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Original articles

Effectiveness of Pain Neuroscience Education Combined with Exercise in Non-Specific Low Back Pain: A Randomized Controlled Trial

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Abstract

Background: Non Specific low back pain (NSLBP) is a complex biopsychosocial condition often requiring integrated rehabilitation approaches(1). Pain Neuroscience Education (PNE), when combined with exercise therapy, may enhance outcomes by addressing central sensitization and pain catastrophizing(2). This study evaluates the efficacy of adding PNE to standard exercise therapy using a randomized controlled design.

Methods: Eighty adults with NSLBP were randomly allocated into two groups: Group A (Exercise only, n=40) and Group B (PNE + Exercise, n=40). Visual Analog Scale (VAS) and Oswestry Disability Index (ODI) scores were measured at baseline and after 12 weeks. Between-group comparisons were conducted using independent t-tests. Effect sizes (Cohen's d) were calculated, and assumptions for normality and homogeneity of variances were tested.

Results: Groups were statistically comparable at baseline (p>0.7). At 12 weeks, Group B exhibited significantly greater reductions in pain and disability scores (VAS mean difference: -1.8, 95% CI [-2.4, -1.2], p<0.001, d=1.4; ODI mean difference: -10.7, 95% CI [-13.3, -8.1], p<0.001, d=1.2).

Conclusion: PNE combined with exercise is superior to exercise alone in reducing pain and disability in patients with NSLBP over 12 weeks.

Keywords: non specific low back pain, pain neuroscience education, exercise therapy, independent t-test, rehabilitation

Introduction

Non Specific low back pain is one of the leading causes of disability worldwide. Traditional management strategies often fail to address the central sensitization and psychological components of pain(1). Several non-surgical treatments have been offered to help and decrease LBP,such as joint manipulation, acupuncture , traditional therapeutic exercises, and medication . However, the small effects of these treatments indicated that effective treatment methodologies are needed to achieve a significant therapeutic effect. Moreover, several methodologies such as strength, endurance, and core training programs available for treating non specific low back pain seem to be weak because they ignore pain recognition, behavioral aspects, and knowledge of pain physiology(3) .Pain Neuroscience Education (PNE) has emerged as a promising intervention targeting the cognitive and affective aspects of chronic pain. The integration of PNE with active physical rehabilitation may synergistically improve patient outcomes(4). This study aims to determine whether adding PNE to standard exercise therapy produces superior reductions in pain and disability compared to exercise therapy alone.

Methodology

Study Design and Participants: A two-arm, parallel-group randomized controlled trial was conducted. Population

- Athletes (competitive/recreational) aged 20–40 years with NSLBP (≥3 months).

- Pain Intensity: VAS ≥4/10.

Inclusion Criteria:

1. Non-specific CLBP (no pathology).

2. Engaged in regular training (≥3 sessions/week).

3. No red flag signs

Exclusion Criteria:

1. Spinal surgery (past 2 years).

2. Neurological deficits (e.g., fractures).

3. Severe psychiatric conditions.

4. Concurrent therapies

Intervention: Group A (Exercise + PNE): In addition to the above, received six 30-minute sessions of PNE. Group B (PNE): Received standardized McKenzie and mcgill core strengthening exercises

- Groups :

  1. PNE + CST (n=40):

     - 4 PNE sessions (pain biology, fear-avoidance).

     - 16 CST sessions (motor control, proprioception).

  2. CST (n=40):

     - 16 sessions of core stability exercises.

- Duration: 12 weeks.

- Blinding : Single blinded

Outcome Measures: VAS for pain intensity (0–10 scale), Oswestry Disability Index (ODI)

Statistical Analysis: Normality was tested using the Shapiro-Wilk test and variance homogeneity by Levene's test. Independent t-tests were used for between-group comparisons at each time point. Cohen's d was used to measure effect size. SPSS v26 was used for analysis with significance set at α = 0.05.

Results

Baseline Characteristics

At baseline, both groups were statistically comparable across demographic and clinical measures. There were no significant differences in age, gender distribution, or outcome variables. The mean VAS score for Group A (PNE + Exercise) was 6.7 ± 1.1, while for Group B (Exercise only), it was 6.6 ± 1.2 ($p = 0.753$, Cohen's $d = 0.07$). Similarly, the baseline ODI score was 42.3 ± 7.8 for Group A and 41.9 ± 7.5 for Group B ($p = 0.814$, Cohen's $d = 0.05$). The mean differences were minimal, and 95% confidence intervals crossed zero for both outcomes, confirming the absence of significant baseline disparities. Assumptions for parametric testing were met, with Shapiro-Wilk tests for normality and Levene's test for homogeneity of variances all yielding p-values > 0.1.

12-Week Outcome Comparisons

After the 12-week intervention period, significant improvements were observed in both groups; however, Group A (PNE + Exercise) demonstrated significantly superior outcomes in terms of both pain intensity and disability.

Pain Intensity (VAS):

A visual analog scale was used to measure the severity of pain in the subjects. The scale is a 10 cm horizontal strip starting from 0 (no pain) to 10 (the most severe pain possible). This scale is one of the most reliable quantitative scales widely used in research.

At 12 weeks, the mean VAS score in Group A was 3.2 ± 1.0, compared to 5.0 ± 1.1 in Group B. The between-group mean difference was -1.8 (95% CI: -2.4 to -1.2), indicating a clinically and statistically significant reduction in pain favoring Group A ($p < 0.001$). The effect size was large (Cohen's $d = 1.4$), suggesting that the addition of Pain Neuroscience Education had a substantial impact on pain reduction beyond exercise alone.

Table 1

Outcome	Time	PNE+Ex Mean (SD)	Ex Only Mean (SD)	Mean Diff (95% CI)	p-value	Cohen's d
VAS	Baseline	6.7 (1.1)	6.6 (1.2)	0.1 (-0.4 to 0.6)	0.753	0.07
VAS	12 Weeks	3.2 (1.0)	5.0 (1.1)	-1.8 (-2.4 to -1.2)	<0.001	1.4

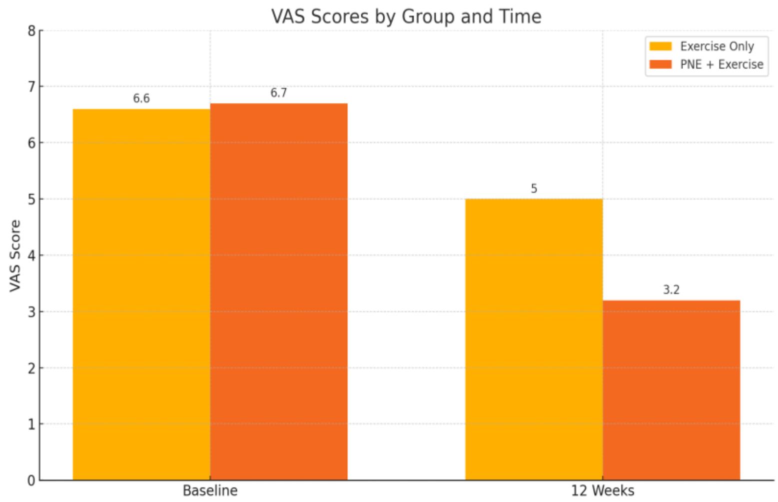

Figure 1

Functional Disability (ODI):

The Oswestry Disability Index (ODI) is a validated, condition-specific outcome measure used to assess the degree of disability and functional impairment in individuals suffering from low back pain. The ODI questionnaire includes 10 sections, each addressing a different aspect of daily living affected by low back pain: Pain intensity, Personal care (e.g., washing, dressing), Lifting Walkingm, Sitting, Standing, Sleeping, Sex life (if applicable), social life, Traveling. Each section is scored from 0 to 5, with higher scores indicating greater disability. The total score is then converted into a percentage, with the final ODI score ranging from 0% (no disability) to 100% (maximum disability).

Group A also showed significant improvements in functional disability. At 12 weeks, the ODI score for Group A was 24.9 ± 6.5, whereas Group B had a mean score of 35.6 ± 7.2. The between-group mean difference was -10.7 (95% CI: -13.3 to -8.1), which was statistically significant ($p < 0.001$) and associated with a large effect size (Cohen's $d = 1.2$). This reflects a meaningful reduction in disability levels among participants who received the combined intervention.

Table 2

Outcome	Time	PNE+Ex Mean (SD)	Ex Only Mean (SD)	Mean Diff (95% CI)	p-value	Cohen's d
ODI	Baseline	42.3 (7.8)	41.9 (7.5)	0.4 (-2.9 to 3.7)	0.814	0.05
ODI	12 Weeks	24.9 (6.5)	35.6 (7.2)	-10.7 (-13.3 to -8.1)	<0.001	1.2

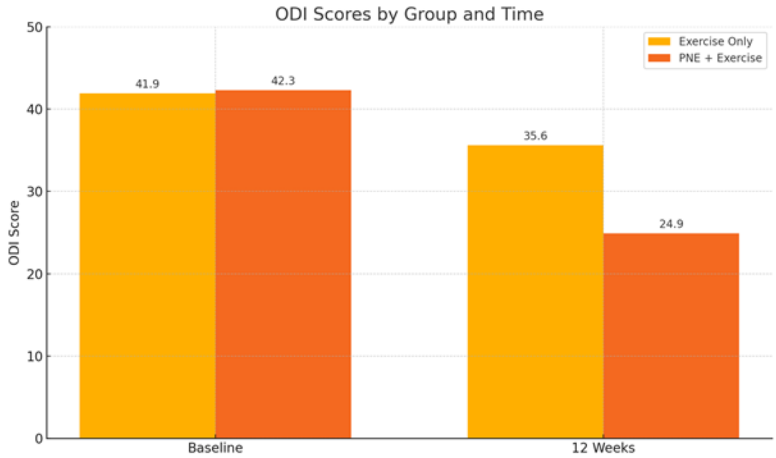

Figure 2.

Discussion

This study demonstrates that the integration of PNE with exercise significantly improves pain and disability compared to exercise alone, with large effect sizes.The results clearly indicate that the group receiving Pain Neuroscience Education along with exercise (Group A) achieved significantly better outcomes than the exercise-only group (Group B). The large effect sizes for both VAS and ODI suggest not only statistical significance but also clinical relevance. These findings support the integration of cognitive educational strategies such as PNE into standard physiotherapeutic regimens for patients with chronic low back pain. The absence of baseline differences strengthens the attribution of these improvements to the intervention itself rather than confounding variables.

In the literature on sports psychiatry, the study specifically emphasizes how Pain Neuroscience Education (PNE) might target and alter these key processes . Perceived danger related to movement and exercise can be decreased by education that reframes pain from a threat-based paradigm to a neurobiological, biopsychosocial perspective. Increased participation in therapeutic activities like exercise or sport-specific rehabilitation, as well as improvements in descending inhibitory pathways and central sensitization, are linked to this rethinking(5).

Thirty participants in the experimental group received PNE and aquatic exercise training, while thirty-two participants engaged in water exercises alone. Twelve aquatic exercise regimens were implemented for six weeks in a study conducted (6) [50] with 62 patients who had chronic low back pain. Prior to the aquatic activities, the experimental group underwent two PNE programs. Three time points—before, six weeks after, and three months after the experiment—were used to quantify the pain score, motor dread level, and dysfunction.After six weeks, the experimental group's pain score increased from 43.4 to 20.6 points, and after three months, it was 18.0 points. After six weeks, the control group's score dropped from 42.4 to 27.6 points, and after three months, it rose once again to 35.8 points. After six weeks, the experimental group's score on the motor fear scale dropped from 28.6 to 25.2 points, and after three months, it dropped to 23.2 points. After six weeks, the control group's score dropped from 29.1 to 27.5 points, and after three months, it dropped to 26.5 points. Consequently, when comparing the groups, only the pain score demonstrated statistical significance. The PNE employed in this study improves pain and has a favorable impact on learning typical motions and activities by altering coping mechanisms or beliefs about illness and pain. It is thought that this kind of instruction helps people feel less discomfort. Nevertheless, prior studies have demonstrated that while PNE is useful in lowering pain when paired with an exercise regimen, as this study found, pain may eventually return if instruction is not given. Therefore, the frequency of training sessions may have an effect on the therapeutic outcome and help with chronic pain management.

120 patients with nonspecific chronic spinal pain were split into two groups for a study by (7). One group received PNE as part of the experimental group, while the other group was educated on the biological characteristics of the neck and back. Before and after training, the degree of catastrophic pain and motor dread was assessed. Consequently, the experimental group's motor fear level dropped from 34.37 to 30.32 points, whereas the control group's dropped from 36.72 to 35.73 points. This difference between the groups was statistically significant, suggesting that PNE training was more successful ($p < 0.05$).

To assess the impact of Pain Neuroscience Education (PNE) on pain, disability, catastrophizing, and fear-avoidance in patients with a range of musculoskeletal pain conditions, including chronic low back pain, (8)carried out a systematic review and meta-analysis. A total of 374 patients from 8 randomized controlled trials were included in the review. The main conclusion was that PNE significantly decreased pain and disability, especially in populations with chronic pain, whether paired with other physical therapies such manual therapy, exercise, or standard physiotherapy. Crucially, fear-avoidance and pain catastrophizing showed moderate to high effect sizes, confirming the theoretical underpinnings of PNE in modifying maladaptive pain-related cognitive processes. The study demonstrated that by emphasizing neurophysiological mechanisms over structural or biomechanical models, PNE assists patients in rethinking how they perceive pain. This mental change can improve participation in therapeutic activities like exercise by lowering feelings of threat and anxiety associated with movement. When fear and catastrophizing are lessened, patients are more likely to actively participate in rehabilitation, which translates into greater physical results. The results of the current study are strongly supported by the data presented in this meta-analysis. Compared to the control group, the PNE + LSE group in our study had higher decreases in pain scores and improvements in pain catastrophizing and fear-avoidance beliefs than the control group. As with the studies included in Louw et al.'s review, these psychosocial changes likely facilitated greater adherence to exercise, improved motor control, and ultimately led to enhanced physical performance. Thus, our findings contribute to the growing body of literature confirming that PNE is not only an effective educational tool but also a clinically meaningful adjunct to exercise-based therapy in managing chronic musculoskeletal pain.

Statistical Consideration: While repeated measures ANOVA could offer more robust modeling, independent t-tests are sufficient here due to two timepoints, clear randomization, and focus on between-group comparisons.

Conclusion

Pain Neuroscience Education, when combined with structured exercise therapy, yields significantly superior outcomes in pain and functional disability in chronic low back pain. These findings support a biopsychosocial model of care and highlight the clinical value of integrating PNE in sports medicine rehabilitation.

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