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Original Article

# The Effects of Pain Neuroscience Education Plus Conventional Physical Therapy on Pain and Quality of Life in Adults with Chronic Nonspecific Neck Pain and Central Sensitization

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ABSTRACT

**Background:** Chronic non-specific neck pain (CNP) is the second most common musculoskeletal disorder. Central sensitization (CS) of pain is likely a contributing factor to the persistence or recurrence of pain cycles in CNP patients. This study aimed to evaluate the effects of pain neuroscience education (PNE) in addition to conventional physical therapy on pain intensity, CS, and quality of life in patients with CNP who have CS.
**Methods:** In this quasi-experimental study, 25 patients with CNP and CS participated in a 4-week intervention program that included conventional physical therapy plus PNE. CS, pain intensity, and quality of life were assessed using the CS inventory, visual analog scale (VAS), and SF-36. All participants were evaluated before and after 12 intervention sessions (three times a week).
**Results:** The results showed that after the intervention, both pain intensity and CS decreased significantly (pain intensity: mean difference=-58.96±16.35, effect size=-3.61; CS: mean difference=-25.52±7.25, effect size=-3.52). Additionally, the quality-of-life score significantly increased (mean difference=24.04±12.50, effect size=1.92). A significant correlation was also found between quality-of-life scores and age.
**Conclusion:** Adding PNE to conventional physical therapy appears to be more effective than conventional physical therapy alone in improving CS, pain intensity, and quality of life in patients with CNP.


## Introduction

According to recent evidence, 32.4% of people with chronic neck pain experience central sensitization (CS) of pain. CS, which occurs due to the dominance of the facilitator system over the inhibitory system, can cause pain, fatigue, and other warning signs even in the absence of actual tissue damage [1-3].

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The effects of conventional physical therapy treatments are not permanent in cases of chronic non-specific neck pain (CNP), and the pain tends to recur [4]. It is worth noting that a new approach to treating patients with chronic musculoskeletal disorders, called pain neuroscience education (PNE), has been proposed. PNE aims to change beliefs about pain by educating patients on pain neurobiology and neurophysiology, with a special focus on the role of the central nervous system [5]. Recent studies confirm the effectiveness of PNE in reducing central sensitivity [6, 7].

PNE aims to reduce the risk of further symptoms by improving participants' behavior by enhancing their knowledge [8]. Some researchers believe that changing one's belief about pain has improved the therapeutic outcomes of chronic pain treatment [9].

Therapeutic interventions based on PNE have emerged as promising [4]. PNE promotes patients' understanding of chronic pain and alters maladaptive thoughts and cognitions (e.g., pain catastrophizing), which are significant barriers to active therapy and exercise [5]. Evidence has shown a positive effect of PNE on pain, disability, and physical performance, especially when combined with exercise [4].

There is substantial evidence supporting the effect of education on pain and disability in patients with chronic pain. Most of this education was implemented alongside other physical treatments, and various educational methods and physical interventions were applied across different populations, including individuals suffering from back pain, neck pain, and spinal pain [5, 7, 10, 11]. Although many studies have demonstrated the effectiveness of PNE in conjunction with physical treatments for patients with chronic pain, there are insufficient studies investigating the effect of PNE on individuals with chronic neck pain, yielding mixed results [7, 12, 13].

In all these studies, subjects with chronic neck pain were included without assessing the presence of CS. In some cases, the participants were younger; in several studies, the control group did not receive any treatment. Therefore, this study aimed to evaluate the effectiveness of PNE combined with conventional physical therapy on pain intensity and quality of life in adults with both CS and CNP.

## Methods

### *Study Design*

This was a quasi-experimental study (before and after, without a control group). Ethical approval was obtained from the Committee of Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran (IR.AJUMS.REC.1400.098).

### *Participants*

The sample size was calculated using G*Power software version 3.1, based on a mean effect size of 0.52 for pain intensity and 0.68 for the CSI score [11], with a power of 80% and an alpha level of 0.05. The required sample size was estimated to be 22 participants, and considering a 10% dropout rate, 25 subjects were ultimately required [14].

Participants were eligible if they were between 18-65 years old [11], had experienced CNP for at least 12 weeks [11], could understand, speak, and write in Persian, had not participated in other treatments during the previous six weeks [11], had a minimum visual analog scale (VAS) score of 30 out of 100 mm for pain intensity [15], and had a CS score above 40 according to the Central Sensitization Inventory (CSI) [16].

Exclusion criteria included neck pain with other etiologies, such as radiculopathy, myelopathy, dizziness, a history of cancer, fractures in the cervical area, rheumatism, cardiovascular or neurological disorders, and widespread pain disorders such as fibromyalgia syndrome or chronic fatigue syndrome [13]. Additional exclusion criteria included unwillingness to continue participation at any stage for any reason and a CS score below 40, according to the CSI [16]. Outcome measures were assessed before and after the intervention.

After recalling patients with CNP from physical therapy clinics in Ahvaz, a trained physical therapist conducted screening based on the inclusion and exclusion criteria. The study process was explained to the participants, and the individuals signed informed consent forms.

### *Outcome Measures*

The CSI questionnaire assesses central sensitization by evaluating 25 symptoms in people with chronic pain (e.g., light sensitivity or difficulty concentrating). Each symptom is rated on a 5-point Likert scale, where 1 indicates that the symptom never occurs, and 5 indicates that the symptom always occurs. This questionnaire was designed as a tool to identify and quantify the main symptoms associated with CS and has performed well in terms of measurement characteristics. The CSI is reliable, consistent, and valid. Furthermore, recent studies have demonstrated that the CSI is responsive in measuring treatment outcomes [16-18]. The Persian version of the questionnaire has also shown good validity and reliability for assessing CS-related symptoms in Persian-speaking patients with chronic pain [19].

The Visual Analog Scale (VAS), a reliable and valid tool, was used to measure pain intensity. The subjects were asked to indicate their pain level during activities over the past week on a 100 mm line. The left end of this line (score of zero) indicated the absence of pain, while the right end (score of 100) indicated the most severe pain [20].

The SF-36 questionnaire is a general health assessment tool that includes two main sections (physical and mental) with eight subscales: physical function, physical limitation, physical pain, general health, vitality, social functioning, mental health limitation, and mental health. Additionally, it contains a question that assesses changes in a person's health status over the course of one year. These eight subscales are scored from 0 to 100, with higher scores indicating better health status [21]. The Persian version of this questionnaire has been validated for the Iranian population [22]. In this study, a short form of the questionnaire was used.

### *Intervention*

The intervention included 4 weeks of conventional physical therapy (3 times a week), with each treatment session lasting 45 minutes, in addition to PNE sessions during the first 4 sessions [23]. The typical physical therapy regimen consisted of 20 minutes of high TENS and a hot pack, followed by exercise therapy (stretching exercises for the pectoralis major and latissimus dorsi muscles, and strengthening exercises for the deep neck muscles, and the shoulder flexor, abductor, lateral rotator, and medial rotator muscles) [24]. The steps of PNE during the first 4 sessions were as follows:

*Session 1*

The first session explained the physiology of pain, neurons, synapses, inhibition and facilitation of pain, characteristics of acute versus chronic pain (flexibility, adaptation, modification, central sensitivity, etc.), development of chronic pain, and neural plasticity. Factors exacerbating central sensitivity, such as emotions, stress, cognition, and pain behavior, were discussed. After the session, participants were given a booklet containing this information and asked questions about activities they feared. The patients also completed the relevant form. The content and images used in the training sessions were derived from the *Explain Pain* book [23, 25].

*Session 2*

The neurophysiology of pain and the role of cortical mechanisms in pain modulation were discussed. A new concept of pain was introduced to change participants' beliefs about pain, and their thoughts were challenged through an interview. Misconceptions about pain were corrected using pictures, booklets, photos, and videos.

Good interaction between the patients and the therapist was essential to mentally prepare the patients before starting the exercises (the second stage). The sessions were face-to-face, with written materials on pain physiology provided as assignments between sessions 1 and 2. Pain physiology education was an ongoing process that began during the training sessions and continued throughout treatment and rehabilitation programs. Additionally, the role of stress was explained using videos and interviews.

Before the third session, the following points were emphasized:

1. Patients were instructed to perform exercises based on the allotted time, regardless of pain (e.g., continuing exercises even if they felt pain).
2. Goal setting was done with the participant using the SMART principle (specific, measurable, achievable, realistic, and time-targeted).
3. Therapists continually assessed and challenged participants' knowledge, understanding of pain, and anticipated exercise outcomes, transforming maladaptive cognitions into positive ones.
4. Exercises were progressively made more challenging (physically, cognitively, and psychosocially), incorporating complex functional movements and activities based on individual conditions.
5. If fear was the main disabling factor, motor imagery was used before advancing to more difficult and fearful exercises (e.g., patients imagined performing the exercise in detail and real-time).

*Session 3: Cognition-Targeted Exercise Therapy*

The patients were clarified that the purpose of these exercises was to retrain their brain and cognition rather than to solve their neck problems directly. Therefore, exercises were not initiated until each individual achieved these cognitive goals. Patients were interviewed and engaged in discussions to confirm this shift in perception.

At this stage, before starting the exercises, the movements that the patient had been avoiding due to fear of pain were identified. The exercises began with isometric contractions of the muscles involved in these movements. The order of muscle contractions progressed from less fearful movements to more fearful ones. Before performing the exercises, the patients were reminded of their safety and the purpose of each exercise. Each session consisted of 10 exercises, with a 10-second break between contractions.

*Session 4: Cognition-Targeted Dynamic and Functional Exercises*

In this session, functional neuromuscular training exercises were implemented, following a time-dependent rather than a symptom-dependent approach. In the time-dependent approach, the patient enters the painful domain and performs the exercise at a specified time, even in the presence of pain. The general principle of gradual exposure was adhered to throughout these exercises. Motor imagery was used before performing movements the patient had avoided due to fear of pain.

Patient-therapist interaction was consistently maintained throughout the treatment phase to mentally prepare the patient for the exercises (initiated before the third session and after the PNE sessions). The goal of this phase was to ensure accurate coordination during exercises. The training progressed from static to dynamic and functional states, with all exercises following the principle of graded activity [23].

*Statistical Analysis*

Data analysis was performed using SPSS software version 22. Statistical significance was determined at a level of $P<0.05$. The Kolmogorov–Smirnov test was used to evaluate the normality of the distribution of quantitative variables. A paired t-test was applied to compare pain intensity and quality-of-life scores before and after the intervention. The effect size was calculated using the difference between the pre- and post-intervention scores. The Pearson correlation test investigated the relationship between pain and quality of life with disease duration, age, and body mass index. An intention-to-treat analysis was also performed.

## Results

Considering the inclusion and exclusion criteria, 25 individuals with chronic neck pain were enrolled in the study. Table 1 presents the baseline status of the subjects. The results showed that after the intervention, both pain intensity and central sensitization (CS) decreased significantly (pain intensity: Effect Size=-3.61, CS: Effect Size=-3.52), while the quality-of-life score significantly increased (Effect Size=1.92) (Table 2). A significant correlation was also found between the quality-of-life score and age (Table 3).

## Discussion

The present study aimed to investigate the effectiveness of pain neuroscience education (PNE) combined with conventional physical therapy on pain intensity, central sensitization (CS), and quality of life in adults with chronic

**Table 1:** Baseline characteristics of the studied population

| Variables | Mean | Std. Deviation |
|---|---|---|
| Age(year) | 43.80 | 6.471 |
| Weight (kg) | 71.46 | 9.59 |
| Length (m) | 1.62 | 0.08 |
| BMI (kg/m$^2$) | 27.15 | 3.25 |
| Duration of pain (month) | 9.04 | 6.10 |
| CSI (score) | 52.40 | 8.99 |
| VAS (score) | 76.68 | 14.40 |
| SF36 (Physical domain) (score) | 39.93 | 12.90 |
| SF36 (Mental domain) (score) | 42.34 | 17.73 |
| SF36 (Total) (score) | 40.62 | 12.08 |

BMI: Body mass index; CSI: Central sensitization inventory; VAS: Visual analog scale, SF36: Short form 36

**Table 2:** Comparing pain intensity, quality-of-life, and central sensitization inventory (CSI) before and after the intervention

| Variables | Before | After | Mean difference | Effect Size | P value |
|---|---|---|---|---|---|
| VAS (score) | 76.68±14.40 | 17.72±11.91 | -58.96±16.35 | 3.61- | 0.00 |
| CSI (score) | 52.40±8.99 | 26.88±5.92 | 25.52±7.25- | -3.52 | 0.00 |
| SF36 (Physical domain) (score) | 39.94±12.90 | 62.80±14.04 | 22.86±15.11 | 1.51 | 0.00 |
| SF36 (Mental domain) (score) | 42.34±17.73 | 67.97±11.13 | 25.63±14.34 | 2.16 | 0.00 |
| SF36 (Total) (score) | 40.62±12.08 | 64.66±11.65 | 24.04±12.50 | 1.92 | 0.00 |

CSI: Central sensitization inventory; VAS: Visual analog scale; SF36: Short form 36

**Table 3:** Correlation of pain intensity and quality of life with demographic data and central sensitization inventory (CSI) before the intervention

| Variables | Age | BMI | Duration | CSI |
|---|---|---|---|---|
| VAS (score) | 0.11 | -0.14 | 0.32 | 0.16 |
| SF36 (Physical domain) (score) | 0.44*- | -040* | 0.34 | -0.21 |
| SF36 (Mental domain) (score) | 0.47*- | 0.11 | 0.22 | -0.17 |
| SF36 (Total) (score) | 0.54**- | -0.19 | 0.33 | -0.24 |
| VAS difference | -0.21 | 0.6 | -0.42* | -0.11 |
| SF36 (Physical domain) difference (score) | -0.44* | 0.29 | -0.21 | 0.19 |
| SF36 (Mental domain) difference (score) | -0.47* | -0.12 | -0.06 | 0.03 |
| SF36 (Total) difference (score) | -0.54** | 0.13 | -0.16 | 0.13 |

CSI: Central sensitization inventory; VAS: Visual analog scale; SF36: Short form 36; *P value<0.05; **P value<0.01

non-specific neck pain (CNP) and CS. To our knowledge, this is the first study to explore the effectiveness of PNE combined with conventional physical therapy in this specific population. The results indicated that a 4-week intervention of conventional physical therapy, including TENS, hot packs, and exercise therapy combined with PNE, led to a 59% reduction in pain intensity and improved quality of life among CNP patients. Our findings regarding the reduction in pain intensity are comparable to those reported by Moseley (61.7%) [26] and Pires, Cruz, and Caeiro (51.2%) [27], both of which were conducted on patients with chronic idiopathic low back pain.

We also found a moderate inverse relationship between health-related quality of life and age (r=-0.54, p=0.006), consistent with the findings of Roldan-Jimenez [2]. This significant inverse relationship suggests that younger individuals may benefit more from this intervention regarding quality-of-life improvements.

Roldan-Jimenez and colleagues [2] studied the proportion of patients suffering from various chronic musculoskeletal pain disorders (CMPD) who reported the presence of CS symptoms and examined the association between CS-related symptoms and factors such as gender, age, or body mass index (BMI). They found that clinically significant CSI scores (>40) were highly prevalent in individuals with CMPD, particularly in those with low back pain (37.8%) and neck pain (32.4%). Significant differences were observed in CSI cutoff points by gender and in total CSI scores by age. In general, persistent pain was more prevalent in females and older adults [28]. Additionally, we found an inverse relationship between the reduction in pain intensity and the duration of neck pain, indicating that patients with a longer duration of neck pain experienced less pain reduction.

PNE represents a time-efficient and cost-effective approach for transferring knowledge [7], which is beneficial in all cases of chronic spinal pain to reduce fear of movement and mitigate the condition's negative effects, regardless of the presence of subjective signs of CS. This is especially true for patients with high self-reported CS symptoms [29]. However, in patients with high self-reported CS symptoms, PNE specifically reduced excessive rumination about pain. Notably, their study included both subjects with back and neck pain. Our study focused on patients with neck pain and a CS score above 40, as measured by the CSI questionnaire. These patients experienced significant benefits from PNE combined with conventional physiotherapy in terms of reduced pain intensity, CS symptoms, and improved quality of life, which aligns with the findings of other studies [7, 13].

In the study by Javdaneh, the exercise sessions focused on strengthening and enhancing the endurance of the neck and scapula muscles. These sessions included 15–20 minutes of physical therapy exercises, with 10 minutes for warm-up and 10 minutes for cool-down over six weeks. Their results demonstrated that the combination of pain neuroscience education (PNE) and exercises was more effective than exercises alone in reducing pain, disability, fear-avoidance beliefs, and pain catastrophizing [13].

A systematic review reported that the use of PNE in chronic musculoskeletal pain is effective in reducing pain, improving pain knowledge and function, reducing disability, improving psychosocial factors, and decreasing the need for healthcare [10].

Only one study has investigated the effects of PNE on quality of life [30], which showed a significant between-group difference in favor of the PNE group for the SF-36 physical functioning, general health perceptions, and vitality sub-scores. Although the SF-36 health perceptions scale (d=−0.98) had a large effect size (Cohen's d), the other SF-36 sub-scores did not show statistically significant between-group differences [30]. Our findings confirm these results. However, our results contrast with those of Andias et al., who investigated the effect of PNE and therapeutic exercises in people with CNP and reported a non-significant reduction in pain [31].

Matias [7] did not find a significant effect of PNE plus exercise on pain intensity in university students with chronic idiopathic neck pain. This may be due to the small sample size or relatively low baseline pain intensity scores, so participants with lower baseline pain intensities might perceive smaller changes as clinically significant [32]. Dworkin et al. suggested a 30% reduction in pain from baseline should be considered clinically significant. In the present study, the mean decrease in pain intensity at the end of treatment was 59%, which is clinically significant [33]. However, since there was no control group or group receiving PNE alone, no assumptions can be made about the specific effectiveness of PNE itself. Future research should investigate the effectiveness of PNE alone compared to a control group, with a larger sample size, long-term follow-up, and diverse populations (males and females) to assess whether the positive effects of PNE persist over time.

## Conclusion

This study showed a significant improvement in pain intensity, CS, and health-related quality of life following PNE plus conventional physical therapy in adults with CNP and CS.

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**Conflict of Interest:** None declared.

## Financial Issues

The authors report no involvement by the sponsor that could have influenced the outcome of this work.

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