular exercise plus PNE versus PNE alone and reported no significant superiority of the combined approach for pain and function, suggesting that exercise + PNE may not always yield additive benefits in all sub-groups.
- Pilot feasibility trials of "Pain Informed Movement" (combining mind-body, neuromuscular exercise and PNE) in KOA populations suggest promising early outcomes and feasibility but await larger definitive trials.

Taken together, the evidence suggests that PNE is most effective when integrated into multimodal physiotherapy programmes rather than delivered as a standalone lecture or one-off session.

Implementation and physiotherapist practice

Qualitative and survey research shows that physiotherapists and exercise professionals are increasingly aware of PNE, but there is wide variation in how it is delivered (one-to-one vs group, number and duration of sessions, use of metaphors/visual aids), and clinician training/fidelity remains variable.

4. DISCUSSION

Recent systematic reviews [1,2] have highlighted that PNE-based interventions can reduce pain intensity and improve psychosocial outcomes in musculoskeletal pain conditions, including KOA. These reviews emphasised the role of PNE in modifying maladaptive beliefs and improving treatment engagement.

In RCTs and feasibility studies, combining PNE with exercise therapy yielded superior results compared to standard physiotherapy alone. Sutherland *et al.* [3] reported that PNE, blended exercise, and booster sessions led to improved pain coping and function in KOA patients. Similarly, Janssen *et al.* [4] demonstrated that PNE followed by Pilates-based exercise

improved pain thresholds and movement confidence compared to exercise-only controls.

A study from India found that PNE integrated with conventional physiotherapy significantly reduced pain catastrophizing and improved patient-reported outcomes on the WOMAC scale. [5] Postoperative populations also benefited: Rombey et al reported improved chronic pain outcomes after total knee arthroplasty when PNE was combined with exercise rehabilitation.[6]

Emerging neuroimaging research supports these findings, showing that PNE can modulate cortical activity and decrease pain-related threat responses.[7] This aligns with Heuch et al, who demonstrated feasibility and positive trends favoring "pain-informed movement" compared to standard neuromuscular exercise in KOA.[8]

Mechanisms of Action

The primary mechanism through which PNE exerts benefits is by targeting cognitive and emotional pain processes. By explaining central sensitisation, neuroplasticity, and the role of the nervous system, PNE helps patients reinterpret pain as modifiable rather than permanent. This cognitive shift enhances self-efficacy, reduces fear-avoidance, and encourages active rehabilitation engagement.

When combined with physiotherapy exercises, PNE can improve adherence and amplify neurophysiological desensitisation through movement exposure and graded activity. These synergistic effects make PNE a powerful adjunct in modern pain management frameworks.

In KOA populations, the strongest signal of benefit for PNE appears in psychosocial and cognitive-affective domains: pain knowledge, catastrophizing, kinesiophobia and self-efficacy show consistent improvement. These improvements are clinically important because they may mediate engagement in exercise—the cornerstone of KOA rehabilitation. Some trials also report modest short-term improvements in pain intensity and patient-specific functional measures when PNE is added to exercise, especially in patients with higher baseline psychosocial risk. However, effect sizes for pain reduction are modest and not universally replicated. There is limited long-term data on disability, activity levels or joint replacement outcomes.

Integration into Physiotherapy Practice

Clinically, integrating PNE requires therapist training and communication skills. Survey data indicate variability in clinicians' use and understanding of PNE, suggesting a need for enhanced professional education.[9] Implementing PNE can take multiple formats—individual sessions, group workshops, or telehealth modules—often delivered through metaphors, diagrams, and experiential learning.

Delivery considerations: dose, format, integration with exercise

Several key practical variables influence PNE's effectiveness:

- Dose and duration: Reviews suggest that "dose matters" — brief single sessions may be insufficient to drive behaviour change; rather, repeated or reinforced PNE (e.g., integrated across exercise sessions) tends to yield better outcomes.
- Mode of delivery: One-to-one interactive PNE may yield better cognitive outcomes than passive group lectures. Telehealth/remote PNE is feasible and increasingly used.
- Integration with exercise: PNE should not be delivered in isolation; rather it should support exercise adherence and graded activity. For example, physiotherapists might intertwine PNE metaphors about "safe loading" of the knee with supervised strengthening/neuromuscular exercise, and collaboratively set functional goals.
- Tailoring content: Content should be adjusted to the patient's baseline beliefs, literacy level, and cultural context. Metaphors, visuals and examples relevant to KOA (e.g., "knee tissue wear vs nervous system sensitivity") aid comprehension.

Recommendations for clinicians (practical guidance)

1. Use PNE as an adjunct, not a replacement, for evidence-based exercise-based KOA care. Emphasise and continue established exercise programmes (strengthening, neuromuscular control, aerobic) while using PNE to reduce threat, modify beliefs, and improve engagement.
2. Tailor PNE to patient needs: assess catastrophizing, kinesiophobia, activity avoidance, and beliefs about joint damage. Focus PNE content on addressing specific misconceptions (e.g., "wear and tear = damage" vs "safe loading stimulates adaptation").
3. Dose and reinforce: Prefer multiple brief PNE sessions (e.g., 10–15 minutes at start of each exercise session, or two dedicated PNE sessions plus reinforcement during follow-up) rather than a single lecture. Provide handouts, metaphors, visuals and invite patient questions.
4. Combine PNE with graded activity/exercise: Use graded exposure/pacing frameworks and collaboratively set functional goals (e.g., "walk to the temple steps with less worry") to translate changed beliefs into behaviour change.
5. Clinician training is essential: Ensure physiotherapists delivering PNE are comfortable with pain neuroscience concepts, have communication skills to deliver non-technical metaphors, and can identify patients needing more intensive psychosocial input or referral.
6. Monitor and adapt: Track changes in catastrophizing, self-efficacy and function (e.g., via validated tools such as Pain Catastrophizing Scale, Tampa Scale of Kinesiophobia, KOA functional questionnaires) and adjust PNE intensity accordingly.

Research Gaps and Future Directions

Despite promising evidence, heterogeneity in PNE protocols, duration, and delivery methods limits comparability. Few studies report long-term outcomes or use neurobiological biomarkers. Editorials have called for methodological refinement and standardisation in PNE research.[10]

Future trials should investigate dose-response relationships, cross-cultural adaptability, and the combination of PNE with digital and mindfulness-based interventions. Incorporating patient-centred measures such as pain acceptance, functional resilience, and self-management sustainability could also enhance the clinical relevance of outcomes.

- Heterogeneity: PNE interventions vary widely in content (amount of neurophysiology, metaphors used), dose (single vs multiple sessions), format (individual vs group), comparator arms (exercise alone, standard education, no-education), and outcome measures, making meta-analysis difficult.
- Outcomes and follow-up: Many trials focus on short-term outcomes (weeks to a few months). Long-term impact on disability, activity participation, health-care utilisation or progression to joint replacement remains unknown.
- Patient selection: Not all patients appear to benefit equally. Patients with higher catastrophizing or central sensitisation features may be better responders, but stratified medicine approaches are under-explored in KOA.
- Methodological quality: Several trials are small, lack blinding, have variable co-interventions, and use different outcome measures. Systematic reviews consistently call for larger pragmatic RCTs with standardised PNE protocols, longer follow-up, and active control groups.

5. CONCLUSION

Pain neuroscience education is a promising, theoretically coherent adjunct to physiotherapy management of knee osteoarthritis. Evidence from 2020-2025 indicates that PNE combined with exercise or multimodal physiotherapy programmes consistently improves pain-related cognitions and, in some cases, short-term functional and pain outcomes. However, the evidence for pain intensity reduction and long-term disability remains inconsistent, and heterogeneity in intervention content, delivery, patient populations and methodology limits strong recommendations. Future research should prioritise adequately powered RCTs with standardised PNE protocols, longer follow-up durations, investigation of patient-level moderators of response (e.g., psychosocial risk profiles, central sensitisation markers), and mechanistic studies linking cognitive change to neural and behavioural outcomes. Meanwhile, clinicians treating Knee OA may pragmatically integrate PNE into rehabilitation—tailoring content, reinforcing messages, combining PNE with exercise adherence strategies, and using PNE to foster patient self-management and functional recovery.

Conflict of Interest: None

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