International Journal of
Disabilities Sports and Health Sciences
e-ISSN: 2645-9094

REVİEW ARTICLE

Effect of Duration of Pain Neuroscience Education on Pain Catastrophizing and Kinesiophobia in Patients with Chronic Low Back Pain: A Systematic Review of the Literature

Ali IKEN[*1], Samia KARKOURI[2], Ismail ZEROUAL[1] and Houda EL MOUDANE[1]

[1]Mohammed V University, Faculty of Medicine and Pharmacy, Laboratory of Biostatistics, Clinical Research, and Epidemiology (LBCRE), Rabat / Morocco
[2]Department of physical medicine and rehabilitation, El Ayachi Hospital, Ibn Sina University Hospital, Rabat / Morocco
*Corresponding author: ali_iken@um5.ac.ma

Abstract

Objective: This study aims to examine the available evidence regarding the effect of the total duration in minutes of Pain Neuroscience Education (PNE) on pain catastrophizing and kinesiophobia in patients with chronic low back pain (CLBP). Methods: A systematic literature search was conducted on PubMed/MEDLINE, Web of Science, Scopus, and PeDro databases covering the last 5 years up to February 2024. No meta-analysis was performed, and qualitative analysis was conducted in narrative and tabular form. Results: Six randomized controlled trials were included in this systematic review. All studies included patients with chronic low back pain aged over 18. PNE was provided either as a standalone intervention or in combination with other therapies such as exercise, with total duration ranging from 100 to 240 minutes. Primary outcome measures focused on pain catastrophizing and kinesiophobia, while secondary outcomes included pain and functional disability. Conclusions: No significant correlation was established between the total duration of PNE and improvement in primary outcome measures. However, findings suggest that combining PNE with exercise in the treatment of chronic low back pain leads to greater improvements in kinesiophobia and pain catastrophizing compared to exercise alone.

Keywords
Pain Education, Kinesiophobia, Catastrophizing, Low Back, Pain

INTRODUCTION

Low back pain is recognized as the most common musculoskeletal disorder (MSK) (Maselli et al. 2020), characterized by pain localized between the thoracolumbar junction and the lower gluteal fold (HAS, 2020). When these symptoms persist beyond 12 weeks, it is referred to as chronic low back pain (CLBP) (Abenhaim et al. 2000). CLBP represents one of the most prevalent health issues globally, significantly contributing to the burden of disease worldwide (Rabiei et al. 2021). Thus, treating this pain is crucial to prevent its psychological, social, financial, and occupational consequences (GTCD, 2019). Current recommendations, issued by Cochrane and the Canadian Chronic Pain Working Group, advocate for a biopsychosocial approach focusing on multidimensional interventions, such as Pain Neuroscience Education (PNE) (GTCD, 2019; Aldington & Eccleston, 2019).

PNE is a therapeutic approach that leverages neurophysiological knowledge to educate patients that pain can be overprotective and occur even in the absence of tissue damage (Moseley & Butler, 2015). Its primary goal is to correct patients' misconceptions and maladaptive thoughts regarding pain (Meeus et al. 2010). Numerous studies have explored the effectiveness of this intervention. A meta-analysis investigating the effects of PNE on kinesiophobia in patients with

Received: 03 May 2024 ; **Revised** ; 14 June 2024 ; **Accepted:** 01 July 2024; **Published:** 25 July 2024

How to cite this article: Iken, A., Karkouri, S., Zeroual, I., and El Moudane, H. (2024). Effect of Duration of Pain Neuroscience Education on Pain Catastrophizing and Kinesiophobia in Patients with Chronic Low Back Pain: A Systematic Review of the Literature. *Int J Disabil Sports Health Sci*;7(4):937-954.https://doi.org/10.33438/ijdshs.1478011

chronic pain demonstrated that a combined intervention of PNE, manual therapy, and exercises was more effective in improving chronic pain and kinesiophobia (Mills et al. 2021; Louw et al. 2016; Arguisuelas et al. 2017).

Similarly, a systematic review highlighted PNE as a promising therapeutic option for CLBP, influencing pain, physical disability, psychological aspects, and social function of patients (Clarke et al. 2011).

Other studies have examined the application of PNE in individual or group sessions. In 2003, Moseley showed that group education, which is less costly than individual sessions, was less effective in terms of reducing pain intensity and disability (Moseley, 2003).

However, the question of dosage (i.e., total session duration) of pain neuroscience education has been underexplored in the literature (Louw et al. 2011). In this regard, it would be beneficial to determine the optimal duration required for pain neuroscience education in CLBP patients to induce clinically significant changes in pain, disability, and psychosocial aspects, thereby designing personalized interventions for future research and clinical practice (Salazar-Méndez et al. 2023).

METHODS

This systematic review was conducted following the guidelines of the PRISMA 2020 Statement (Page et al. 2021), and its protocol was registered with PROSPERO (Booth et al. 2012) (CRD42024500793).

Eligibility Criteria

Study Design

Only randomized controlled trials (RCTs) published in French or in English were considered eligible. No further restrictions were applied.

Participants

Inclusion criteria focused on patients aged over 18 years experiencing persistent chronic low back pain for at least 3 months

Inclusion Criteria: Inclusion criteria were based on the PICOS methodology (population, intervention, comparison, outcomes, and study).

(1) Population: Adults aged>18 years suffering from chronic low back pain; (2) Intervention: PNE alone or combined with other therapeutic modalities; (3) Comparison: Active or passive therapeutic interventions or waiting list; (4) Outcomes: Assessment of kinesiophobia and pain catastrophizing. Knowledge regarding pain and functional disability were considered secondary outcomes; (5) Study Design: Randomized controlled trials (RCTs) and peer-reviewed original articles, written in English or French, published in the last 5 years up to February 2024.

Exclusion Criteria: RCTs involving patients aged <18 years; specific populations (elderly subjects, women or men only, or patients who have undergone surgical intervention); Symptomatic, acute, or subacute low back pain, or any pain caused by specific pathologies (pulmonary, cardiac, neurological, oncological, visceral, cognitive, psychiatric disorders).

Interventions

RCTs were included if they involved an intervention based on PNE in any form, without restriction on its combination with other interventions.

Comparisons

Educational interventions, waiting lists, placebo interventions, and other active therapeutic approaches (e.g., strengthening exercise) or passive approaches (e.g., manual therapy) were eligible for inclusion.

Outcomes and Outcome Measures

RCTs evaluating at least one of the following criteria were included: (1) kinesiophobia, (2) pain catastrophizing, (3) pain, and (4) functional disability.

Search Methods for Inclusion of Studies

A systematic search was conducted on PubMed/MEDLINE, Web of Science, Scopus, and PeDro databases for articles published in the last 5 years, using MeSH (Medical Subject Headings) terms and keywords combined with Boolean operators (AND, OR, and NOT) according to the PICO model. The comprehensive search strategy for the 4 databases is available in the appendix (Appendix 1).

Study Selection and Data Extraction

After removing duplicates, the titles and abstracts of articles were reviewed by the first author (A-I), and abstracts were reviewed by the second author (I-Z).

Full-text articles were requested from the library service of the Faculty of Medicine and Pharmacy of Rabat. If unavailable, requests made via direct email contact with the corresponding authors.

Subsequently, the two were evaluators (A-I, I-Z) individually extracted data from the selected articles according to the inclusion criteria, using a data extraction form developed in accordance with the PICO model of the clinical question. In case of missing data, an email was sent to the authors. Disagreements were resolved by a third examiner (S-K) not involved in the data extraction process.

Inter-Rater Agreement

To quantify inter-rater agreement between the two authors (A-I, I-Z) for full-text selection, Cohen's Kappa (K) was used. The K value was calculated and interpreted according to Altman's definition (Altman, 1990): poor ($k < 0.2$), fair ($0.2 < k < 0.4$), moderate ($0.41 < k < 0.61$), good ($0.61 < k < 0.80$), excellent ($x > 0.80$).

Risk of Bias

The PEDro score was used to assess the methodological quality of each RCT (De Morton, 2009; Maher et al. 2003). A positive score on a minimum of 5 items qualified a study as high quality.

Analysis

Due to study heterogeneity, no meta-analysis was conducted. Results were presented qualitatively. An alpha level with a significance threshold set at $p < 0.05$. All relevant data were reported for each outcome measure, including point estimates, confidence intervals, and effect sizes

RESULTS

Following the electronic search, a total of 278 articles were identified. After removing duplicates, the retrieved articles underwent title and abstract screening, resulting in the identification of 184 potentially relevant studies. Based on full-text examination, an additional 155 articles were excluded, leaving 29 articles for in-depth evaluation. Among these, 23 were further excluded after comprehensive review. Ultimately, 6 articles met the inclusion criteria and were included in this systematic review. The selection process is presented in Figure 1.

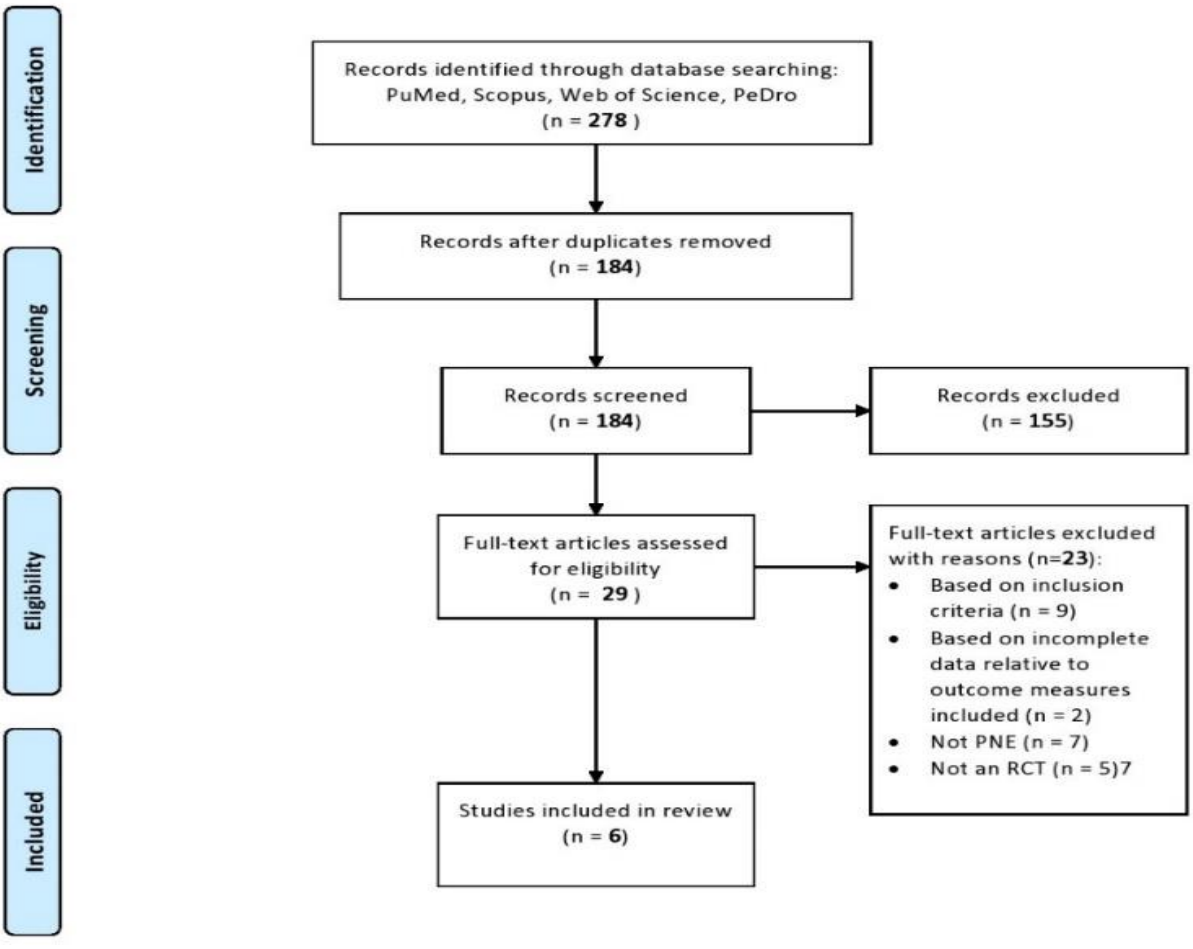

Figure 1: Flowchart and Process of Primary Studies Inclusion

Study Characteristics

Six RCTs were selected for this analysis (Saracoglu et al. 2022; Gül et al. 2021; Orhan et al.

2021; Rabiei et al. 2021; Yamada et al. 2023; Song et al. 2023). All relevant characteristics including study design, recruitment, age, gender, duration of pain, intervention, comparison, and number of participants are detailed in Table 1. Specifically, 5 studies divided participants into 2 groups (intervention group and control group) (Gül et al. 2021; Orhan et al. 2021; Rabiei et al. 2021; Yamada et al. 2023; Song et al. 2023), except for the study by Saracoglu et al. (2022), which adopted a multi-arm approach.

Table 1: Characteristics of RCTs included in the systematic review

Author (y), Country	Randomi-sation Method	Total sample size, Age, Recruitment	Duration Of Symptoms	Intervention (Participants, Gender)		Comparison (Participants, Gender)		Intervention Group	Comparison Group	Outcome Measures and Follow-Up
				Number	Gender	Number	Gender			
Saraco-glu et al., 2020 Turkey	Three-arm, Single-blind randomi-zed controlled trial	N = 69 Age: 18-65 Patients recruited by the physical therapy department of Kutahya University Hospital	CLBP > 6 months	Group 1 N = 20	Group 1 M = 9 F = 12	Group 2 N = 19 Group 3 N = 18	Group 2 M = 11 F = 10 Group 3 M = 10 F = 10	Group 1: PNE + Manual Therapy + Home exercise program	Group 2: Manual Therapy + Home exercise program Group 3: only home exercise program	*Numerical Pain Rating Scale* (NPRS) *Oswestry Disability Index* (ODI) *Tampa Scale of Kinesiophobia* (TSK-17) Baseline 4 weeks 12 weeks
Gül et al., 2021 Turkey	Randomi-zed controlled trial	N = 31 Age: 20-58 Patients recruited from the clinic in Antalya	CLBP > 3 months	N = 16	-	N = 15	-	TNE + Physiothe-rapy	Physiothe-rapy	*Visual Analogue Scale* (VAS) *Tampa Scale of Kinesiophobia* (TSK-11) *Roland Morris Disability* Questionnaire (RMDQ) Baseline 3 weeks
Orhan et al., 2021 Belgium	Randomi-zed controlled trial	N = 29 Age: 18-65 Patients recruited at a private medical center in Ghent (BE).	CLBP > 3 months	N = 15	M = 4 F = 11	N = 14	M = 4 F = 10	Culture-sensitive PNE	Standard PNE	*Numerical Rating Scale* (NRS) *Roland Morris Disability* Questionnaire (RMDQ) *Pain Beliefs Questionnaire* (PBQ) *Pain Catastrophizing Scale* (PCS-13) *Tampa Scale of Kinesiophobia* (TSK-17) Baseline 1 weeks 4 weeks
Rabiei et al., 2021 Iran	Randomi-zed controlled trial	N = 73 Age: 30-60 Patients recruited by physiothera pists through leaflets exposed in rehab clinics	CLBP > 3 months	N = 37	M = 16 F = 21	N = 36	M = 18 F = 18	PNE + Motor control exercise (MCE)	Group-based exercise (GE)	*Visual Analogue Scale* (VAS) *Roland Morris Disability* Questionnaire (RMDQ) Fear Avoidance Beliefs Questionnaire (FABQ) *Pain Self Efficacy*

										Questionnaire (PSEQ) Baseline 8 weeks
Yamada et al., 2023 Brazil	Single-blind randomi-zed clinical trial	N = 40 Age > 18 Participants registered at the Clinical School of Physiotherapy at CEULP/ULBRA, in Palmas/TO	CLBP > 3 months	N = 20	M = 8 F = 12	N = 20	M = 5 F = 15	The PNE intervention + Physiothe-rapy treatment	Physiothe-rapy treatment	*Numerical pain scale* (NPS) *Central sensitization* (CSI) *Roland Morris disability questionnaire* (RMDQ) *Pain catastrophizing scale* (PCS) *Tampa scale of Kinesiophobia* (TSK) *Hospital anxiety and depression scale* (HADS) SF-6D questionnaire Baseline 6 weeks
Song et al., 2023 Korea	Randomi-zed Single-Blind Controlled Trial	N = 28 Age: 20 -75 Participants registered at the Gwangju Heemang Hospital.	CLBP > 3 months	N = 14	M = 8 F = 6	N = 14	M = 9 F = 5	PNE + Soft-tissue mobilization (STM)	Soft-tissue mobilization	*Numerical Pain Rating Scale (NPRS)* *Korean version of the Roland Morris Disability Questionnaire (K-RMDQ)* *Central sensitization (CSI)* *Pressure pain threshold (PPT)* *Pain catastrophizing scale (PCS)* *Tampa scale of kinesiophobia-17 (TSK-17)* Baseline 4 weeks 6 weeks 8 weeks

Follow-ups

Post-treatment follow-up periods vary considerably from one study to another. Follow-up intervals range from a minimum of one week after treatment (Orhan et al. 2021) to a maximum of 12 weeks (Saracoglu et al. 2022). Additional details are available in Table 1.

Type of Participants

All studies included patients aged over 18 years suffering from chronic low back pain. Five studies (Gül et al. 2021; Orhan et al. 2021; Rabiei et al. 2021; Yamada et al. 2023; Song et al. 2023) recruited patients with chronic low back pain persisting for more than 3 months, while only one study (Saracoglu et al. 2022) included patients with chronic low back pain for more than 6 months. However, only the study by Gul et al. did not specify the gender of participants (Table 1).

Sample

The total sample size of included and randomized participants was 270 individuals. The study conducted by Song et al. (2023) had the smallest sample size (n=28), while the study by Rabieri et al. (2021) had the largest sample size (n=73).

Dropout and Loss to Follow-up

Among the 270 recruited patients, 15 (5.55%) dropped out, and 12 (4.44%) were lost to follow-up. Details are specified in Table 2.

Table 2. Dropout and loss to follow-up in included RCTs

Study	Drop-Outs (n° ; %)		Lost to Follow-Up (n°; %)	
	Experimental Group	Control Group	Experimental Group	Control Group
Saracoglu et al., 2020	0	0	Group 1: 3 at 12 weeks (13%) Group 2: 4 at 12 weeks (17,39%)	Group 3 : 5 at 12 weeks (21,73%)
Gül et al., 2021	0	0	0	0
Orhan et al., 2021	4 at 1 week (26,6%)	4 at 1 week (28,5%)	0	0
Rabiei et al., 2021	3 (8,1%)	4 (11,1%)	0	0
Yamada et al., 2023	0	0	0	0
Song et al., 2023	0	0	0	0

Type of Interventions

Therapeutic experimental interventions varied in content and execution methods across studies. Five studies used therapeutic approaches without PNE as the comparison group. The types of exercises used were varied: soft tissue mobilization (Song et al. 2023); physiotherapy protocol (Gül et al. 2021; Orhan et al. 2021; Rabiei et al. 2021; Yamada et al. 2023); home exercise program and manual therapy (Gül et al. 2021); sensorimotor control exercises and low back strengthening exercises (Rabiei et al. 2021). In contrast, only one study used PNE as a single experimental intervention (culture-sensitive PNE approach, based on beliefs, cognitions, and pain-related behaviors of Turkish patients, adapted from a previous Delphi study) (Orhan et al. 2021).

The mode of execution also varied across studies, including group sessions (Song et al. 2023) and individual sessions (Saracoglu et al. 2022; Gül et al. 2021; Orhan et al. 2021; Rabiei et al. 2021; Yamada et al. 2023). The total duration of PNE sessions ranged from 90 minutes (Orhan et al. 2021) to 240 minutes (Gül et al. 2021).

PNE administration modalities differed in terms of frequency, number of sessions, total session duration, responsible professional, and content used (Table 3).

Type of Control Groups

Participants in the comparison group were exposed to various therapeutic approaches, including soft tissue mobilization (Song et al. 2023); physiotherapy protocol (Gül et al. 2021; Orhan et al. 2021; Rabiei et al. 2021; Yamada et al. 2023); home exercise program and manual therapy (Saracoglu et al. 2022); sensorimotor control exercises and low back strengthening exercises (Rabiei et al. 2021). Only the study by Orhan et al. (2021) administered PNE in the control group (standard PNE). Additional information is provided in Table 3.

Table 3. Characteristics and types of interventions

Author, Y	Comparaison Details					PNE intervention Details			
	Type	Freque-nce	Total session duration	Progr-am length	Method of delivery	Type	Frequ-ence	Total session duration	Method of delivery
Gül et al., 2021	Physiotherapy: Hot-pack, ultrasound, TENS and acupuncture TENS. + isotonic and isometric reinforcement, exercises for trunk muscles, stretching	15 sessions of physiotherapy, 5 each week	Hot-pack=20 min TENS=20 MIN	3 weeks	One-on-one sessions applied by a physiotherapist	TNE concept, as described by Moseley and Butler (2015)	2 sessions per week 3 weeks	Each session 40 min Total = 240 min	Conducting a one-to-one interview performed by a physiothe-rapist
Yamada et al., 2023	kinesiotherapy exercises: bridge; board; spinal mobility exercise; walking on the treadmill for 4 min; sensory-motor training; motor coordination; trunk extension; hip	12 physiotherapy sessions, twice a week	Each session lasted 50 min	6 weeks	One-on-one sessions applied by the treatment researcher	PNE as described by Louw et al. (2013)	3 individual sessions of PNE	Each session 50 min Total = 150 min	individual PNE sessions Performed by the education researcher

	abduction; pelvic tilt and posterior chain muscle stretch.								
Song et al., 2023	STM techniques: transverse sliding of the lumbar muscles; thoracolumbar myofascial release; quadratus lumborum myofascial release; and psoas myofascial release	8 STM sessions, 2 sessions per week	40 min per session	4 weeks	One-on-one sessions performed by a physical therapist	PNE based on PNE by Louw et al. (2018), Pardo et al. (2018)	2 sessions, one before and one after receiving STM program	Each session 30 - 50 min Total = 100 min	Group sessions in the hospital's rehabilitation treatment room
Orhan et al., 2021	Standard PNE translated into Turkish by 2 independent native Turkish-speaking translators.	2 educational sessions in 2 weeks	The first session lasting around 45 to 60 min. The second session was lasted 45 min	4 weeks	An individual education session performed by the first author instructed by 2 physiotherapists experts in PNE	Culture-sensitive PNE approach developed during a study "Delphi modified" (Orhan et al., 2019) based on: "*Explain Pain*" (Butler and Moseley, 2003) and "Pijneducatie: Een Praktische Handleiding voor (Para) medici" (Van Wilgene Nijs, 2010).	2 educational sessions in 2 weeks	The first session lasting around 45 to 60 min. The second session was lasted 45 min Total = 105 min	An individual education session performed by the first author instructed by 2 physiotherapists experts in PNE
Rabiei et al., 2021	Exercise program: group warm-up; muscle strengthening exercises; light exercises	2 times a week	Each session lasting 60 min (10 min group warm-up, 45 min muscle strengthening exercises, 5 min light exercises).	8 weeks	An individual session performed by a physiotherapist not involved in the intervention group	PNE according to the method recommended by Nijs (2014)	3 educational sessions	each lasting 30 - 60 min Total = 180 min	An individual education session performed by Persian native physiotherapist, trained in PNE program
Saracoglu et al., 2020	Group 2: Manual therapy: personalized treatment Use different techniques with variable speed, range, direction of force application and patient position 2. Home exercise program: stretching, heating, reinforcement. The program was developed by Koumantakis, Watson and Oldham (2005). Group 3: only home exercise program, with the same group 1 and group 2 modes	Group 2: 1. Manual therapy: 2 sessions per week 2. Home exercise program: 10 repetitions, 3 times a day.	Manual therapy: Each session lasting 30 min	4 weeks	Group 2: 1. Manual therapy: physiotherapist (I.S.) who holds an MSc degree and has 10 years of experience in MT. 2. Home exercise program: The same physiotherapist (I.S.)	PNE according to the method recommended by Louw, Nijs and Puentedura (2017).	4 individual educational sessions, one per week	Each lasting about 40-45 min, after the manual therapy session Total = 180 min	An individual education session performed by a physiotherapist (I.S.) trained at the International Spine and Pain Institute

Type of Outcome and Outcome Measures

There is significant diversity in outcome measures used across all included studies. Regarding pain intensity assessment, two studies used the NPRS scale (Saracoglu et al. 2022; Song et al. 2023), two others used VAS (Gül et al. 2021; Rabiei et al. 2021), one used the NRS scale (Orhan et al. 2021), and another used the NPS scale (Yamada et al. 2023). To assess disability, five studies used the RMDQ disability index (Gül et al.

2021; Orhan et al. 2021; Rabiei et al. 2021; Yamada et al. 2023; Song et al. 2023), while one used the ODI disability index (Saracoglu et al. 2022). Kinesiophobia was evaluated using the PCS questionnaire in 5 studies (Saracoglu et al. 2022; Gül et al. 2021; Orhan et al. 2021; Rabiei et al. 2021; Song et al. 2023), and pain catastrophizing was assessed using the PCS in 3 studies (Gül et al. 2021; Rabiei et al. 2021; Song et al. 2023)

Risk of Bias

The assessment of the quality of each article, established using the PEDro scale, is summarized in Table 5. The 6 included studies were RCTs, assessed as having a moderate to low risk of bias, all scoring 5/10 or higher on the PEDro scale (PEDro score ≥ 5). The main reason for score reduction was the inability to achieve blinding of subjects and therapists. This limitation is partly attributable to the fact that the PNE intervention is administered face-to-face, making blinding implementation challenging.

PEDro scores for 5 studies were extracted from the PEDro database (Saracoglu et al. 2022; Gül et al. 2021; Orhan et al. 2021; Rabiei et al. 2021; Song et al. 2023), while one study required score calculation by the authors (Yamada et al. 2023).

Table 4. Evaluation of the quality of included RCTs

Study	Question*											Score
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	
Orhan et al. 2021	**Y**	**Y**	**N**	**Y**	**N**	**N**	**N**	**N**	**Y**	**Y**	**Y**	5/10
Rabiei et al. 2021	**Y**	**Y**	**Y**	**Y**	**N**	**N**	**N**	**Y**	**N**	**Y**	**Y**	6/10
Gül et al. 2021	**Y**	**Y**	**N**	**Y**	**N**	**N**	**N**	**Y**	**N**	**Y**	**Y**	5/10
Saracoglu et al. 2022	**Y**	**Y**	**Y**	**Y**	**N**	**N**	**Y**	**Y**	**N**	**Y**	**Y**	7/10
Yamada et al. 2023	**Y**	**Y**	**Y**	**Y**	**N**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**9/10**
Song et al. 2023	**Y**	**Y**	**N**	**N**	**N**	**N**	**Y**	**Y**	**Y**	**Y**	**Y**	6/10

*** :** 1, eligibility criteria were specified (**not counted in PEDro score**); 2, subjects were randomly allocated to groups; 3, allocation was concealed; 4, the groups were similar at baseline regarding the most important prognostic indicators; 5, there was blinding of all subjects; 6, there was blinding of all therapists who administered the therapy; 7, there was blinding of all assessors who measured at least one key outcome; 8, measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups; 9, all subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome were analysed by "intention to treat"; 10, the results of between-group statistical comparisons are reported for at least one key outcome; and 11, the study provides both point measures and measures of variability for at least one key outcome.
N, no; **Y**, yes.

Agreement

The inter-rater agreement index (A-I and I-Z) was excellent (K = 0.8125) for the selection of full-text articles. The data are detailed in Table 6.

Table 5. Agreement for full-text selection

Agreement for Full-Text Selection		Evaluator 1 (A-I)		TOTAL
		Positive Evaluation	Negative Evaluation	
Evaluator 2 (I-Z)	Positive Evaluation	**24**	**1**	**25**
	Negative Evaluation	**2**	**5**	**7**
TOTAL		**26**	**6**	**32**

Intervention Effects

All included studies focus on the effect of PNE on kinesiophobia, pain catastrophizing, pain, and functional abilities in individuals with chronic low back pain. A qualitative synthesis of the results was presented based on the intervention dosage or total intervention duration in minutes ("moderate dose" ≤ 150 minutes and "high dose" > 150 minutes). Details are available in Table 7.

At Moderate Dose (≤ 150 min)

According to the included studies, participants underwent variable intervention durations. Studies by Orhan et al. (2021), Song et al. (2023), and Yamada et al. (2023) examined the intervention's effectiveness when the duration was ≤ 150 minutes.

Three studies (Orhan et al. 2021; Yamada et al. 2023; Song et al. 2023) assessed the effectiveness of PNE on pain (NRS, NPS, NPRS), functional disability (ODI, RMDQ), and kinesiophobia (TSK), while 2 studies (Yamada et al. 2023; Song et al. 2023) investigated pain catastrophizing (PCS).

Kinesiophobia and Pain Catastrophizing

In Orhan et al.'s study (2021), no significant difference was observed between the intervention group (sensitized PNE) and the control group (standard PNE) regarding PCS or TSK, although both PNE types showed significant improvements over time in both groups (Orhan et al. 2021).

In contrast, Song et al. (2023) demonstrated significant improvement in TSK and K-PCS in the group receiving PNE combined with soft tissue mobilization (BG; PNE + STM) compared to the group receiving only soft tissue mobilization (SMG) at post-test follow-ups, at 2 and 4 weeks ($p<0.013$). Similar results were observed in Yamada et al.'s study (2023), where the group (IG) receiving PNE combined with physiotherapy showed significantly lower kinesiophobia compared to the group (CG) receiving only physiotherapy ($p <0.001$).

Pain and Disability

Orhan et al.'s study (2021) revealed significantly lower scores compared to baseline scores for NRS at week 1 ($p = 0.02$) and for RMDQ scores at week 1 ($p = 0.01$) and week 4 ($p = 0.01$). Similarly, Yamada et al. (2023) observed a clinically significant decrease in pain intensity (NPS) and functional disability (ODI) in both groups, with more pronounced improvement in the IG. However, no significant improvement was observed in the experimental group compared to the control group in these two trials (Orhan et al. 2021; Yamada, 2023).

In contrast, Song et al. (2023) showed significant improvement in pain intensity (NPRS) and functional abilities (K-RMDQ) in the group receiving PNE (BG) compared to the SMG group at 2 and 4 weeks ($p<0.013$). In NPRS, the MCID was reached in the experimental group (BG) with a decrease of more than 2 points (Table 7).

At High Dose (More than 150 min)

Three studies assessed the effectiveness of PNE on pain and functional abilities when the intervention duration exceeded 150 min. Two studies examined the effectiveness of PNE on kinesiophobia under these conditions (Saracoglu et al. 2022; Gül et al. 2021), while no study evaluated pain catastrophizing.

Kinesiophobia and Pain Catastrophizing:

In Saracoglu et al.'s study (2022), TSK-17 scores were significantly lower in group 1 (PNE+ HEP+MT) receiving PNE combined with home exercise and manual therapy compared to groups receiving only home exercise (HEP) or home exercise plus manual therapy (HEP+MT) (Table 7). However, Gül et al.'s clinical trial (2021) did not show statistically significant improvement in kinesiophobia in the experimental group compared to the control group.

Pain and Disability:

A post-hoc test showed that group 1 (PNE+HEP+MT) had significantly lower NPRS values than group 2 (HEP+MT) ($p= 0.01$) and the control group (HEP) ($p< 0.001$), similarly for the ODI score which was significantly lower in group 1 ($p<0.001$) and group 2 ($p=0.05$) compared to the control group (Table 7).

In Rabiei et al.'s study (2021), a statistically significant improvement in pain intensity and functional disability was observed in the experimental group PNE + combined with motor control exercise (MCE) at 8 weeks ($p < 0.001$). Indeed, the group (PNE+MCE) showed greater improvements with a moderate effect on pain intensity VAS ($P = 0.041$) and on disability and RMDQ ($P=0.021$) compared to the EG group.

In contrast, the study conducted by Gül et al. (2021) did not show statistically significant improvement in pain (VAS) or function (RMDQ) in the experimental group at 3 weeks after the intervention ($p> 0.05$).

Table 6. Results of included RCTs

Study	Intervention	Comparison	Total duration of PNE and Follow-up	Results (EX: Experimental Group; C: Control Group)	*p* value No Difference between Groups
Orhan et al.,2021 Belgium	PNE "culture-sensitive"	PNE standard	90 min = 1h30 Baseline 1 weeks 4 weeks	**NRS** EX: 6.50 ± 1.80 → 5.80 ± 2.07 → 5.86 ± 2.35 C: 6.85 ± 2.21 → 5.85± 2.24 → 6.00 ± 2.48 **RMDQ** EX: 16.66 ± 4.32 → 15.40 ± 4.82 → 15.60 ± 6.12 C: 16.21 ± 4.62 →14.42 ± 5.98 → 13.07 ± 5.91 **PBQ (organic score)** EX: 4.23 ± 0.93 → 3.67 ± 0.99 → 3.87 ± 0.65 C: 4.02 ± 0.75 →3.64 ± 0.70 → 3.50 ± 0.92 **PBQ (psychological score)** EX: 4.10 ± 1.22 → 4.86 ± 1.22 → 4.36 ± 1.14 C: 4.35 ± 0.93 → 4.51 ± 1.04 → 4.12 ± 1.07 **PCS-13** EX: 29.40 ± 10.68 → 25.93 ± 11.21 → 24.80 ± 11.21 C: 24.14 ± 10.86 → 19.35 ± 10.77 → 19.00 ± 11.08 **TSK-17** EX: 45.33 ± 5.17 → 42.73 ± 5.37 → 43.26 ± 6.06 C: 43.64 ± 3.65 → 41.71 ± 3.45 → 40.50 ± 3.87	Both follow-ups: **NRS** ($p > 0.05$) **RMDQ** ($p > 0.05$) **PBQ** ($p > 0.05$) **PCS-13** ($p > 0.05$) **TSK-17** ($p > 0.05$)
Song et al., 2023 Korea	PNE + Soft-tissue mobilization	Soft-tissue mobilization	100min = 1h40 **Baseline** 4 weeks (post-test) 6 weeks 8 weeks	**NPRS** EX: 4.73 ± 0.90 → 2.40 ± 0.85 → 1.95 ± 0.65 → 1.78 ± 0.50 C: 4.66 ± 0.92 → 2.59 ± 0.64 → 2.64 ± 0.67 → 2.93 ± 0.67 **K-RMDQ** EX: 9.71 ± 2.46 → 5.07 ± 1.38 → 14.36 ± 1.22 → 4.21 ± 1.19 C: 9.07 ± 2.76 → 6.29 ± 1.86 → 6.64 ± 2.02 → 7.14 ± 2.07 **CSI-K** EX: 41.00 ± 7.39 → 33.07 ± 6.11 → 31.64 ± 5.84 → 29.57 ± 5.69 C: 39.93 ± 8.07 → 36.57 ± 7.45 → 35.43 ± 6.98 → 34.79 ± 6.49 **PPT** EX: 33.13 ± 11.95 → 52.90 ± 8.21 → 54.13 ± 8.58 → 54.89 ± 7.98 C: 29.23 ± 8.74 → 40.36 ± 8.32 → 39.18 ± 8.56 → 37.47 ± 8.39 **K-PCS**	**NPRS** ($p < 0.001$) **K-RMDQ** ($p < 0.001$) **CSI** ($p < 0.001$) **PPT** ($p < 0.001$) **K- PCS** ($p < 0.001$) **TSK-17** ($p < 0.001$)

				EX: 29.86 ± 3.80 → 20.14 ± 3.08 → 18.57 ± 2.38 → 17.57 ± 1.91 C: 30.93 ± 5.01 → 27.93 ± 5.27 → 28.86 ± 6.49 → 30.00 ± 6.30 **TSK-17** EX: 39.21 ± 5.12 → 31.57 ± 3.41 → 29.93 ± 2.84 → 29.50 ± 3.11 C: 40.86 ± 4.93 → 38.43 ± 3.78 → 37.43 ± 3.99 → 37.57 ± 3.63		
Yamada et al., 2023 Brazil	PNE + Physiotherapy treatment	Physiotherapy treatment	150 min = 2h30 Baseline 6 weeks	**NPS** EX: Δ → 3.20 ± 2.69 C: Δ → 4.30 ± 2.60 **CSI** EX: Δ → 40.3 ± 14.16 C: Δ → 37.65 ± 17.8 **RMDQ** EX: Δ → 9.10 ± 7.28 C: Δ → 11.6 ± 6.46 **PCS** EX: Δ → 0.89 ± 1.07 C: Δ → 1.29 ± 1.12 **TSK-11** EX: Δ → 32.4 ± 8.83 C: Δ → 40 ± 7.33 **HADS-A** EX: Δ → 6.45±3.47 C: Δ → 8.5±4.01 **HADS-D** Δ → 5.10±4.08 C: Δ →6.7±3.54 **SF-6D** EX: Δ → 0.75±0.09 C: Δ → 0.75±0.08	**TSK-11** 6 weeks (*p*=0.006)	**NPS** (*p* > 0.05) **CSI** (*p* > 0.05) **RMDQ** (*p* > 0.05) **PCS** (*p* > 0.05) **HADS-A** (*p* > 0.05) **HADS-D** (*p* > 0.05) **SF-6D** (*p* > 0.05)
Saracoglu et al., 2020 Turkey	Group 1: PNE + Manual therapy + Home exercise	Group 2: Manual therapy + Home exercise Group 3: Home exercise	180 min = 3h Baseline 4 weeks 12 weeks	**NPRS** G1: 7.29 ± 1.41 → 3.05 ± 1.50 → 2.09 ± 1.64 G2: 7.58 ± 1.47 → 4.42 ± 1.78 → 4.52 ± 1.84 C: 7.32 ± 1.48 → 5.89 ± 2.03 → 5.47 ± 1.95 **ODI** G1: 34.45 ± 7.39 → 22.80 ± 6.77 → 19.90 ± 5.72 G2: 32.00 ± 6.87 → 25.00 ± 7.88 → 25.89 ± 7.37 C: 34.74 ± 8.55 → 31.77 ± 9.27 → 32.33 ± 8.49 **TSK-17** G1: 44.35 ± 4.30 → 35.55 ± 5.75 → 35.19 ± 3.99 G2:	**NPRS** Both follow-ups: Group 1 vs. G. 3 (*p* < 0.001) **ODI** Both follow-ups: Group 1 vs. G. 3 (*p* < 0.001) **TSK-17** Both follow-ups: Group 1 vs. G. 2 (*p* < 0.001) Group 1 vs. G.3 (*p* < 0.001)	**NPRS** Both follow-ups: Group 1 vs. G. 2 (*p* = 0.01) **ODI** Both follow-ups: Group 1 vs. G.2 (*p* = 0.67)

				45.10 ± 4.45 → 41.63 ± 5.23 → 42.21 ± 5.04 C: 45.55 ± 4.10 → 44.94 ± 4.70 → 44.88 ± 5.10		
Rabiei et al., 2021 Iran	PNE + Motor control exercise	Group-based exercise	180 min = 3h Baseline 8 weeks	**VAS** EX: 6.45 ± 1.21 → 3.79 ± 1.02 C: 6.36 ± 1.14 → 4.91 ± 1.67 **RMDQ** EX: 14.6 ± 1.55 → 7.94 ± 2.17 C: 15.0 ± 2.14 → 9.50 ± 3.25 **FABQ-W** EX: 24.2 ± 10.4 → 11.5 ± 6.41 C: 21.6 ± 8.02 → 14.9 ± 6.43 **FABQ-PA** EX: 17.2 ± 4.25 → 8.24 ± 3.72 C: 15.7 ± 5.17 → 10.2 ± 4.15 **PSEQ** EX: 26.6 ± 9.53 → 43.9 ± 11.6 C: 29.5 ± 10.9 → 38.9 ± 12.0	**VAS** 8 weeks (p = 0.041) **RMDQ** 8 weeks (p = 0.021)	**FABQ** 8 weeks (p > 0.05) **PSEQ** 8 weeks (p > 0.05)
Gül et al., 2021 Turkey	PNE + Physiotherapy	Physiotherapy	240 min = 4h Baseline 3 weeks	**VAS** EX: Δ → −35.9 ± 28.3 C: Δ →33.8 ± 29.5 **TSK-11** EX: Δ → −17.3 ± 12.1 C: Δ →−2.9 ± 6.4 **RMDQ** EX: Δ → −8.8 ± 5.5 C: Δ →−5.7 ± 4.4		**VAS** 3 weeks (p > 0.05) **TSK-17** 3 weeks (p = 0.410) **RMDQ** 3 weeks (p > 0.05)

DISCUSSION

This systematic review aims to examine the impact of intervention duration on the effectiveness of PNE in patients with CLBP, to optimize outcomes and better tailor the implementation of this intervention in clinical practice. It is noteworthy that this is the first systematic review specifically evaluating the impact of total PNE duration on individuals with CLBP. The six clinical trials included in this review provided data on differences in pain intensity, disability, kinesiophobia, and pain catastrophizing, using both moderate and higher doses of PNE.

Results from these studies are heterogeneous within different dosage groups, yet they demonstrated significant differences in all outcome measures favoring the combination of PNE with other therapeutic approaches compared to the use of therapeutic approach alone. Indeed, only the studies by Song, Yamada (for moderate doses), and Saracoglu (for high doses) reported a positive effect of the intervention on kinesiophobia and pain catastrophizing. In Song's study, a significant reduction in both criteria was observed only in the group receiving PNE, surpassing the clinically important difference (MCID) reported for TSK-17 (5.5 points) (Monticone et al. 2016), and the minimal detectable change (MDC) for K-PCS (10.28 points) (Cho et al. 2013). For Yamada et al. (2023), a statistically significant difference was observed between the intervention group and the control group regarding kinesiophobia (p = 0.006). While Saracoglu et al. found a significant improvement in kinesiophobia in patients receiving PNE with manual therapy (MT) and home exercise program (HEP) compared to the other two groups (MT + HEP and HEP alone).

These findings are consistent with previous literature on the effectiveness of PNE in treating chronic musculoskeletal pain in adults (Siddall et al. 2022; Romm et al. 2021; Watson et al. 2019).

However, contrary to expectations, no correlation was observed between intervention duration and improvement in kinesiophobia and pain catastrophizing. It is important to note that most studies included in this review presented either non-significant or significant results for one or more criteria, except for one. Song's study is the only one to have found a significant difference in all variables, which may be attributed to the application of PNE in groups.

These findings diverge from those of a previous meta-analysis which suggested a linear relationship between PNE duration and reduction in symptoms of these two factors (Salazar-Méndez et al. 2023). In reality, estimates suggest that a duration of 400 minutes of PNE is needed to achieve a clinically significant improvement in pain catastrophizing (Salazar-Méndez et al. 2023), measured by a clinically important change MCID of 6.71 points for PCS (Woby et al. 2005), whereas a dose of 100 min is needed to observe an MCID of 4 points for TSK-11 (Suzuki et al. 2020). Although the dosage (PNE duration) has been statistically significant (Salazar-Méndez et al. 2023), the fact that many studies use shorter sessions of 30 to 45 minutes suggests that PNE is more effective when combined with other therapies (Nijs et al. 2011; Louw et al. 2018)

These observations also extend to secondary criteria of pain and functional disability. Three studies in each group concluded a benefit of PNE in reducing pain and improving function. At moderate doses, only Song's study showed a statistically significant improvement on NPRS and K-RMDQ scales. Conversely, at higher doses, combining PNE with other therapies such as manual therapy and home exercises led to more significant improvements in pain and disability in the short and mid-term. Available data suggests a moderate to significant improvement in pain and functional disability, immediately after treatment (Tegner et al. 2018) in the short term in CLBP patients who underwent PNE (Woby et al. 2005).

However, the meta-analysis by Wood and Hendrick revealed a clinically insignificant effect on pain intensity, although clinically and statistically significant improvements were observed in disability index (RMDQ), likely due to a better understanding of pain and reduction in fear-avoidance beliefs among patients (Fletcher et al. 2016).

Indeed, it has been reported that reconceptualization through increased pain knowledge via PNE leads to a positive improvement in pain catastrophizing, which could potentially reduce kinesiophobia by gradually decreasing fear and encouraging physical activity (Tu et al. 2019; Kong et al. 2013; Mittinty et al. 2018). Additionally, the significant improvement in RMDQ scores is due to the fact that the disability index correlates with fear avoidance (Chung et al. 2013). Despite variability in PNE duration and dosage among studies, the content of PNE remains relatively standardized, which appears to lead to improved pain-related outcomes (Romm et al. 2021). Lastly, while most studies included in this review presented either significant or non-significant results for various criteria, only one study showed a significant difference in all variables, suggesting that implementing PNE in groups may have additional benefits in terms of improving outcomes

Strengths and Limitations

The strengths and limitations of this systematic review deserve particular attention when evaluating its results and their relevance for clinical practice and future research. Firstly, only 6 studies were included in this review after selection. This small number may be considered insufficient to provide a comprehensive representation of the scientific literature on this topic. This limitation can be partly attributed to the inclusion criterion regarding the publication date, which excluded studies prior to 2019.Moreover, the lack of precise data on the exact duration of PNE sessions in some studies (Saracoglu et al. 2022; Orhan et al. 2021; Rabiei et al. 2021; Song et al. 2023) may introduce classification errors and affect the obtained results.

Another significant limitation concerns the absence of data on the pain catastrophizing variable in three studies (Gül et al. 2021; Rabiei et al. 2021). This gap diminishes the robustness of the analysis of results related to this primary variable, highlighting the importance of including a sufficient number of studies for a more reliable interpretation. The authors also identified other limitations such as short-term follow-up and evaluation of interventions, rendering long-term effects unknown. Future trials, with larger samples, will be necessary to assess these long-term effects and provide robust conclusions.

Despite these limitations, this review presents several strengths that justify its interest. Firstly, it

addresses a common condition and studies a technique applicable in different care contexts, thus reinforcing its clinical importance. Secondly, PNE is part of a patient-centered bio-psycho-social care approach, in line with the current physiotherapy model and evidence-based approaches. Lastly, the fact that all articles included in this review were published after 2020 ensures that the review examined the most recent literature available on this topic, strengthening its relevance.

Conclusion

This study focuses on evaluating the impact of the total duration of PNE on kinesiophobia and pain catastrophizing in patients with chronic low back pain. The results of the systematic review, based on randomized controlled clinical trials, reveal no significant correlation between the total duration of PNE and improvement in key criteria, although a longer duration (exceeding 100 minutes) appears to be associated with increased reduction in kinesiophobia and pain catastrophizing related to chronic musculoskeletal pain (Salazar-Méndez et al. 2023). This finding opens up interesting perspectives for future research. Furthermore, it is important to note that PNE does not seem to result in any undesirable side effects in patients and that its combination with exercise therapies leads to more significant improvements compared to exercise alone in the treatment of chronic low back pain.

However, it should be noted that clinical trials have methodological biases, including lack of blinding and lack of standardization of therapist discourse. These limitations emphasize the need for future studies that are better controlled and more rigorous to confirm the conclusions of this review and establish more precise recommendations for clinical practice.

Author Contributions

Conceptualization, A.I., I.Z and H.E.; methodology, A.I., I.Z. and H.E.; investigation, A.I.; data curation, A.I.; writing - original draft preparation, A.I. and S.K.; writing - review and editing, A.I. and S.K.; supervision, S.K. All authors have read and agreed to the published version of the manuscript.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. This research received no external funding.

Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

Not applicable.

Conflicts of Interest

The authors declare no conflict of interest.

REFERENCES

Abenhaim, L., Rossignol, M., Valat, J., Nordin, M., Avouac, B., Blotman, F., Charlot, J., Dreiser, R. L., Legrand, E., Rozenberg, S., & Vautravers, P. (2000). The role of activity in the therapeutic management of back pain: Report of the international paris task force on back pain. *Spine*, *25*(Supplement), 1S-33S. [PubMed]

Aldington, D., & Eccleston, C. (2019). Evidence-based pain management: Building on the foundations of cochrane systematic reviews. *American Journal of Public Health*, *109*(1), 46-49. [PubMed]

Altman, D. G. (1990). Practical Statistics for Medical Research (1st ed.). Chapman and Hall.

Arguisuelas, M. D., Lisón, J. F., Sánchez-Zuriaga, D., Martínez-Hurtado, I., & Doménech-Fernández, J. (2017). Effects of myofascial release in nonspecific chronic low back pain: A randomized clinical trial. *Spine*, *42*(9), 627-634. [PubMed]

Booth, A., Clarke, M., Dooley, G., Ghersi, D., Moher, D., Petticrew, M., & Stewart, L. (2012). The nuts and bolts of PROSPERO: An international prospective register of systematic reviews. *Systematic Reviews*, *1*(1), 2. [PubMed]

Cho, S., Kim, H.-Y., & Lee, J.-H. (2013). Validation of the Korean version of the Pain Catastrophizing Scale in patients with chronic non-cancer pain. *Quality of Life Research*, *22*(7), 1767-1772. [PubMed]

Chung, E. J., Hur, Y.-G., & Lee, B.-H. (2013). A study of the relationship among fear-avoidance beliefs, pain and disability index in patients with low back pain. *Journal of Exercise Rehabilitation*, *9*(6), 532-535. [PubMed]

Clarke, C. L., Ryan, C. G., & Martin, D. J. (2011). Pain neurophysiology education for the management of individuals with chronic low back pain: A systematic review and meta-analysis. *Manual Therapy*, *16*(6), 544-549. [PubMed]

De Morton, N. A. (2009). The PEDro scale is a valid measure of the methodological quality of clinical trials: A demographic study. *Australian Journal of Physiotherapy*, *55*(2), 129-133. [PubMed]

Fletcher, C., Bradnam, L., & Barr, C. (2016). The relationship between knowledge of pain neurophysiology and fear avoidance in people with chronic pain: A point in time, observational study. *Physiotherapy Theory and Practice*, *32*(4), 271-276. [PubMed]

Gouvernement du Canada. (2019, June). Rapport du Groupe de travail canadien sur la douleur (GTCD). [CrossRef]

Gül, H., Erel, S., & Füsun Toraman, N. (2021). Physiotherapy combined with therapeutic neuroscience education versus physiotherapy alone for patients with chronic

low back pain: A pilot, randomized-controlled trial. *Turkish Journal of Physical Medicine and Rehabilitation*, *67*(3), 283-290. [PubMed]

Haute Autorité de Santé (HAS). (2019). Prise en charge du patient présentant une lombalgie commune. [CrossRef]

Kong, J., Jensen, K., Loiotile, R., Cheetham, A., Wey, H.-Y., Tan, Y., Rosen, B., Smoller, J. W., Kaptchuk, T. J., & Gollub, R. L. (2013). Functional connectivity of the frontoparietal network predicts cognitive modulation of pain. *Pain*, *154*(3), 459-467. [PubMed]

Louw, A., Diener, I., Butler, D. S., & Puentedura, E. J. (2011). The effect of neuroscience education on pain, disability, anxiety, and stress in chronic musculoskeletal pain. *Archives of Physical Medicine and Rehabilitation*, *92*(12), 2041-2056. [PubMed]

Louw, A., Puentedura, E. J., Zimney, K., & Schmidt, S. (2016). Know pain, know gain? A perspective on pain neuroscience education in physical therapy. *Journal of Orthopaedic & Sports Physical Therapy*, *46*(3), 131-134. [PubMed]

Louw, A., Zimney, K., Puentedura, E. J., & Diener, I. (2016). The efficacy of pain neuroscience education on musculoskeletal pain: A systematic review of the literature. *Physiotherapy Theory and Practice*, *32*(5), 332-355. [PubMed]

Maher, C. G., Sherrington, C., Herbert, R. D., Moseley, A. M., & Elkins, M. (2003). Reliability of the pedro scale for rating quality of randomized controlled trials. *Physical Therapy*, *83*(8), 713-721. [PubMed]

Maselli, F., Storari, L., Barbari, V., Colombi, A., Turolla, A., Gianola, S., Rossettini, G., & Testa, M. (2020). Prevalence and incidence of low back pain among runners: A systematic review. *BMC Musculoskeletal Disorders*, *21*(1), 343. [PubMed]

Meeus, M., Nijs, J., Van Oosterwijck, J., Van Alsenoy, V., & Truijen, S. (2010). Pain physiology education improves pain beliefs in patients with chronic fatigue syndrome compared with pacing and self-management education: A double-blind randomized controlled trial. *Archives of Physical Medicine and Rehabilitation*, *91*(8), 1153-1159. [PubMed]

Mills, K. M., Preston, E. B., Choffin Schmitt, B. M., Brochu, H. K., Schafer, E. A., Robinette, P. E., Sterling, E. K., & Coronado, R. A. (2021). Embedding pain neuroscience education in the physical therapy management of patients with chronic plantar fasciitis: A prospective case series. *Journal of Manual & Manipulative Therapy*, *29*(3), 158-167. [PubMed]

Mittinty, M. M., Vanlint, S., Stocks, N., Mittinty, M. N., & Moseley, G. L. (2018). Exploring effect of pain education on chronic pain patients' expectation of recovery and pain intensity. *Scandinavian Journal of Pain*, *18*(2), 211-219. [PubMed]

Monticone, M., Ambrosini, E., Rocca, B., Foti, C., & Ferrante, S. (2016). Responsiveness of the Tampa Scale of Kinesiophobia in Italian subjects with chronic low back pain undergoing motor and cognitive rehabilitation. *European Spine Journal*, *25*(9), 2882-2888. [PubMed]

Moseley, G. L. (2003). Joining forces – combining cognition-targeted motor control training with group or individual pain physiology education: A successful treatment for chronic low back pain. *Journal of Manual & Manipulative Therapy*, *11*(2), 88-94. [CrossRef]

Moseley, G. L., & Butler, D. S. (2015). Fifteen years of explaining pain: The past, present, and future. *The Journal of Pain*, *16*(9), 807-813. [PubMed]

Nijs, J., Paul Van Wilgen, C., Van Oosterwijck, J., Van Ittersum, M., & Meeus, M. (2011). How to explain central sensitization to patients with 'unexplained' chronic musculoskeletal pain: Practice guidelines. *Manual Therapy*, *16*(5), 413-418. [PubMed]

Orhan, C., Lenoir, D., Favoreel, A., Van Looveren, E., Yildiz Kabak, V., Mukhtar, N. B., Cagnie, B., & Meeus, M. (2021). Culture-sensitive and standard pain neuroscience education improves pain, disability, and pain cognitions in first-generation Turkish migrants with chronic low back pain: A pilot randomized controlled trial. *Physiotherapy Theory and Practice*, *37*(5), 633-645. [CrossRef]

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, n71. [PubMed]

Rabiei, P., Sheikhi, B., & Letafatkar, A. (2021). Comparing pain neuroscience education followed by motor control exercises with group-based exercises for chronic low back pain: A randomized controlled trial. *Pain Practice*, *21*(3), 333-342. [PubMed]

Romm, M. J., Ahn, S., Fiebert, I., & Cahalin, L. P. (2021). A meta-analysis of therapeutic pain neuroscience education, using dosage and treatment format as moderator variables. *Pain Practice*, *21*(3), 366-380. [PubMed]

Salazar-Méndez, J., Núñez-Cortés, R., Suso-Martí, L., Ribeiro, I. L., Garrido-Castillo, M., Gacitúa, J., Mendez-Rebolledo, G., Cruz-Montecinos, C., López-Bueno, R., & Calatayud, J. (2023). Dosage matters: Uncovering the optimal duration of pain neuroscience education to improve psychosocial variables in chronic musculoskeletal pain. A systematic review and meta-analysis with moderator analysis. *Neuroscience & Biobehavioral Reviews*, *153*, 105328. [PubMed]

Saracoglu, I., Arik, M. I., Afsar, E., & Gokpinar, H. H. (2022). The effectiveness of pain neuroscience education combined with manual therapy and home exercise for chronic low back pain: A single-blind randomized controlled trial. *Physiotherapy Theory and Practice*, *38*(7), 868-878. [PubMed]

Siddall, B., Ram, A., Jones, M. D., Booth, J., Perriman, D., & Summers, S. J. (2022). Short-term impact of combining pain neuroscience education with exercise for chronic musculoskeletal pain: A systematic review and meta-analysis. *Pain*, *163*(1), e20-e30. [PubMed]

Song, J., Kim, H., Jung, J., & Lee, S. (2023). Soft-tissue mobilization and pain neuroscience education for chronic nonspecific low back pain with central sensitization: A prospective randomized single-blind controlled trial. *Biomedicines*, *11*(5), 1249. [PubMed]

Suzuki, H., Aono, S., Inoue, S., Imajo, Y., Nishida, N., Funaba, M., Harada, H., Mori, A., Matsumoto, M., Higuchi, F., Nakagawa, S., Tahara, S., Ikeda, S., Izumi, H., Taguchi, T., Ushida, T., & Sakai, T. (2020). Clinically significant changes in pain along the Pain Intensity Numerical Rating Scale in patients with chronic low back pain. *PLOS ONE*, *15*(3), e0229228. [**PubMed**]

Tegner, H., Frederiksen, P., Esbensen, B. A., & Juhl, C. (2018). Neurophysiological pain education for patients with chronic low back pain: A systematic review and meta-analysis. *The Clinical Journal of Pain*, *34*(8), 778-786. [**PubMed**]

Tu, Y., Zhang, B., Cao, J., Wilson, G., Zhang, Z., & Kong, J. (2019). Identifying inter-individual differences in pain threshold using brain connectome: A test-retest reproducible study. *NeuroImage*, *202*, 116049. [**PubMed**]

Watson, J. A., Ryan, C. G., Cooper, L., Ellington, D., Whittle, R., Lavender, M., Dixon, J., Atkinson, G., Cooper, K., & Martin, D. J. (2019). Pain neuroscience education for adults with chronic musculoskeletal pain: A mixed-methods systematic review and meta-analysis. *The Journal of Pain*, *20*(10), 1140.e1-1140.e22. [**PubMed**]

Woby, S. R., Roach, N. K., Urmston, M., & Watson, P. J. (2005). Psychometric properties of the tsk-11: A shortened version of the tampa scale for kinesiophobia. *Pain*, *117*(1), 137-144. [**PubMed**]

Yamada, A. S. (2023). Physiotherapeutic treatment associated with neuroscience of pain education for patients with chronic non-specific low back pain-Single-blind randomized pilot clinical trial. *Ağrı - The Journal of The Turkish Society of Algology*. [**PubMed**]

Addition

Appendix 1

DATABASES	SEARCH STRING	RESULTS
PubMed	((((((((((((((((((((chronic lower back pain[MeSH Terms]) OR (chronic lower back pain[Title/Abstract])) OR (chronic back pain[MeSH Terms])) OR (chronic back pain[Title/Abstract])) OR (Low Back Pain[MeSH Terms])) OR (Low Back Pain[Title/Abstract]))) OR (chronic non-specific low back pain[MeSH Terms])) OR (chronic non-specific low back pain[Title/Abstract])) AND (pain neuroscience education[Title/Abstract])) OR (pain neuroscience education[MeSH Terms])) OR (pain neurophysiology education[MeSH Terms])) OR (pain neurophysiology education[Title/Abstract])) OR (neuroscience education[Title/Abstract])) OR (neuroscience education[MeSH Terms])) OR (neurophysiological pain education[MeSH Terms])) OR (neurophysiological pain education[Title/Abstract])) OR (neurobiology education[Title/Abstract])) OR (neurobiology education[MeSH Terms])) OR (therapeutic neuroscience education[MeSH Terms])) OR (therapeutic neuroscience education[Title/Abstract])) AND (pain OR sore OR disability OR invalidity OR handicap OR kinesiophobia OR catastrophizing)	**TOTAL = 41**
Web of Science	((((((((((TI="chronic lower back pain" OR AB="chronic lower back pain")) OR ((TI="chronic back pain" OR AB="chronic back pain"))) OR ((TI="chronic low back pain" OR AB="chronic low back pain"))) OR (ALL="Low Back Pain")) OR (ALL="chronic low back pain"))) OR (ALL="low back pain")) AND (ALL="chronic pain")) OR (ALL="Low Back Ache")) AND (ALL="chronic pain")AND ((((((((TI="pain neuroscience education" OR AB="pain neuroscience education"))) OR ((TI="pain neurophysiology education" OR AB="pain neurophysiology education"))) OR ((TI="neuroscience education" OR AB="neuroscience education"))) OR ((TI="neurophysiological pain education" OR AB="neurophysiological pain education"))) OR ((TI="neurobiology education" OR AB="neurobiology education"))) OR ((TI="therapeutic neuroscience education" OR AB="therapeutic neuroscience education"))) OR ((TI=PNE OR AB=PNE)) AND ((((((((((((ALL="clinical trials") OR ((TI="clinical trials" OR AB="clinical trials"))) OR ((TI="clinical trials as a topic" OR AB="clinical trials as a topic"))) OR (ALL="clinical trials as a topic")) OR (ALL="randomized controlled trial")) OR ((TI="randomized controlled trial" OR AB="randomized controlled trial"))) OR ((TI="Randomized Controlled Trials as Topic" OR AB="Randomized Controlled Trials as Topic"))) OR (ALL="Randomized Controlled Trials as Topic")) OR (ALL="controlled clinical trial")) OR (ALL="controlled clinical trial")) OR (ALL="Double-Blind Method")) OR ((TI="Double-Blind Method" OR AB="Double-Blind Method"))) OR ((TI="Single-Blind Method" OR AB="Single-Blind Method"))) OR (ALL="Single-Blind Method")	**TOTAL = 98**
Scopus	(((((((((((((((((((INDEXTERMS ("chronic lower back pain")) OR (TITLE-ABS ("chronic lower back pain"))) OR (INDEXTERMS ("chronic back pain"))) OR (TITLE-ABS ("chronic back pain"))) OR (INDEXTERMS ("Low Back Pain"))) OR (TITLE-ABS ("Low Back Pain")))) OR (INDEXTERMS ("chronic non-specific low back pain"))) OR (TITLE-ABS ("chronic non-specific low back pain"))) AND (TITLE-ABS ("pain neuroscience education"))) OR (INDEXTERMS ("pain neuroscience education"))) OR (INDEXTERMS ("pain neurophysiology education"))) OR (TITLE-ABS ("pain neurophysiology education"))) OR (TITLE-ABS ("neuroscience education"))) OR (INDEXTERMS ("neuroscience education"))) OR (INDEXTERMS ("neurophysiological pain education"))) OR (TITLE-ABS ("neurophysiological pain education"))) OR (TITLE-ABS ("neurobiology education"))) OR (INDEXTERMS ("neurobiology education"))) OR (INDEXTERMS ("therapeutic neuroscience education"))) OR (TITLE-ABS ("therapeutic neuroscience education"))) AND (pain OR sore OR disability OR invalidity OR handicap OR kinesiophobia OR catastrophizing) AND (INDEXTERMS ("clinical trials" OR "clinical trials as a topic" OR "randomized controlled trial" OR "Randomized Controlled Trials as Topic" OR "controlled clinical trial" OR "Controlled Clinical Trials" OR "random allocation" OR "Double-Blind Method" OR "Single-Blind Method" OR "Cross-Over Studies" OR placebos OR "multicenter study" OR "double blind procedure" OR "single blind procedure" OR "crossover procedure" OR "clinical trial" OR "controlled study" OR randomization OR placebo)) OR (TITLE-ABS-KEY (("clinical trials" OR "clinical trials as a topic" OR "randomized controlled trial" OR "Randomized Controlled Trials as Topic" OR "controlled clinical trial" OR "Controlled Clinical Trials as Topic" OR "random allocation" OR "randomly allocated" OR "allocated randomly" OR "Double-Blind Method" OR "Single-Blind Method" OR "Cross-Over Studies" OR placebos OR "cross-over trial" OR "single blind" OR "double blind" OR "factorial design" OR "factorial trial"))) OR (TITLE-ABS ("clinical trial*" OR trial* OR rct* OR	**TOTAL = 88**

	random* OR blind*)) AND PUBYEAR > 2018 AND PUBYEAR < 2024 AND (LIMIT-TO (LANGUAGE , "English") OR LIMIT-TO (LANGUAGE , "French")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (EXACTKEYWORD , "Controlled Study"))	
PEDro	**First search :** • **Abstract & Title: neuroscience** • **Therapy: education** • **Problem: pain** • **Topic: chronic pain.** • **Method: clinical trial** **Second search :** • **Abstract & Title : neurophysiology** • **Therapy: education** • **Problem: pain** • **Topic: chronic pain.** • **Method: clinical trial**	**First search = 38** **Second search = 13** **TOTAL = 51**