Patient oriented neuroscience education:

Clinical applications concerning pain perception and rehabilitation outcomes

A narrative review

Alexandros Sideris, BSc Physiotherapy

Athens, Greece

Molecular and Applied Physiology MSc Program

Experimental Physiology Laboratory, Medical School

National Kapodistrian University of Athens

Supervisor:

Damianos Sakas

Professor

Abstract

Introduction: Chronic pain is one of the most prevalent problems of our time with severe health and economic consequences. One emerging treatment option focusing directly on pain perception is pain neuroscience education (PNE). This narrative review investigates the effect of PNE in pain and function for patients with chronic pain. **Methods:** Pubmed and PEDro were used to scan for articles on the effects of PNE on pain and function for chronic pain patients. **Results:** The search yielded eighteen articles. Six studies concluded that PNE reduced pain in subjects, while the rest found no significant results. On function, only three studies concluded that PNE was ineffective, while the rest agreed that PNE increased function and decreased disability. **Discussion:** The results of this review are in line with current evidence that PNE as a stand-alone practice has no effect on pain, but seems to decrease disability and increase function. It is important to note that PNE is not meant to be used alone but rather as part of a well-rounded tailor-made intervention treatment program. Research should focus on developing a clear protocol of such a treatment and testing its results on pain and function in the long term. **Conclusion:** PNE as stand-alone intervention for patients with chronic pain is ineffective on pain while it seems to increase function. More research might shed light to the effect of PNE as part of a multimodal program, on pain and function in the long term.

Keywords: "pain neuroscience education", "PNE", "explain pain", "pain education", "cognitive functional therapy", "CFT" "chronic pain"

Περίληψη

Εισαγωγή: Ο χρόνιος πόνος είναι ένα από τα πιο ευρέως διαδεδομένα προβλήματα υγείας του καιρού μας, με σοβαρές επιπτώσεις στην υγεία και την οικονομία. Μια από τις αναδυόμενες προοπτικές παρέμβασης που αφορά κυρίως στον χρόνιο πόνο είναι η νευροεπιστημονική εκπαίδευση των ασθενών (PNE – Pain Neuroscience Education), στο να εκπαιδεύονται δηλαδή στην κατανόηση των μηχανισμών που οδηγούν στην σύνθεση του επώδυνου ερεθίσματος και της γενικότερης εμπειρίας του πόνου. Η παρούσα ανασκόπηση ερευνά τα αποτελέσματα της PNE στον πόνο και την λειτουργικότητα σε ασθενείς με χρόνιο πόνο. **Μεθοδολογία:** Οι βάσεις δεδομένων Pubmed και PEDro χρησιμοποιήθηκαν στην αναζήτηση πειραματικών ερευνών σχετικά με την επίδραση της νευροεπιστημονικής εκπαίδευσης (PNE), στον πόνο και την λειτουργικότητα ασθενών με μακροχρόνιο πόνο. **Αποτελέσματα:** Η έρευνα κατέληξε σε δεκαοχτώ άρθρα. Έξι από αυτά συμπέραναν πως η παρέμβαση ελάττωσε τον πόνο των ασθενών, ενώ οι υπόλοιπες δεν ανίχνευσαν καμία επίδραση. Σχετικά με την λειτουργικότητα, μόνο τρεις έρευνες κατέληξαν πως η παρέμβαση δεν είχε καμία επίδραση, ενώ όλες οι υπόλοιπες συμφώνησαν πως η παρέμβαση αύξησε την λειτουργικότητα και ελάττωσε την ανικανότητα. **Συζήτηση:** Τα αποτελέσματα αυτής της ανασκόπησης συμβαδίζουν με τα ως τώρα ερευνητικά δεδομένα. Η εν λόγω παρέμβαση σαν αποκλειστική πρακτική δεν επιδρά σημαντικά στον πόνο, αλλά δείχνει να ελαττώνει την ανικανότητα και να βελτιώνει την λειτουργικότητα. Είναι σημαντικό να σημειώσουμε πως η νευροεπιστημονική εκπαίδευση σχετικά με τον πόνο δεν δημιουργήθηκε για να χρησιμοποιείται

σαν αυτόνομη παρέμβαση αλλά σαν συμπληρωματικό εργαλείο, στα πλαίσια ενός πολύπλευρου προγράμματος αποκατάστασης προσαρμοσμένου στις ανάγκες του εκάστοτε ασθενή. Περαιτέρω έρευνα θα πρέπει να επικεντρώσει στη δημιουργία πρωτοκόλλων που θα δοκιμάζουν την εν λόγω παρέμβαση, αλλά ως προς τις μακροχρόνιές της επιδράσεις. **Συμπέρασμα:** Η παρέμβαση (PNE) σαν αυτόνομη πρακτική αποκατάστασης είναι μη αποτελεσματική στον χρόνιο πόνο ενώ φαίνεται πως καταφέρνει να βελτιώσει την λειτουργικότητα στους ίδιους ασθενείς. Περαιτέρω έρευνα πιθανώς θα μας αποκαλύψει πως λειτουργεί η παρέμβαση στα πλαίσια ενός ολοκληρωμένου προγράμματος αποκατάστασης, αλλά και τις μακροχρόνιες επιδράσεις της στον πόνο και την λειτουργικότητα.

Λέξεις-κλειδιά: "pain neuroscience education", "PNE", "explain pain", "pain education", "cognitive functional therapy", "CFT" "chronic pain"

Introduction

Definitions

Pain

Pain is part of the human experience. It is normal and expected to experience pain, in fact it is essential. Pain perception protects from imminent health hazards and ensures survival under a number of situations. Chronic pain though is a different beast, one that is not normal for one to live with (Louw et al. 2016B). The definition of chronic pain is that of pain persisting beyond the expected healing period, or alternatively, pain lasting for 3-6 months or longer (Merskey et al. 1996). Chronic pain makes people seek help, because of its grave consequences in daily life (Louw et al. 2016B). Thus, pain has troubled clinicians since the beginning of time, and numerous theories and approaches have emerged to combat it. Modern pain neuroscience introduced us to the idea that pain and tissue damage are not interchangeable terms. One can exist without the other, and the level of one does not reflect that of the other (Malfliet et al. 2017).

Non-neuropathic central sensitization

Modern neuroscience for the last few years has been demonstrating interesting evidence on chronic pain patients. Their central nervous systems seem to exist in an apparently irreversible state of hyperexcitability (Wijma et al. 2016). This state is named “non-neuropathic central sensitization pain” and its definition is “an amplification of neural signaling in the central nervous system that elicits pain hypersensitivity” (Woolf, Salter 2000). In other words, it is a generalized hypersensitivity of the somatosensory nervous system. The main result of this condition is pain, even when nociceptive stimuli is not present (Wijma et al. 2016). This particular complication is involved in conditions like chronic fatigue syndrome, migraine and fibromyalgia, but also

musculoskeletal and neurological problems like low back pain, pelvic pain, tennis elbow, subacromial impingement syndrome persisting traumatic neck pain, tension-type headache, nonspecific arm pain, osteoarthritis and chronic whiplash. It is also often presented in post-cancer pain and autoimmune conditions like rheumatoid arthritis and Irritable Bowel Syndrome (Malfliet et al. 2017, Wijma et al. 2016).

Non-neuropathic central sensitization causes neuroplastic changes in the peripheral nervous system as well as the central nervous system. The endogenous descending nociceptive modulatory systems appear malfunctioning and causing neurological pain. Different parts of the brain like the prefrontal cortex, the limbic system and the periaqueductal grey matter are also involved, while abnormalities in structure are reported in those areas in chronic pain patients (Malfliet et al. 2016). What is interesting is that these changes seem to be reversible, caused by chronic pain, not permanent damage. Cessation of pain through different methods, including physiotherapy, seems to reverse the aforementioned effects in recent studies (Mlafliet et al. 2016).

Patient oriented neuroscience education

Since traditional methods have failed time and again to deal with pain, chronic pain and the associated disability, a new intervention is needed for these types of patients (Louw et al. 2016B). The last few decades, there is one emerging treatment option focusing directly on pain, and that is the practice of patient education (Louw et al. 2016B). It includes an array of different educational approaches, and has conned a few different names in academia, stemming from the different applications that have been tried and tested (Moseley et al. 2015).

A very common name used for this type of intervention is ‘pain neuroscience education’ (PNE). It describes the intervention of specifically teaching patients about the neurobiology and neurophysiology of pain and discussing issues associated with anatomical structures. Other names

used for this concept are Explain Pain, pain biology education and therapeutic neuroscience education (Louw et al. 2016A, Watson et al. 2019).

The first use of the treatment is documented at the International Association for the Study of Pain conference Austria by Louis Gifford in 1999. Early call for further study brought on a big influx of research on the topic (Louw et al 2016B). Since then and with the help of evidence based science, PNE has been tried and applied by many clinicians in different fields (Louw et al. 2016A). The field of physiotherapy specifically has experienced a big shift in research towards this intervention. Because there is a lack of proper protocol for application, clinical practice hasn't been very consistent with PNE so far (Louw et al. 2016A). Several studies have reported positive outcomes in reducing pain, catastrophizing and disability.

Different applications of PNE include application in acute pain, abbreviated PNE, telehealth and PNE, aquatic therapy and PNE, dry needling and PNE, exercise and PNE and manual therapy and PNE (Louw et al. 2016A). One on one sessions, small group tutorials, large group seminars and presentations have also been tried, while booklets and story books have been used by different clinicians (Moseley et al. 2015).

The core of all those practices is one and the same, explaining to the patient the main biological concepts that take part in their condition and their pain, so that they can understand its cause. Through that understanding they can change their beliefs, attitudes, their behaviour and their lifestyle (Moseley et al. 2015). It is not the mere explanation of the problem that takes place, but the actual shift of old beliefs of the patient, challenging existing patterns and refining learning for them (Moseley et al. 2015). The focus is to make it clear to patients that any credible evidence of danger to the tissues can cause pain triggered by the brain to protect those tissues. The main goal of PNE is re-educating patients in order to change the concept they have created in their minds about their symptom and how it is produced (Puentedura et al. 2016). By addressing misconceptions

about what happens in the body, PNE shifts the idea that all symptoms are dependent on biology alone, and makes the point that pain has a lot to do with the meaning pinned to it by the patient. That is, how the brain signals to commence the pain phenomenon, and not mere pathology (Robins et al. 2016). Conceptual change and instructional design theory merge to increase knowledge, decrease catastrophizing and change patients' understanding of pain. This is the difference between PNE and previous interventions for pain based on CBT. Educational psychology lends its lenses to create a prism through which to look at pain, not a protocol to follow strictly. The main conceptual shift that occurs is that of changing the understanding of pain from a marker of tissue damage to that of sensitivity of the tissue (Moseley et al. 2015).

According to literature, PNE is highly personal to each patient, linked to their own experience of pain. Patient rapport is also very important and plays a big role in the effect PNE can have. Proper assessment is critical while pacing the intervention and helping the patient apply it at home are also important steps. Goal setting can help with compliance and improve self-efficacy (Louw et al. 2016A). The main learning goals for PNE according to the Explain Pain concept are: the relation between nociception and the emergence of pain, the vast importance of the context in which pain emerges, the fact that the duration of pain makes nociception greater and greater, the fact that several protective systems in the body act together at the same time, and ultimately the fact that our physiology and morphology can be trained, though slowly, and adapt to the new state to become normalized again (Moseley et al. 2015).

PNE is an application of the biopsychosocial model to pain (Moseley et al. 2015). It can be used alone, but used as part of a well-rounded tailor-made therapeutic program is best. All chronic pain patients can benefit from a shift in perception of the systems that produce pain, but for patients suffering from centralized pain it can be critical (Robins et al. 2016).

The biopsychosocial model

Several theoretical models have been used throughout the years to explain pain and chronic pain, more specifically, the oldest one being the biomedical model. It is the concept that assumes that tissue damage and pain sensation have a direct correlation (Robins et al. 2016). Any psychological or behavioural symptoms of the patient according to this model have nothing to do with the emergence of pain, but are mere byproducts of the patient's condition (Robins et al. 2016).

This image started changing by the late 20th century. Research started proving that motivational, affective and cognitive processes could affect or even initiate pain. This concept is known as the biopsychosocial model, and it has largely replaced the biomedical model in our days. It is closely related to cognitive behavioral theories like the “Common Sense Model of Self-Regulation”, a well-established model dividing conceptions about pain into five categories (identity, cause, time-line, consequences, controllability) (Robins et al. 2016). Another theory used to establish this model is that of John D.Loeser, describing the layers of the experience of pain. Just like an onion, nociception, pain, suffering and pain behaviour all cover each other to create the pain experience, keeping the actual phenomenon, pain, deeply private and hidden at the core of the onion. Those layers must be acknowledged before the patient can start to heal (Robins et al. 2016).

The biopsychosocial model is supported by recent data unveiling the global brain connectivity reorganization that takes place in chronic pain patients, suggesting that pain is a complex phenomenon with several cortical and subcortical regions of the brain taking part in it. If all this neural activity is not properly and timely regulated, the brain can continue to produce pain a long time after tissue damage has been repaired (Robins et al. 2016).

A third model closely related to the biopsychosocial model is the Fear-Avoidance Model, describing the cycle of fear, avoidance and pain that can lead to disability so often. In chronic pain settings, fear inducing during traditional therapy is a real threat (Louw et al 2016A). This cycle can be

broken through PNE to avoid the grave consequences of chronic pain and improve quality of life (Robins et al 2016).

Traditional physical therapy treatment

Physical therapy has been trying to tackle the problem of pain for decades. Starting from 1987, when the Quebec Task Force published the first low back pain clinical practice guideline (Puentedura et al. 2016), many protocols and guidelines have emerged. A lot has changed since then, but the fast-appearing evidence on neuroscience are yet to be properly implemented everywhere. Current intervention strategies for chronic pain and pain in general are based on the biomedical and cognitive behavioral model mainly, failing to follow on the new data on the biopsychosocial model and PNE. Interventions commonly used are neuromuscular training, myofascial treatment, graded exposure and graded activity, focusing either on treating muscles and joints or on motor control, failing to notice the central nociceptive processing mechanisms (Moseley et al. 2015).

Most physical therapists and manual therapists are educated in the biomedical model of pain, treating the underlying pathology in order to eliminate pain (Louw et al. 2016b). In the case of acute pain, this model makes sense and can result in reduction of the symptoms. But for chronic pain, this model doesn't seem appropriate anymore. Indeed often these models, applied in chronic pain patients can create or increase fear, avoidance and stress for the patient (Louw et al 2016b). They can not produce lasting improvements in symptoms, nor explain the more complex phenomena of chronic pain. Peripheral and central sensitization are not accounted for, nor the phenomena of facilitation and inhibition, the concept of neuroplasticity along with the immune and endocrine changes taking place (Louw et al. 2016b, Puentedura et al. 2016).

Current evidence suggests pain neuroscience education can fill that gap in therapy and help treat chronic pain. This doesn't mean that the proper treatment for chronic pain is a “hands-off” treatment. It is merely a suggestion to criticise current practice and implement new tools to the already existing toolbox of the physical or manual therapist (Puentedura et al. 2016).

Description of the problem

Pain is not the simple matter the biomedical model makes it out to be. The changes that occur during non neuropathic central sensitization are related to the changes in the pain neuromatrix. They are affecting the different pain processes through different factors, some behavioral, some emotion, cognitive and even social. Different situations such as catastrophizing, anxiety, neuroticism, depression, stress, low levels of self-efficacy, difficult life events, post traumatic stress disorder are affecting chronic pain patients. Those situations can arise from the feeling of pain, or they can exist prior to the pain and give rise to it (Wijma et al 2016). The prevalence of chronic pain in our society creates the great need for interventions that treat pain in a well rounded manner, using the biopsychosocial model to improve patients quality of life.

Prior literature

The efficacy of PNE has been proven by large systematic reviews in pathologies like chronic low back pain, lumbar radiculopathy, fibromyalgia, chronic fatigue syndrome, whiplash, generic chronic pain. The intervention has been shown to increase physical performance, decrease perceived pain, decrease catastrophizing, albeit not always at the same level and not in the long term (Louw et al. 2016). This discrepancy between the results of different studies can be due to the diversity of the delivery methods of the reviews, the level of competency of the therapists applying PNE, the size of the studies and the fact that blinding the therapist for PNE is almost impossible (Louw et al. 2016, Moseley et al. 2015).

Lately evidence has been looking critically at PNE, suggesting it is not viable as an intervention and is not expected to give long lasting improvements in pain and disability. The important take on this view is that, this was never the intention of PNE. The suggestion was that the biology of pain is asking for management based on the biopsychosocial model, requiring many different tools to be used in conjunction with traditional physiotherapy, in a multimodal approach. A large issue seems to be the understanding of how PNE is clinically intended to be applied. In literature we see again and again highlighted the fact that PNE is supposed to be applied in a multimodal approach, not as a stand-alone therapy. Testing it alone will definitely alter the results (Moseley et al. 2015).

Literature on the subject has been increasing in volume over time. The results look promising, with recent evidence in heterogeneous chronic musculoskeletal pain reporting improvements in pain and function, while the results on psychosocial factors differ between patient populations. These results come from studies that use PNE as a tool and not as stand alone therapy, that can alter results as we discussed earlier. Narrative reviews on the subject have also demonstrated strong evidence for PNE in pain and disability, again highlighting that PNE alone is not viable (Watson et al 2019, Louw et al 2016).

While PNE alone is not effective in the long term, PNE combined with movement therapies has strong growing evidence in the management of chronic pain, even more than the combination of PNE with more passive therapies. A large narrative review made the case for a balanced approach between those tools in pain management (Louw et al. 2016, Puentedura et al. 2016). Overall, evidence of PNE in the adult patient population is modest when it comes to long term results. Combining PNE with therapy and exercise has been showing consistently significant reductions in pain and disability in different pain populations. These results show that PNE, applied in a multidisciplinary cognitive behavioral pain management program can help pain patients in the long

term as well. It has also been proven that PNE helps both the patient and the therapist with their understanding of pain (Louw et al. 2016, Robins et al. 2016).

Lastly, cognitive behavioural therapy, PNE and graded exposure, in a multimodal program, seem to be the most effective therapies to date for pain and disability in patient populations dealing with pain (Barbari et al. 2019, Puentedura et al. 2016).

Clinical relevance

Pain in general and chronic pain specifically is presenting as one of the most important health problems worldwide. It is a healthcare issue with a prevalence of 17-27% globally (Wijma et al. 2016). In the US alone it is more prevalent than major health conditions such as diabetes, heart disease and cancer. It is associated with huge increases in medical costs, along with a decreasing income while it lowers the patients quality of life substantially (Wijma et al. 2016). Lasting disability, absenteeism and excessive health care utilization are very common results of the condition (Puentedura et al. 2016).

It is interesting that 20% of adults worldwide are affected by chronic musculoskeletal pain and the societal financial burden it involves. Chronic low back pain specifically is the most common of all chronic pain disorders globally, the most costly and the most difficult to treat (Nijs et al. 2017). Its prevalence in 2010 was estimated at 9.4%, with Western Europe presenting the highest prevalence rate at 15%. It is also seen to be increasing in the US up to 10.2% (Nijs et al. 2017). Chronic low back pain can double the annual health care costs, while in the UK the estimated cost for this condition is at >2.1 billion pounds, and the total costs even higher (Watson et al. 2019). In the US the same costs rise up to 365-560 billion per year (Puentedura et al. 2016). Conservative and pharmacological treatment for the condition needs improvement, as it is mainly shown to slightly reduce pain and disability (Nijs et al. 2017)

Given the great prevalence of chronic pain and untreated chronic pain, and the promise PNE shows in literature, the clinical relevance of this narrative review is high. So far, PNE implementation has been limited to the field of manual musculoskeletal therapy. There is evidence that it can be applied to different populations suffering from pain like post-cancer, paediatric and sports-related patients. It's not just how promising PNE seems for treating the underlying mechanisms in chronic pain, but also the fact that the presence of central sensitization in a patient predicts poor therapy outcome. That means that even if the case of a patient seems simple enough, the onset of central sensitization can increase the difficulty and lead to chronic pain (Malfliet et al. 2017).

An interesting suggestion that makes PNE clinically relevant is treating pain like an autonomous, stand-alone problem, not a byproduct of the patients pathoanatomy, so that we can effectively treat it. Instead of a diagnosis-based classification, we could use a mechanism-based classification of pain types, that can help us triage the patients and avoid or halt the development of chronic pain (Malfliet et al. 2017).

Purpose of the study

The purpose of this narrative review is to investigate whether PNE is an effective addition in a traditional physiotherapy program, for decreasing pain and increasing function for patients with chronic pain. The paper will be submitted as a thesis for the masters program “Molecular and Applied Physiology” for the physiology department of the Medical School of Athens.

Research question.

What is the effect of patient oriented neuroscience education in pain and function outcomes for patients with chronic pain, compared to traditional treatment or no treatment at all.

Sub-questions.

Is patient education effective in reducing symptoms in chronic pain patients?

Methods

Research design

This research attempts to cover all standards of a narrative review. It is submitted as a thesis for the masters program “Molecular and Applied Physiology” for the physiology department of the Medical School of Athens.

Search engines and databases

For this narrative review, the search engines and databases used were Pubmed and PEDro. Between the many different available databases, these were elected for a number of different reasons. Pubmed is the most comprehensive and relevant database for life sciences at the moment. PEDro, as a database oriented towards physiotherapy research, is very relevant to the topic of this review. Since this paper is a narrative review, and the writer is an active physiotherapist, the subject is approached from this particular academic point of view. This makes PEDro the best choice for a database, that provided the writer with material to most effectively present the subject.

Keywords

The keywords used for the current review can be found in **Table 1**. Those are “pain neuroscience education”, “PNE”, “explain pain”, “pain education”, “cognitive functional therapy”, “CFT” and “chronic pain”.

Table 1: Different keywords for the present literature review.

	Keyword	Pubmed results	PEDro results
#1	Pain neuroscience education	988	20
#2	PNE	606	16
#3	explain pain	6414	58
#4	Pain education	38096	2701
#5	cognitive functional therapy	18985	-
#6	CFT	2350	5
#7	Chronic pain	115695	5724

Research strategy

After establishing the keyword searches, combined searches were performed in order to reach articles with all relevant keywords (See **Table 2**).

Table 2: Keyword combination for the present literature review.

Keyword combination	Pubmed	PEDro
Pain neuroscience education OR PNE OR explain pain OR Pain education CFT OR cognitive functional therapy AND chronic pain	2422	2

Next step was screening the search results for potential relevant articles. Screening included reading the title, keywords and abstract, if available, of every search result, and deciding whether it was relevant based on specified inclusion/exclusion criteria (See **Table.3**).

Table 3: Inclusion/Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
RCT	pregnancy, injury, trauma, recent surgery
Patients with chronic pain	medication that can alter the sense of pain and cognition
Pain education intervention	other known pathology that plays a role in pain perception
English or greek language	
Published after 2010	

Study selection

For inclusion, studies had to follow certain criteria. Those criteria were kept reasonably wide, to make sure all information on the matter were included, to assist with the goal of this review of gathering and evaluating all relevant data on the research question. All variations in criteria (time frame, type of interventions, etc) are clearly described and reported, in order for a valuable comparison to be made in the discussion of this review.

Participants

The studies, in order to be selected, needed to address the subject of pain education. Participants of the studies had to suffer from chronic pain, that is pain experience for 3-6 consecutive months or more as defined in the introduction of the review.

Interventions

For a study to be eligible, it had to test a pain education intervention according to the definition described in the introduction of this study. As mentioned before, examples of interventions include pain neuroscience education, explain pain, reading material, seminars or sessions that educate the patient on their condition, pain theory and the available tools to resolve their condition. The interventions had to be tested against any control intervention such as no intervention or classic physical therapy.

Outcome measures

For a study to be included, it was important to investigate and yield results on pain and/or function. Those could be included in the study as primary or secondary measures.

Time frame

The time frame of the intervention applied was wide. The choice was made to include all studies regardless of how long the intervention was applied, or when the follow up took place, in order to collect as much evidence as possible. This choice was made to accommodate the overall aim of the review, of presenting all available evidence so far on papin education interventions.

Inclusion - Exclusion criteria

Inclusion criteria included type of study (RCT), patients dealing with chronic pain, intervention relating to pain education, articles published after 2010 and english or greek language used. Exclusion criteria include pregnancy, injury, trauma, recent surgery or other known pathology. Also studies were excluded that are looking into patients using medication that can alter their sense of pain and cognition.

Extraction of data

After study selection, the characteristics of the studies were extracted for each one individually. All data were combined into one table (**Table.**6). Data collected were citation, type of study, number of participants, characteristics of the participants, intervention description, comparison description, frequency of the interventions, all outcomes reported in the study, relevant outcome results (pain, function) and authors conclusions.

Results

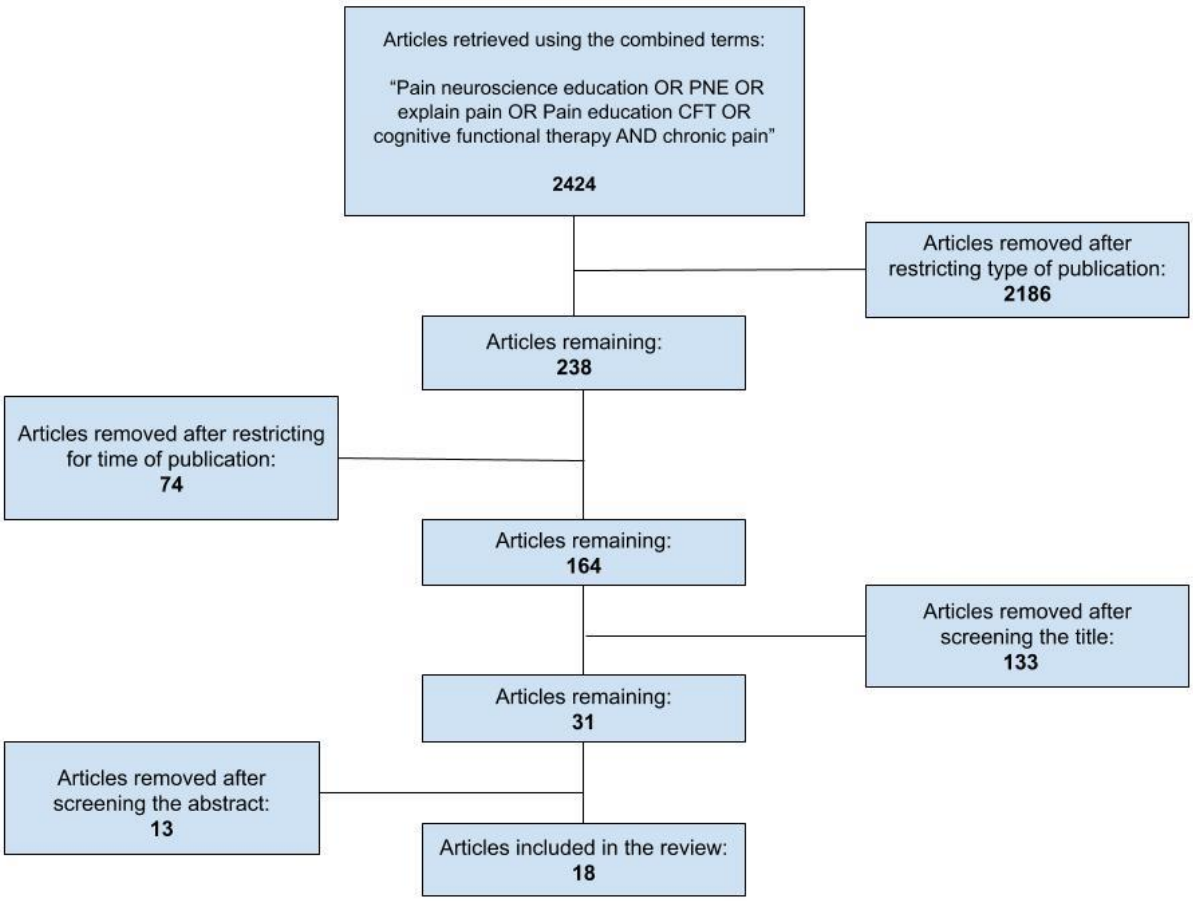
Search results

The PubMed and PEDro search for the keywords yielded numerous results. See **Table 1**. The combined search of the keywords presented yielded 2424 articles. After restricting for type of publication (RCT) and time of publication (after 2010) the remaining articles were 164. They were all screened by title for eligibility by means of the inclusion/exclusion criteria. Of the 164 articles 133 were rejected by screening the title and abstract. 31 of them were subjected to further screening. After that 18 relevant articles were retrieved. See **Flowchart 1.**

Description of included studies.

A summary of the characteristics of the included studies, along with the primary results, is available in **Table 6**.

Overall, the search yielded 18 RCTs, one of which was a preliminary study (Brage et al. 2015) and another a pilot RCT (Walti et al. 2015). The study participants ranged from 28 to 353, but the mean size was 128. Participants all dealt with chronic pain in one way or another. Most studies included patients sick-listed for musculoskeletal pain (Andersen et al. 2015, Andias et al. 2015, Bennell et al. 2017, Brage et al. 2015, Bramberg et al.2017, Bodes-Pardo et al.2017, Chaleat-Valayer et al. 2016, Garaud et al. 2018, Heapy et al. 2017, Jay et al. 2016, Malfliet et al. 2018, Ris et al.2016, Saper et al. 2017, Walti et al. 2015). One study included women with fibromyalgia (Bagdatli et al. 2015). Two studies included hip/knee osteoarthritis patients (Kloek et al. 2018, Saw et al. 2016).



Flowchart 1. Research sequence

Frequency of treatment was similar in all studies. It ranged from daily to weekly sessions for all treatments but the duration varied from 2-12 weeks. The interventions applied greatly varied. Most studies compared some form of PNE with another intervention or a control group. Most studies focus on several endpoints. Relevant outcomes for this narrative review revolved around pain and function. In **table 7**. the reader can find the tools used from the included studies to measure pain and/or function. Most tools were used by more than one study.

A list of the interventions applied follows:

- E-exercise
- PNE
- Pain education
- Yoga
- Physiotherapy
- Multimodal treatment
- Physical-cognitive mindfulness training
- Cognitive behavioural therapy
- Therapeutic education
- Manual therapy
- Balneotherapy
- Chronic pain self management program

A list of the control group treatment follows:

- Single session of physiotherapy
- TENS
- No treatment
- Usual treatment
- PNE alone
- Manual therapy alone
- E-educational material
- Educational material

Table 7. Measured outcomes and tools.

Outcome in pain	No of studies using the tool	Outcome in function	No of studies using the tool
pain (VAS)	4	FAB Questionnaire	1
pain catastrophizing (PCS)	2	Visual Analog Fatigue Scale	3
neurophysiology of pain questionnaire	1	kinesiophobia by Tampa scale	4
Pain (NPRS)	3	Beck Depression Index (BDI)	1
pain medication use	1	Neck Disability Index	2
back and neck pain and disability	1	Fear Avoidance Beliefs Questionnaire	1
Dallas Pain Questionnaire (functional status)	1	physical function (Western Ontario and McMaster Universities Osteoarthritis Index)	1
Average pain intensity 11-point NRS (0,no pain; 10,worst pain imaginable)	3	self reported health (SF36)	3
Pain Disability Index	1	sickness absenteeism	1
pain (Brief Pain Inventory)	1	sickness presenteeism	1
		percentage of participants with >=1 recurrence of LBP with sick leave	1
		EIFEL score (quality of life)	2

In t**able 8.** the results of the studies are available to the reader, grouped per outcome. One study from 2015 compared a tailored-to-the-patient physical activity group combined with health guidance, aerobic exercise and fitness training, and a group that followed a chronic pain self-management program including education and mutual support, to a control group that was offered a single dialogue session with a health supervisor (Andersen et al. 2015). The taylored physical activity group showed an increase in return to work outcome compared to control, that didn't appear for the chronic pain self-management program group. Both interventions showed shorter return to work time compared to the control. Overall the physical activity group was deemed superior to the multimodal program.

Five studies compared PNE and exercise as a multimodal treatment to usual treatment (Andias et al. 2018, Chaleat-Valayer et al. 2016, Kloek et al. 2018, Saw et al. 2016, Walti et al. 2015). Physiotherapy along with PNE was compared to TENS (Garaud et al. 2018) in the same mindset. Pain was decreased by the intervention for ⅘ studies (Andias et al. 2018, Kloek et al. 2018, Saw et al. 2016, Walti et al. 2015), while one didn't measure for it (Chaleat-Valayer et al. 2016). Function improved only for the intervention group in one study (Chaleat-Valayer et al. 2016) and two studies didn't measure for it (Saw et al. 2016, Andias et al. 2018). One study found no improvement (Kloek et al. 2018) and Walti et al. 2015 found similar improvements in both groups.

Three studies compared exercise and PNE to PNE alone (Bodes-Pardo et al. 2017, Brage et al. 2015, Ris et al. 2016). All studies found large reduction in pain intensity, while two of them found a significant improvement in function (Brage et al. 2015, Ris et al. 2016). Similarly, one study compared physiotherapy combined with an educational e-module as PNE to the e-module alone (Bennell et al. 2017) and found significant improvements in both change and function in the intervention group.

A study compared balneotherapy and PNE to balneotherapy alone (Bagdatli et al. 2015), and found significant changes in many outcomes in both groups, while the balneotherapy group was superior for pain and function. Another study compared manual therapy and PNE to manual therapy alone and found the intervention group to have decreased pain and increased function (Beltran-Alacreu et al. 2015).

A study compared either yoga or strength training to a form of PNE consisting of an educational book on back pain (Bramberg et al. 2017), and found yoga to be superior for function, while another compared yoga or physiotherapy to PNE (Saper et al. 2017) and found yoga and physiotherapy to

have similar effects on pain and function, while yoga compared to PNE for both outcomes was not superior.

One study compared three sessions of PNE to a biomedically focussed back/neck school education (Malfliet et al. 2018). It found no effect in any group for pain, while the PNE group had a significant effect in function.

Lastly, in-person CBT was compared to CBT from distance (Heapy et al. 2017) and both groups evolved similarly for pain while function was not measured. Similarly, a study compared physical-cognitive mindfulness training interventions to no treatment (Jay et al. 2016). They only measured for function outcomes and found work related fear avoidance beliefs to be improved slightly in the intervention group.

Table 8. *Relevant results of each study in pain and function.*

STUDY	RESULTS IN PAIN	RESULTS IN FUNCTION
Andersen et al. 2015	no significant differences	shorter time return to work for interventions
Andias et al. 2018	Intervention decreased pain	-
Bgdatli et al. 2015	Differences from the baseline are greater in the balneotherapy group in pain.	Both groups showed significant improvements in function, fatigue, sleep, anxiety and depression. Differences from the baseline are greater in the balneotherapy group in function. No significant difference in disability.
Beltran-Alacreu et al. 2015	Statistically significant differences between baseline outcomes and all follow-up periods pain.	Statistically significant differences between baseline outcomes and all follow-up periods for function, disability, kinesiophobia.
Bennell et al. 2017	Statistically significant changes in pain.	Statistically significant changes in physical function.
Bodes-Pardo et al. 2017	large change in pain intensity.	
Brage et al. 2015	significantly larger reduction of pain for the INV group compared to CTRL group	significantly larger reduction in function observed for the INV group
Bramberg et al. 2017		statistically not significant effects on absenteeism larger significant effects among the adherers to

		kundalini yoga versus evidence-based advice
Chaleat-Valayer et al. 2016		the time from inclusion to the first recurrence of LBP with sick leave was similar between groups
Garaud et al. 2018	no significant differences between the groups with respect to resting pain scores and movement pain scores	Function evolved similarly between groups
Heapy et al . 2017	Both groups evolved similarly for pain	-
Jay et al. 2016		work-related fear-avoidance beliefs improved slightly for the intervention
Kloek et al. 2018	In both groups, there were significant improvements for pain.	No significant differences for function. In both groups, there were significant improvements for tiredness, quality of life, and self-efficacy.
Malfliet et al. 2018	None of the treatment groups showed a significant change in the perceived disability (pain disability index) due to pain.	Significant interaction effects for kinesiophobia and several subscales of the Illness Perception Questionnaire. Only in the PNE group these outcomes significantly improved.
Ris et al. 2016	The exercise group showed statistically significant improvement in cervical pressure pain threshold.	The exercise group showed statistically significant improvement in function and quality of life.
Saper et al. 2017	Noninferiority of yoga to PT for pain. Yoga is not superior to education for pain.	Non-inferiority of yoga to PT for function. . Yoga is not superior to education for function.
Saw et al. 2016	The intervention significantly improved pain severity and had moderate to large effects on pain interference.	
Walti et al. 2015	Pain reduction is higher in the MMT and lower in the UPT.	Reduction in disability similar for both interventions.

Table 6. *Characteristics of included studies.*

Citation	N	Participants	Intervention	Comparison	Frequency	Relevant outcome	Results	Conclusion
Andersen et al. 2015	140	sick-listed due to back/upper Body pain	1: Tailored physical activity group AND health guidance 2:workshop, education on pain and mutual support	health supervisor session	1: 50 minsx3 per week for 10 weeks 2: 2.5h weekly for 6 weeks, control: 1.5h	pain (VAS), kinesiophobia by Tampa scale	shorter time return to work for interventions not significant differences	TPA promising, CPSMP non significant for return to work. no benefits of interventions for kinesiophobia or capacity
Andias et al. 2018	43	students with neck and shoulder pain	PNE and exercises	control	1 session x 4 weeks	neck pain (VAS), pain catastrophizing (PCS), neurophysiology of pain questionnaire	A significant increase in the score of the NPQ ($p < 0.001$) were found in the intervention group PNE: 85.7% “a slight but noticeable change” 47.6% “definite improvement that has made a real and worthwhile difference”, CONTROL: 1.8%	Results suggest a potential benefit of PNE and exercise for adolescents with CINP. Further studies with larger sample sizes are needed.
Bagdatli et al. 2015	70	Women with fibromyalgia	balneotherapy and PNE	PNE	3h x 2days PNE, 5 sessions x 2 weeks balneotherapy	pain, Fatigue Beck Depression Index (BDI)	BALNEOTHERAPY: Significant improvements in global assessment scores, total FIQ score, and pain intensity, fatigue,non-refreshed awaking, stiffness, anxiety and depression subscales of FIQ and BDI. CONTROL: significant improvements in similar outcome measures. Differences from the baseline are greater in balneotherapy group in pain, FIQ. No significant difference in BDI score.	balneotherapy group was superior for pain intensity, patient’s and investigator’s global assessment, fatigue, non-refreshing sleep, stiffness, anxiety, depression and FIQ scores

Citation	**N**	**Participants**	**Intervention**	**Comparison**	**Frequency**	**Relevant outcome**	**Results**	**Conclusion**
Beltran-Alacreu et al. 2015	45	non specific chronic pain, 18-65 yo	1: manual therapy and therapeutic patient education, 2: manual therapy, therapeutic patient education and therapeutic exercise	manual therapy	8 sessions, 1 month	Neck Disability Index, the 11-item Tampa Scale of Kinesiophobia, the Fear Avoidance Beliefs Questionnaire, the Visual Analog Fatigue Scale	Statistically significant differences between baseline outcomes and all follow-up periods for NDI (P G 0.01), VAS (P G 0.05), Tampa Scale of Kinesiophobia, F = 3.613, P = 0.005, Fear Avoidance Beliefs Questionnaire, F = 2.803, P = 0.022 Minimal detectable changes in both experimental groups for Tampa but not in the control group.	A multimodal treatment is a good method for reducing disability in patients with nonspecific chronic neck pain in the short and medium term.
Bennell et al. 2017	148	chronic knee pain , >50yo	educational material, video conferencing sessions and a pain coping skills training program	Internet based educational material	7 sessions, 3 months	pain during walking (11-point numerical rating scale) physical function (Western Ontario and McMaster Universities Osteoarthritis Index)	INTERVENTION: Statistically significant changes in pain (mean difference, 1.6 units [95% CI, 0.9 to 2.3 units]) and physical function (mean difference, 9.3 units [CI, 5.9 to 12.7 units])	For persons with chronic knee pain, Internet delivered, physiotherapist-prescribed exercise and PCST provide clinically meaningful improvements in pain and function that are sustained for at least 6 months
Bodes-Pardo et al. 2017	56	CLBP for over 6 months	motor control, stretching, and aerobic exercises and PNE	motor control, stretching, and aerobic exercises	2 sessions	Pain (NPRS)	INTERVENTION: large change in pain intensity (numerical pain rating scale: 2.2; 2.93 to 1.28; P<.001; d=1.37)	Combining PNE with TE resulted in significantly better results for participants with CLBP, with a large effect size, compared with TE alone
Brage et al. 2015	20	women with chronic neck pain	pain education, specific training	pain education	8 weeks, 4 sessions of pain education 8 training sessions	pain (NRPS), neck related disability (NDI), self reported health (SF36),	significantly larger reduction of pain for the INV group compared to CTRL group (NRS, present pain: -1.63 vs 1.20; p=0.013, increased GPE in the INV group (1.86 vs -0.38, p=0.06),	Pain education combined with specific training and aerobic exercise reduce neck pain more than pain education alone in women with

						pain medication use	significantly larger reduction in the mental component of the SF-36 was observed for the INV group (-6.57 vs -2.71 respectively; p=0.04)	chronic neck pain.
Citation	**N**	**Participants**	**Intervention**	**Comparison**	**Frequency**	**Relevant outcome**	**Results**	**Conclusion**
Bramberg et al. 2017	159	chronic back and neck pain patients	1: kundalini yoga, 2: strength training	evidence based advice by the "back book"	6 weeks	sickness absenteeism, sickness presenteeism, back and neck pain and disability	statistically not significant effects on absenteeism larger significant effects among the adherers to kundalini yoga versus evidence-based advice: RR = 0.47 (CI 0.30; 0.74, p = 0.001), strength training versus evidence-based advice: RR = 0.60 (CI 0.38; 0.96, p = 0.032).	Guided exercise in the forms of kundalini yoga or strength training does not reduce sickness absenteeism more than evidence-based advice alone.
Chaleat-Valayer et al. 2016	353	LBP	education session, exercise training in the workplace, home based self managed exercise program	usual LBP care	5 weeks	percentage of participants with >=1 recurrence of LBP with sick leave	the time from inclusion to the first recurrence of LBP with sick leave was similar between groups [11.8 (SD 7.8) months and 13.4 (SD 8.2) months in the control and intervention group, respectively; P=0.511, log-rank test] The reduction of recurrence of LBP episode without sick leave in the intervention group (N=106) as compared to the control group (N=123) almost reached statistical significance (P=0.053).	the program was effective in improving muscle endurance and reducing fear-avoidance beliefs and GP and physiotherapy visits as well as pain medication.
Garaud et al. 2018	97	LBP	routine care, therapeutic education	TENS	6 months	EIFEL score (quality of life) Dallas Pain Questionaire (functional status)	The EIFEL score and the Dallas score had a similar evolution over time between groups (P=.18 and P=.50). no significant differences between the groups with respect to resting pain scores (P=.94 for back pain and P=.16 for leg pain) and movement pain scores (P=.52 for back pain and P=.56 for leg pain).	This study does not support the use of TENS in the treatment of patients with chronic LBP even though patients benefited from a therapeutic education program by a pain resource nurse.

Citation	**N**	**Participants**	**Intervention**	**Comparison**	**Frequency**	**Relevant outcome**	**Results**	**Conclusion**
Heapy et al . 2017	125	chronic back pain	individual CBT sessions with a therapist, IVR monitoring of pain, sleep, activity levels, and pain coping skill practice during treatment	self-help manual and therapist feedback	11 weeks	Average pain intensity 11-point NRS (0,no pain; 10,worst pain imaginable)	adjusted change IVR-CBT = −0.77 (95% CI, −1.39 to −0.29) in-person CBT= −0.84 (95% CI, −1.29 to −0.26) IVR-CBT noninferior to inperson CBT in posttreatment NRS: mean difference between groups:0.07; 95%CI, −0.67 to 0.80, with an upper limit (0.80) below the non inferiority margin of 1.	IVR-CBT is a low-burden alternative that can increase access to CBT for chronic pain and shows promise as a nonpharmacologic treatment option for chronic pain, with outcomes that are not inferior to in-person CBT.
Jay et al. 2016	112	Women with chronic musculoskeletal pain	mobility exercises, strength training, cognitive behavioral therapy including PNE, mindfulness group training	control	10 weeks	FAB Questionnaire	A significant group by time interaction was observed ($P<0.05$) for work-related fear-avoidance beliefs. The between-group difference at follow-up was –2.2 (–4.0 to –0.5), corresponding to a small to medium effect size (Cohen's d=0.30).	The study shows that work-related, but not leisure time activity-related, fear-avoidance beliefs, can be significantly reduced by 10 weeks of physical-cognitive-mindfulness training in females with chronic pain.
Kloek et al. 2018	208	hip/knee OA 40-80 yo	physical therapy sessions, online application of graded activity, exercise and information modules	usual physiotherapy	5 and 12 sessions	pain, tiredness quality of life self-efficacy	No significant differences in primary outcomes between the e-Exercise group and the usual physical therapy group were found. Within-group analyses for both groups showed a significant improvement in physical functioning. In both groups, there were significant improvements for pain, tiredness, quality of life, and self-efficacy.	The blended intervention, e-Exercise, was not more effective than usual physical therapy in people with hip/knee OA.
Citation	**N**	**Participants**	**Intervention**	**Comparison**	**Frequency**	**Relevant outcome**	**Results**	**Conclusion**

Malfliet et al. 2018	120	non specific chronic spinal pain	PNE	biomedically-focussed back/neck school education	2 weeks	Pain Disability Index Pain Catastrophizing Scale Tampa Scale for Kinesiophobia	None of the treatment groups showed a significant change in the perceived disability (pain disability index) due to pain (mean group difference post-education: 1.84; 95%CI: -2.80;6.47). Significant interaction effects for kinesiophobia(p=.002) and several subscales of the Illness Perception Questionnaire, including 'negative consequences'(p=.003), 'timeline cyclical' (p<.000) and 'timeline acute/chronic'(p=.003). Only in the PNE group these outcomes significantly improved (9 to 17% improvement; .37≤Cohen's D≥.86).	Blended learning PNE improves kinesiophobia and illness perceptions in patients with chronic spinal pain. PNE should not be used as sole treatment, but rather as key element within a comprehensive active rehabilitation program.
Ris et al. 2016	200	neck pain patients	pain education, exercise, graded activity training	pain education	4 sessions of pain education, additional 8 sessions of training	SF36-PCS	The exercise group showed statistically significant improvement in physical HR-QoL, mental HRQoL, depression, cervical pressure pain threshold, cervical extension movement, muscle function, and oculomotor.	This multimodal intervention may be an effective intervention for chronic neck pain patients.
Saper et al. 2017	320	low-income, racially diverse adults with nonspecific cLBP	1. yoga 2. PT	education	12 weeks	back-related function (Roland Morris Disability Questionnaire) pain, 11-point scale	One-sided 95% lower confidence limits were 0.83 (RMDQ) and 0.97 (pain), demonstrating noninferiority of yoga to PT. Yoga is not superior to education for either outcome.	A manualized yoga program for nonspecific cLBP was noninferior to PT for function and pain.The hypothesis, that yoga is superior to education for both function and pain, was not supported
Citation	**N**	**Participants**	**Intervention**	**Comparison**	**Frequency**	**Relevant outcome**	**Results**	**Conclusion**
Saw et al. 2016	74	arthroplasty waiting list patients	education including PNE, exercise and relaxation	usual care	2hr/week	pain (Brief Pain Inventory)	The intervention group had significant improvements compared with the control group on pain severity	The intervention resulted in sustained significant improvements

							[week 6: p < 0.01, ES = 0.94, 95 % CI (0.45,1.41), month 6: p = 0.02. ES = 0.74, 95 % CI (0.26,1.2)] and moderate to large effects on pain interference [week 6: p < 0.01, ES = 1.2, 95 % CI (0.70,1.69),week 12: p = 0.04, ES = 0.68, 95 % CI (0.20,1.14), month 6: p < 0.01, ES = 0.98, 95 % CI (0.49,1.45)]. 53 % of participants reported that the intervention improved their pain.	in pain severity and interference in patients with hip/knee osteoarthritis, awaiting arthroplasty compared with a control group. Such an intervention appears to be effective in managing pain in this population and should be incorporated into practice for appropriate patients.
Walti et al. 2015	28	NSCLBP	MultiModal Treatment including PNE	usual physiotherapy	16 sessions 8-12 weeks	pain (NRS 0-10)	Pain reduction (NRS; [95% CI]) was 2.14 [1.0 to 3.5] in the MMT and 0.69 [-2.0 to 2.5.] in the UPT. The between-group difference was 1.45 [0.0 to 4.0] (p = 0.03), representing a moderate effect size of 0.66 [-0.1 to 1.5]. Reduction in disability on the RMDQ was 6.71 [4.2 to 9.3] in MMT and 4.69 [1.9 to 7.4] in UPT, with a non-significant between-group difference of 2.02 [-1.5 to 5.6] (p = 0.25).	MMT was found to be feasible and to significantly reduce pain in the short term when compared with UPT.

Discussion

Discussion of articles.

The results of this review include two levels of information. One on the results of PNE in pain and one on its results in function.

Regarding pain, we encountered six studies that clearly concluded that PNE reduces pain in chronic pain patients (Beltran-Alacreu et al. 2015, Bennell et al. 2017, Bodes-Pardo et al. 2017, Brage et al. 2015, Saper et al. 2017, Saw et al. 2016, Walti et al. 2015). These results are in line with a recent review concluding that PNE for musculoskeletal pain is supported by evidence in reducing pain (Louw et al. 2016).

A little later than that, a meta analysis (Watson et al. 2019) concluded that PNE versus control has low clinical relevance in the short and medium term for pain. Indeed the rest of the studies we looked into, resulted in one way or another in rejecting PNE as the main treatment for pain. Two studies were found that concluded PNE helped just as much as the control intervention (Heapy et al . 2017, Kloek et al. 2018). There was one study claiming that PNE alone wasn't effective but when added to the intervention program it yielded better results (Ris et al. 2016). The rest of the studies were clear that the PNE intervention did not have any effect on the patients pain (Andersen et al. 2015, Bagdatli et al. 2015, Garaud et al. 2018, Malfliet et al. 2018,).

Of the studies that looked into function, three concluded that PNE is ineffective (Bagdatli et al. 2015, Bramberg et al. 2017, Kloek et al. 2018). The majority of the studies found PNE more effective than the comparison for function measures (Andersen et al. 2015, Beltran-Alacreu et al. 2015, Bennell et al. 2017, Brage et al. 2015, Jay et al. 2016, Malfliet et al. 2018, Ris et al. 2016, Saper et al. 2017). A few studies concluded than PNE was not superior to the comparison but

showed statistically significant increases in function from the baseline (Chaleat-Valayer et al. 2016, Garaud et al. 2018, Walti et al. 2015). These results confirm earlier data that generally agree that PNE can act favorably for function measures. According to a meta analysis on the matter (Watson et al. 2019) while PNE had low clinical relevance for disability in the short and medium term, it was clinically relevant for kinesiophobia and pain catastrophizing. These factors are very important in our study population even in terms of measurements, since most tools used to measure function include items on kinesiophobia and pain catastrophizing. Systematic reviews on the subject clearly support PNE for function increase (Louw et al. 2016, Barbari et al. 2019) and are generally concluding that PNE especially as part of a multimodal intervention is the most effective for helping patients stick with the treatment, go through with it and reap the benefits in the long term for disability and function. These results are in line with the updated narrative on PNE by leading scientists. PNE or the biopsychosocial model to pain according to Moseley (2015) while it can be used as stand alone treatment, it is not how it is meant to be implemented. PNE is developed to be used as part of a well rounded patient specific treatment program, and that is when evidence on it is best. According to this, maybe testing PNE alone against standard treatment doesn't make a lot of sense. PNE is merely a suggestion to look closer at current practice and widen our tool box for treating chronic pain (Puentedura et al. 2016).

Answer to research question.

"*What is the effect of patient-oriented neuroscience education in pain and function outcomes for patients with chronic pain, compared to traditional treatment or no treatment at all?"*

Looking into 18 RCTs conducted on patients with chronic pain, comparing any type of PNE alone or as a part of a multimodal treatment plan, compared to other treatments, to PNE alone or to no

treatment, this review concludes PNE increases function and decreases disability in the long term, while its effect on pain in the short and medium term are not encouraging at the moment.

"*Is patient education effective in reducing symptoms in chronic pain patients?"*
PNE, according to this review and in line with current evidence, seems to have a positive effect on function while decreasing disability in the long term. Its effect on pain in the short and medium term are not promising.

Strengths and limitations of the review.

The first thing to notice about this review is that it does not cover the subject of the quality of the studies. Indeed, no quality review was performed on the articles, they were included in the study right as they emerged from the research strategy. As this is a narrative review, the focus was given on covering the overarching themes on the field, and not performing a strict systematic review, that would definitely ask for the use of quality appraisal tools like the PEDro scale or the Cochrane tool.
Nevertheless, all studies were RCTs, and that says something on their quality level. Still, with no quality appraisal performed, one can only guess how valid their conclusions are.

A second point to be made is that the included studies are limited to 18 experiments. The number is not alarmingly small, but, on such a well covered topic, one would expect more material for a review.

The interventions covered a wide range of PNE, including workshops, consultations, discussions with the therapist, self management materials like videos or books. It also included interventions that used PNE as part of them, but also used different tools like CBT, exercise, manual therapy and modalities. While looking at evidence from all different applications of PNE can be very helpful to

gain insight on the direction treatments should take, it is possible that we could get clearer answers on whether PNE effects pain and function if we would focus on one application at a time.

Lastly, a strong point for this review are the outcome measures used by the included RCTs. As seen in **table 7.** The measures for pain and function are common for many of the studies, and are very well acclaimed and established tools in academia. Valid tools make for valid research.

Suggestions for further study.

After looking closely at the recent evidence on PNE and its effects on chronic pain patients in pain and function, a few suggestions for academia can arise. It is clear that there is no specific protocol application of PNE so far, and that makes researching very risky (Louw et al. 2016A). Developing a specific protocol for treating with PNE can help with the level of evidence on this practice.

Evidence so far shows that PNE works best in combination with other treatments as part of a multidisciplinary and tailor-made treatment program. Future studies should focus on testing that kind of treatments, instead of PNE as stand alone practice.

Also it might be interesting to look further into studies that have identified components that optimize PNE as a treatment option, and use them to develop and test similar protocols (Watson et al. 2019)

Lastly, there is need for evidence on the long term effects of PNE implementation in the specific population as there is a trend that suggests that its effects might be more long lasting that most interventions on chronic pain (Watson et al. 2019).

Conclusion

This narrative review concluded that PNE interventions seem to increase function and decrease disability in patients with chronic pain, while their effect on pain is not significant. Nevertheless evidence on PNE interventions for chronic pain patients is limited. More research is needed focusing on the specific intervention. Research suggests that it is important to develop clear PNE protocols, preferably protocols that include PNE as part of a well rounded, multidisciplinary, tailor made and patient focused intervention plan, and to test these interventions for effectiveness in pain and function in the long term.

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