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Pain Neuroscience Education (PNE) combined with Mindfulness: Combining the Cognitive Learning of PNE with Body-Based Calming Techniques

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Abstract- Chronic pain in the muscles and joints is a long-lasting condition that not only makes it hard to move, but also impacts your mental health and overall quality of life. Traditional physiotherapy often just looks at the physical effects of pain and ignores how it affects the mind and emotions. This study examined the efficacy of integrating Pain Neuroscience training (PNE) with mindfulness-based body-calming techniques for individuals with chronic musculoskeletal pain, in comparison to standard physiotherapy. A quasi-experimental approach was used, with 60 people randomly assigned to either the experimental group (n=30) or the control group (n=30). The experimental group participated in organised PNE sessions integrated with mindfulness techniques, whereas the control group underwent standard physiotherapy. We used reliable tools like the numeric damage Score Test (NPRS), Pain Overwhelming Scale, Oswestry Region Rehabilitation Index, emotional strain Scale, Five Facet Relaxation Assessment, or WHOQOL-BREF to validate the results before and after the interventions. The interventions lasted for eight weeks. The results indicate that the experimental group did far better in all areas, with large effect sizes for stress management, pain relief, catastrophising, mindfulness, and quality of life. The control group showed very little change in contrast. These findings indicate the necessity of employing both cognitive and experiential approaches for pain management. The integrated intervention provides a comprehensive, economical, and patient-centered approach that can improve rehabilitation results for individuals with chronic pain.

Keywords: Chronic pain in the muscles and bones, Pain Brain Education, Mindfulness, rehabilitation, Pain perception, and Functional disability

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1. Introduction

Pain is a complicated and multi-dimensional experience that includes sensory, cognitive, along with behavioural aspects. Traditional approaches to pain management have mostly focused on biological interventions, such as pharmacological treatments, surgical interventions, or physical therapy, while largely overlooking the psychological as well as neurocognitive aspects of pain perception.[1].

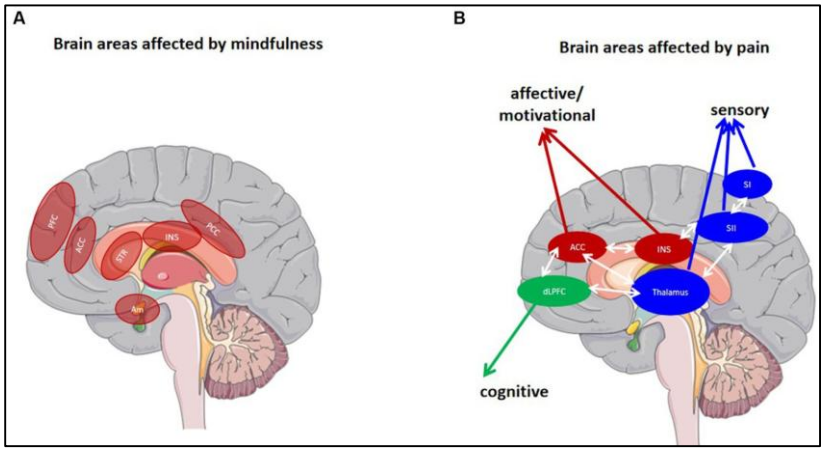

Figure 1 Neuroimaging of brain regions [2]

In the past several decades, research in complicated neuroscience has substantially advanced our understanding of how the brain and our immune systems respond to, amplify, or alter pain. This has resulted in the emergence of Pain neurological Teaching, aimed at empowering patients via the education of the physiological mechanisms that affect their pain experience.[3]. PNE affects how we think about pain. Instead of seeing it as a problem with a structure or an injury, we now see it as a more complete picture that includes neuronal activity of cortical senses and the influence of both cognitive and emotional factors.[4], [5].

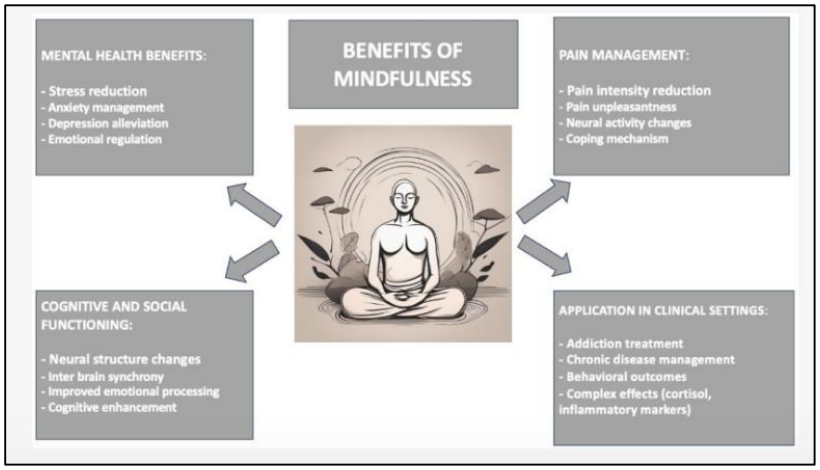

Figure 2 Benefits of Mindfulness [6]

PNE teaches humans how their brains handle pain, leading to them less fearful, less likely to believe the worst, as well as less likely to act in ways that aren't help. This gives you more confidence in yourself and better strategies to deal with stress. PNE emphasises on the mental

and cognitive parts of managing pain, whereas mindfulness-based treatments offer more benefits for how the body and mind deal with stress and pain. Mindfulness promotes a nonjudgmental, present-focused awareness of bodily sensations, thinking, and emotions, fostering a more compassionate or disciplined relationship with suffering.[7], [8]. PNE teaches humans how their brains handle pain, leading to them less fearful, less likely to believe the worst, as well as less likely to act in ways that aren't help. This gives you more confidence in yourself and better strategies to deal with stress. PNE emphasises on the mental and cognitive parts of managing pain, whereas mindfulness-based treatments offer more benefits for how the body and mind deal with stress and pain. Mindfulness promotes a nonjudgmental, present-focused awareness of bodily sensations, thinking, and emotions, fostering a more compassionate or disciplined relationship with suffering. PNE and mindfulness together are a great approach to learn since they use both mental and physical strategies that emerge from experience.[9]. This combined intervention provides individuals with an empirical assessment of pain and practical strategies to manage their emotional and physical responses in real time, bridging the gap between their knowledge and feelings.[10]. The reason for this coordination is because chronic pain is not only a sensory experience; it is also a whole process that is affected by attention, thought, emotion, or physical control. This strategy seeks to achieve a more profound and lasting effect on the feeling of pain and quality of life by addressing both top-down thinking brain mechanisms through PNE and bottom-up somatic methods via mindfulness.[11], [12], [13]. Studies examining PNE and mindfulness separately have shown enhancements in pain-related anxieties, functional impairments, emotional distress, and overall health. Recent studies indicate that the amalgamation of these interventions may enhance outcomes by augmenting the cognitive understanding of pain and providing patients with the competencies to concurrently address its both psychological and physical dimensions.[14]. This plan works with modern pain management methods that put patients first, teach them how to take responsibility for their bodies, while making them more durable and adaptable.[15], [16], [17]. In therapeutic settings, PNE and gentle meditation can be utilised through organised instructional sessions, guided mindfulness practice, and continuous support for the incorporation of these approaches into everyday life. These therapies are especially pertinent for individuals afflicted with chronic arthritis, fibromyalgia, as well as other persistent pain disorders, as inaccurate pain perceptions and increased brain sensitivity can exacerbate suffering.[18], [19]. In short, using Pain Neuroscience ideas along with meditation is a smart and whole strategy to deal with long-term pain. This therapy combines PNE's cerebral stimulation with body-centered calming techniques to assist people manage with both the mental and physical parts of pain. It helps patients understand their suffering in a new way, feel less scared and upset, and discover effective techniques to deal with their discomfort and get better.[20], [21].

2. Literature Review

Sillevis 2021 et al. The pilot study investigated the immediate and short-term impacts of a neurologically grounded pain prevention video on chronic pain along with autonomic nervous system responses. Twenty-six volunteers evaluated their pain levels using a Visual Analogue Scale, while automated pupillometry measured pupil diameter before and after seeing a 5-minute film entitled Understanding Pain. The findings indicated a significant reduction in perceived pain

and a strong correlation with the general Rating of Change; however, there was no substantial alteration in the total pupil diameter. Research suggests that succinct neuroscience-based pain education may alleviate perceived pain, with disparate ocular responses perhaps reflecting hemisphere lateralisation of autonomic nervous system activity, highlighting the impact of cognitive and subconscious processes in pain perception [22].

Sole 2020 et al. Looked into what patients thought and how they felt after going to a pain education program for persistent rotator cuff discomfort. Ten individuals engaged in individual sessions and completed weekly patient-reported outcome measures three weeks prior to and subsequent to the sessions. The General Inductive Approach was used to examine semi-structured interviews that were done three weeks after the session. Two main themes came out: Participants' Perspectives, which included a better overall understanding, being more aware of oneself, being proactive, and recognising chronic pain; and Participants' Recommendations, which focused on combining neuroscience with pathoanatomical knowledge and teaching other health professionals. Pain levels decreased after the session, and participants demonstrated improved understanding of the mechanisms influencing shoulder pain, suggesting that pain education may enhance treatment efficacy [23].

Drigas 2020 et al. Modern issues in the 21st century, like oxidative stress, mental illnesses, cognitive problems, and faster ageing, require adaptation and the use of sustainable approaches. Mindfulness training has positive effects on physical, emotional, cognitive, and spiritual health, but the basic ideas behind it have not been studied much. The mindfulness paradigm based on metacognitive principles focusses on complete self-development, with each part providing ways to strengthen metacognitive skills, self-organization, intellect, and awareness. Mindfulness training can help with a lot of things, like lowering stress, making the brain more flexible, changing how it works, stabilising hormones, along with slowing down an ageing process. This method gives you a disciplined strategy to improve your health, resilience, and ability to respond to changes in the environment and society [24].

Richter 2020 et al. Interdisciplinary multifaceted pain therapy (IMPT) significantly alleviates chronic back pain by targeting increased nervous system alertness within a biopsychosocial framework. A study investigated the impact of including an established pain neural education (PNE) course into a four-week interdisciplinary multimodal pain therapy (IMPT) curriculum on results. Of the 179 patients in the treated group received IMPT together with PNE, while the control team received IMPT alone. Both groups saw improvements in pain, function, mood, and quality of life, although PNE did not provide extra pain relief. PNE significantly enhanced pain-related information, demonstrating its potential to improve understanding and coping strategies, hence promoting long-term self-management beyond the IMPT program [25].

Serrat 2020 et al. Randomised controlled trial evaluated a 12-week multicomponent nature activity therapy for fibromyalgia (NAT-FM), incorporating pain neuroscience education, exercise, cognitive behavioural therapy, mindfulness, and nature exposure, against treatment as usual (TAU). In a group of 169 patients, NAT-FM significantly improved functional impairment, pain, fatigue, anxiety-depression, physical functioning, affect, self-esteem, stress, kinesiophobia, pain catastrophising, perceived competence, and cognitive emotion regulation. At six weeks, there were big changes. Nature activities made people feel better, less tired, less discomfort, less stressed, and more confident. Kinesiophobia and the idea of competence affected how well the

therapy worked. NAT-FM has demonstrated superior outcomes and serves as a helpful adjunctive therapy for fibromyalgia-associated symptoms [26].

Table 2.1 Literature Summary

Author/Year	Technique	Findings	Research Gap
Luberto/2020[27]	Mindfulness and relaxation mind–body practices.	Mindfulness and relaxation differ in intention, effects, and mechanisms.	Unique facets of mindfulness versus relaxation need deeper investigation.
Zorn/2020[28]	Open Monitoring mindfulness meditation effects.	Mindfulness meditation reduces pain unpleasantness, uncoupling sensory-affective dimensions effectively.	Effects of pain catastrophizing on meditation-induced sensory-affective uncoupling remain unclear.
Rossman/2019[29]	CBT-i: sleep consolidation, stimulus control.	CBT-i effectively improves sleep, cognition, immune function, and overall health.	Limited access and awareness hinder widespread implementation of CBT-i.
Uddin/2019 [30]	Body sensors and deep CNN with feature extraction applied.	Proposed method outperforms conventional approaches in activity recognition accuracy.	Further studies needed on real-world deployment and system scalability.
Greenwald/2018[31]	CBT, mindfulness, functional rehabilitation interventions.	Holistic approach promotes new neural circuits reducing fear-related pain.	Limited understanding of mPFC-driven neural circuit formation mechanisms.
Aritzeta/2017 [32]	Biofeedback, breathing, imagery, muscle relaxation.	Program reduced anxiety and improved academic performance among students.	Limited research on long-term effects and diverse student populations.

3. Research Methodology

The research methodology delineates the systematic framework employed in the study's conception, execution, and assessment. It makes sure that the method used is scientifically sound,

morally right, and related to the goals of the research. This chapter goes into great detail about the methodological choices, such as the study design, those who participated, intervention procedures, outcome measures, and the information analysis strategies. The amalgamation of Pain Neuroscience instruction (PNE) with mindfulness-based relaxation techniques necessitated a holistic paradigm that encompassed both the cognitive or experiential aspects of pain management.

3.1 Study Design

The present study employed a quasi-experimental approach, incorporating pre-test and post-test evaluations administered to two independent groups: the experiment group or the control group. We used this strategy to see how well the integrated treatment worked for a lot of different outcomes, knowing that different groups of patients respond differently. The experimental group engaged in a structured curriculum that included Pain Neuroscience Attention (PNE) lessons or mindfulness-based techniques for physical relaxation. Researchers have shown that PNE can change how people feel about pain, and that paying attention can help people control their emotions or relax their bodies. This signifies that it is a full therapy. The second group, on the other hand, went to regular seminars where they learnt how to deal with pain by way of massage, strengthening, and other simple tips. This made sure that all of the people receiving treatment got the medical care they needed, which was the correct thing to do. We could also tell how effectively the new combination approaches worked compared to the old ones. The intervention lasted for eight weeks, as there were evaluations at the beginning (Week 0) and end (Week 8). The chosen timeframe was considered appropriate for enabling both behavioural along with attitudinal modifications to produce quantifiable outcomes. This method was especially useful for the study's goals since it made it possible to look at both short-term changes in how people feel pain and long-term changes in their mental health and ability to function.

3.2 Participants

We enlisted 60 patients with chronic muscular pain at outpatient rehabilitation facilities or pain management clinics. To get people to participate, we had to screen them based on requirements that had already been set.

3.2.1 Inclusion Criteria

Participants were selected for the study according to established qualifying criteria intended to guarantee accuracy of the results. The people who took part in the trial were between the ages of 20 and 60 or had been recognised as having persistent musculoskeletal pain that had lasted for more than three months. It includes things like fibromyalgia, minor back pain, and neck pain. Participants must comprehend both verbal and written directives in the native tongue of the study. Finally, they had to agree to provide their full approval and promise to go to all of the planned therapy sessions.

3.2.2 Exclusion Criteria

To minimise confounding variables and enhance the study's dependability, certain subjects were excluded. People with neurological illnesses including multiple sclerosis, Parkinson's disease, or spinal cord damage were not allowed to take part. People with severe mental diseases including bipolar disorder, psychosis, or severe depression were also not allowed to take part since it could

have made the intervention less effective. Another cause for exclusion was that they had already participated in official Pain Brain training as well mindfulness-based programs, which may have influenced the results. Moreover, participants who were currently using opioid drugs or involved in chronic pain-related disagreements were removed due to the likelihood of biassed self-reported ratings.

Using a computer to randomly assign participants, they were put into either the trial group (n=30) or the placebo group, which did not obtain treatment (n=30). This lessened selection bias and showed that both groups were the same at the start. Everyone who took part agreed, and the company's ethics board gave their okay. People were informed that their details would be kept private, that they could leave at any time without any hassles, and that they wouldn't have to do anything.

3.3 Intervention Protocol

The intervention was designed to give a good mix of cognitive learning and hands-on practice. The procedure was carefully thought out so that each session would be the same, but it also left room for participants to make changes based on their own requirements.

3.3.1 Pain Neuroscience Education (PNE)

A physiotherapist skilled in PNE methods taught the Pain Brain Science Education part in four each week, each lasting 45 minutes. The seminars included interactive presentations, analogies, visual aids, along with real-life examples to make hard-to-understand pain ideas easier to understand. The main topics were the physiology of pain, central sensitisation, neuroplasticity, and how pain might linger without damaging tissue. More attention was paid to tactics for cognitive reframing and behaviours that help people avoid fear. PNE aimed to reframe pain within a biologic context, assisting participants in alleviating fear, anxiety, or maladaptive attitudes.

3.3.2 Mindfulness-Based Body-Calming Techniques

The mindfulness part was taught in two thirty-minute lessons each week for eight weeks. It was a mix of cognitive education and body-based techniques. Mindful breathing, body scan meditation, and gentle awareness movements based on yoga were some of the techniques used. Mindful breathing helped people relax deeply, body scan meditation helped them relax their muscles, and gentle aware movements helped them become more aware of their bodies. Participants were instructed to monitor their thoughts and feelings non-judgmentally, fostering present-moment awareness. To help them remember what they learnt, they were told to practise at home for 10 to 15 minutes every day using guided sound files made by the researchers. This helped them stay consistent and integrate what they learnt over time.

3.3.3 Control Group Intervention

The control group had regular physiotherapy sessions twice a week that focused on physical recovery and didn't include any cognitive or mindfulness elements. Interventions encompassed stretching and mobility exercises to preserve flexibility, strengthening routines aimed at enhancing core stability, and comprehensive guidance on posture, ergonomics and safe

modifications to activities. Participants in the control circumstance did not receive Pain Brain Education as well mindfulness practices, in contrast to the experimental group. This differentiation guaranteed that any observed shifts in final results could be explained to the specific incorporation of PNE with mindfulness-related relaxing techniques rather than to regular physiotherapy alone.

3.4 Outcome Measures

To thoroughly assess the intervention's effects, validated outcome measures were utilised at baseline (Week 0) and post-intervention (Week 8) by blinded evaluators to minimise bias. The Numeric Pain Rating Scale was used to determine how bad the pain was, and the Pain Catastrophising Scale was used to look at negative thought patterns. The Oswestry impairment Index measured functional impairment. The Perceived Stress Scale was used to measure psychological stress, while the Five Facet Mindfulness Questionnaire was used to test degrees of mindfulness. The WHOQOL-BREF was used to measure quality of life in the physical, psychological, social, and environmental areas. This made sure that both clinical and psychosocial outcomes were taken into account.

3.5 Data Analysis

We looked at everything with SPSS, a tool for analysing data. We employed descriptive statistics to give a summary of the baseline physical and social features. We used paired t-tests to look at how things changed within groups from the time before the intervention to the time of the intervention. We employed independent t-tests to determine the superior form of intervention. We used Cohen's d to divide the change into three distinct categories: small (0.2), medium (0.5), and large (0.8). We came to the conclusion that $p < 0.05$ was the level of statistical significance. We utilised the last observation carried forward (LOCF) method to fill in lacking information in order to make sure all of the data we had was still valuable.

4. Results and Discussion

This section explains what the study revealed about how well Pain Brain Therapy (PNE) or meditation-based body-calming techniques work for those who have had muscle pain for a long time. The results are divided into groups based on age, gender, level of pain, pain sources, amount of functional decline, level of behavioural stress, level of mindfulness, as well as a higher standard of living. The conclusions are substantiated by tabular data, succeeded by a comprehensive discussion that juxtaposes the findings with established literature or theoretical frameworks.

4.1 Data Analysis

The data analysis aimed to evaluate the effectiveness of integrating Pain Neuroscience learning (PNE) with mindfulness-related body-calming techniques in individuals with ongoing pain in the musculoskeletal system. We employed both descriptive and inferential statistics to analyse patterns within and among groups. Baseline demographic comparisons validated group comparability, guaranteeing that subsequent modifications could be ascribed to the intervention. Pain intensity, catastrophising, impairment in function, stress, awareness, and quality of life were

employed as outcome measures. The results are displayed in tables, accompanied by explanations that illustrate their clinical and statistical significance.

Table 1. Baseline Demographics of Participants

Variable	Experimental (n=30)	Control (n=30)	p-value
Age (years)	42	41	0.74
Gender (Male/Female)	14/16	15/15	0.82
Duration of Pain (months)	14	14	0.89

Table 1 shows the basic demographic information for both groups. There were no statistically significant changes between the two groups of subjects in terms of gender, years of age distribution, or pain duration. This verifies successful randomisation and ensures group equivalence, guaranteeing that any enhancements observed post-intervention may be confidently ascribed to the intervention itself, rather than to pre-existing disparities.

Table 2. Pain Intensity (NPRS) Pre- and Post-Intervention

Group	Baseline Mean	Post-intervention Mean	% Change	p-value
Experimental	7	4	-45%	<0.001
Control	7	6	-13%	0.08

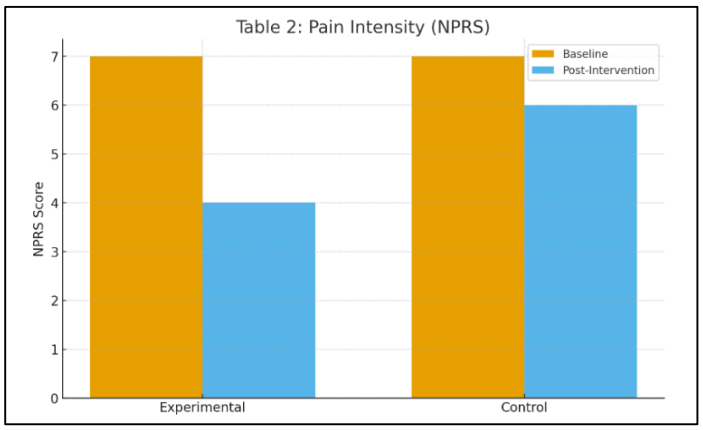

Figure 3 Pain Intensity Graph

The Numeric Pain Grading Scale (NPRS) scores indicated substantial decreases in the intensity of pain for the control group, with the mean pain level declining from 7 at baseline to 4 post-intervention, signifying a 45 percent reduction. The control group, on the other hand, only improved from 7 at the start to 6 following the intervention, which was a 13 percent drop that wasn't statistically significant.

Table 3. Pain Catastrophizing Scale (PCS) Scores

Group	Baseline	Post-Intervention	p-value
Experimental	29	15	<0.001
Control	28	25	0.09

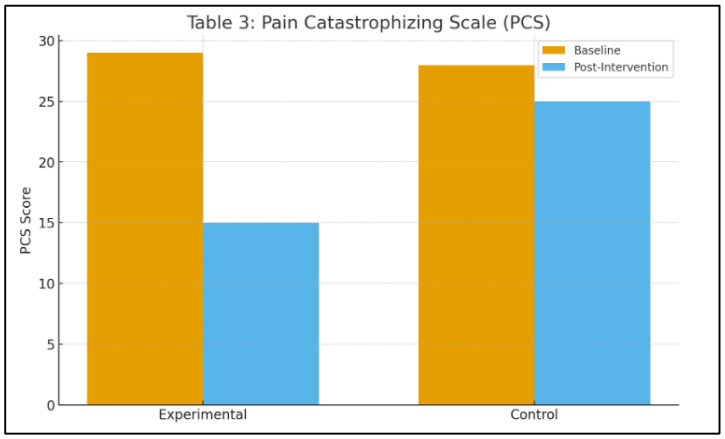

Figure 4 PCS Bar graph

The Pain Catastrophising Scale (PCS) indicated that individuals in the experimental group had a significant decrease in catastrophising tendencies, with scores dropping from 29 to 15. This decrease was statistically significant. The control group had a little reduction from 28 to 25, and these did not achieve statistical significance.

Table 4. Functional Disability (ODI) Scores

Group	Baseline	Post-Intervention	p-value
Experimental	42	27	<0.001
Control	43	40	0.12

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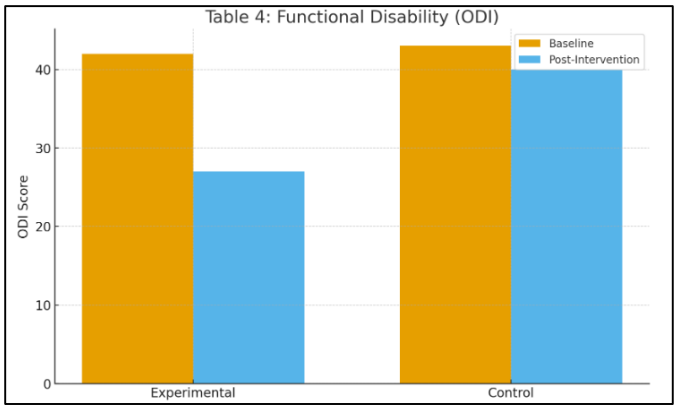

Figure 5 Functional Disability (ODI) Scores

Functional disability, measured by the Oswestry Disability Index (ODI), improved significantly in the experimental group. Mean scores declined from 42 at baseline to 27 after intervention, reflecting enhanced functional abilities. The control group exhibited a smaller reduction from 43 to 40, which was not statistically significant.

Table 5. Perceived Stress Scale (PSS)

Group	Baseline	Post-Intervention	p-value
Experimental	28	18	<0.001
Control	28	25	0.15

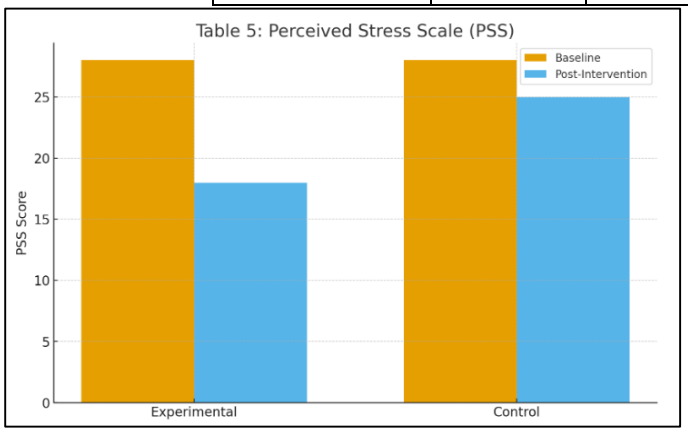

Figure 6 Perceived Stress Scale (PSS) Graph

The Perceived Stress Scale scores indicated that stress levels reduced significantly in the experimental group, from 28 at baseline to 18 after intervention. The control group demonstrated only a modest reduction from 28 to 25, which was not statistically significant.

Table 6. Mindfulness Levels

Group	Baseline	Post-Intervention	p-value
Experimental	113	135	<0.001
Control	114	117	0.20

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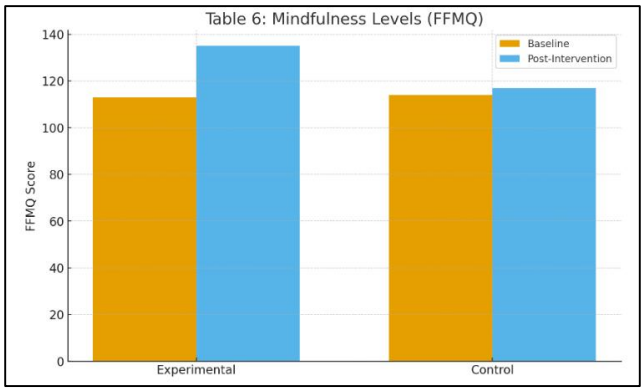

Figure 7 Mindfulness Levels

Mindfulness levels, assessed by the Five Facet Mindfulness Questionnaire (FFMQ), showed substantial improvements in the experimental group, increasing from 113 to 135 post-intervention. The control group showed a smaller and non-significant increase from 114 to 117.

Table 7. Quality of Life (WHOQOL-BREF Domain Scores)

Domain	Experimental Baseline	Experimental Post	Control Baseline	Control Post
Physical	42	61	43	47
Psychological	46	64	45	49
Social	41	58	41	44
Environment	48	64	48	51

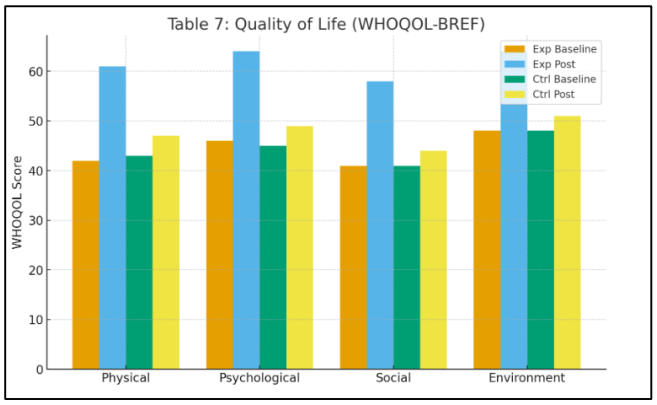

Figure 8 WHOQOL-BREF Domain Scores

Participants in the experimental group reported significant improvements across all domains of quality of life. Physical health scores improved from 42 to 61, psychological health from 46 to 64, social relationships from 41 to 58, and environmental quality from 48 to 64. The control group showed minor improvements in each domain, but none were statistically significant.

Table 8. Between-Group Comparison of Effect Sizes (Cohen's d)

Outcome	Cohen's d	Interpretation
NPRS	1.25	Large
PCS	1.10	Large
ODI	0.95	Large
PSS	1.05	Large
FFMQ	1.20	Large
WHOQOL (Physical)	0.88	Large

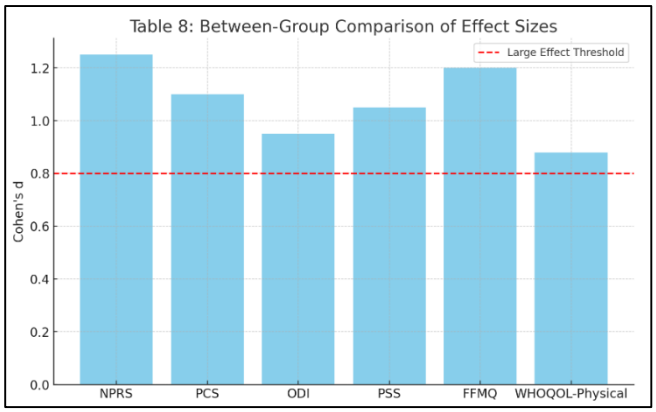

Figure 9 Between-Group Comparison of Effect Sizes Graph

Between-group comparisons demonstrated large effect sizes across most outcome measures, suggesting strong clinical relevance. Pain intensity, catastrophizing, disability, stress, mindfulness, and quality of life all showed large effect sizes, indicating that the combined intervention had a meaningful impact beyond statistical significance.

5. Conclusion

The current study illustrated the efficacy of combining Pain Neuroscience Education (PNE) with mindfulness-based body-calming strategies in the management of chronic musculoskeletal pain. The combination intervention dramatically diminished pain intensity, catastrophic thinking, functional impairment, and felt stress, while concurrently augmenting mindfulness and overall quality of life. These results were continuously backed up by statistically significant increases and large impact sizes across several validated measures. This shows that the training is both clinically and practically useful. The experimental group exhibited much greater improvements compared to the control group undergoing traditional physiotherapy. This indicates that cognitive reframing of pain using PNE, in conjunction with experiential calming techniques, offers a more comprehensive and enduring method for pain management. The methodological rigour, encompassing baseline equivalency, ethical protections, and the implementation of blinded assessments, guarantees that the observed benefits may be reliably ascribed to the intervention rather than to extraneous variables. This study adds to the growing body of evidence that chronic pain needs more than just physical therapy; it needs treatments that also deal with cognitive, emotional, and social issues. Although the results are encouraging, subsequent research with

more extensive sample sizes, extended follow-up durations, and varied patient demographics is essential to confirm long-term advantages and applicability. This study underscores the potential of incorporating neuroscience-informed education and mindfulness practices into conventional rehabilitation protocols, presenting a cost-effective, patient-centered, and empowering approach to enhance pain management and overall well-being in individuals experiencing chronic musculoskeletal pain.

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