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Archives of Physical Medicine and Rehabilitation

journal homepage: www.archives-pmr.org

Archives of Physical Medicine and Rehabilitation 2018;99:338-47

ORIGINAL RESEARCH

Pain Neurophysiology Education and Therapeutic Exercise for Patients With Chronic Low Back Pain: A Single-Blind Randomized Controlled Trial

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Abstract

Objective: To assess the effect of a pain neurophysiology education (PNE) program plus therapeutic exercise (TE) for patients with chronic low back pain (CLBP).

Design: Single-blind randomized controlled trial.

Setting: Private clinic and university.

Participants: Patients with CLBP for ≥6 months (N=56).

Interventions: Participants were randomized to receive either a TE program consisting of motor control, stretching, and aerobic exercises (n=28) or the same TE program in addition to a PNE program (n=28), conducted in two 30- to 50-minute sessions in groups of 4 to 6 participants.

Main Outcomes Measures: The primary outcome was pain intensity rated on the numerical pain rating scale which was completed immediately after treatment and at 1- and 3-month follow-up. Secondary outcome measures were pressure pain threshold, finger-to-floor distance, Roland-Morris Disability Questionnaire, Pain Catastrophizing Scale, Tampa Scale for Kinesiophobia, and Patient Global Impression of Change.

Results: At 3-month follow-up, a large change in pain intensity (numerical pain rating scale: −2.2; −2.93 to −1.28; $P<.001$; $d=1.37$) was observed for the PNE plus TE group, and a moderate effect size was observed for the secondary outcome measures.

Conclusions: Combining PNE with TE resulted in significantly better results for participants with CLBP, with a large effect size, compared with TE alone.

Archives of Physical Medicine and Rehabilitation 2018;99:338-47

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Low back pain is the most common musculoskeletal health problem and remains an economic burden for society, in part because of the peak incidence in the working-age population.[1-3]

Evidence-based guidelines for the management of chronic low back pain (CLBP) emphasize the importance of active rehabilitation, including therapeutic exercise (TE), but there is no clear consensus about the most effective type of exercises.[2,4] Recent systematic reviews support the effectiveness of motor control exercise in patients with CLBP,[5,6] whereas some argue that it is not necessary to have such specific exercises when managing patients with CLBP.[4] Some authors have even argued that motor control exercises could have an adverse effect because they may increase hypervigilance and fear-avoidance behaviors.[7]

However, even effective treatments (including TE) for CLBP have only modest effect sizes.[8] These disappointing results may be a result of treatments mainly targeting only peripheral pain

Clinical Trial Registration No.: ACTRN12617000097347.
Disclosures: none.

0003-9993/17/$36 - see front matter © 2017 by the American Congress of Rehabilitation Medicine
https://doi.org/10.1016/j.apmr.2017.10.016

generators. Differences in central pain-transmitting systems have been suggested as a cause of chronic pain in patients with a variety of unexplained disorders, including nonspecific low back pain.[9]

Pain neurophysiology education (PNE) is thought to desensitize the central nervous system, especially when combined with TE.[10-13] PNE aims to change patients' beliefs,[14] which is a preliminary step to changing behavior, according to the Leventhal common sense model.[15,16]

Previous studies combining PNE and TE for CLBP included small sample sizes and were performed by the research group that developed PNE. Further research is necessary to reduce potential bias and improve generalizability. There is large variation in PNE format because most clinical trials use individualized PNE.[17-20] Some authors propose several sessions,[10,17] whereas others suggest a single session,[18] and the duration of the PNE session varies across trials.

The primary aim of this study was to compare the effects of combined PNE plus multimodal TE versus TE only on pain intensity in patients with CLBP. The secondary aim was to assess the effects of both interventions on disability, psychological factors, physical performance, and pain pressure thresholds. We hypothesized that patients receiving PNE plus TE would obtain superior results in all outcome measures compared with those receiving TE only.

Methods

Study design

A single-blind randomized controlled trial with 2 intervention groups (PNE plus TE group and TE group) and repeated measures was performed conforming to Consolidated Standards of Reporting Trials guidelines.[21] The study was approved by the Human Research Ethics Committee at the Universidad de Alcalá and conducted in accordance with the Declaration of Helsinki.

Participants

Patients were recruited by announcements placed in 4 private physiotherapy practices and in Alcalá University in Madrid, Spain. Sixty-five individuals willing to participate in the study contacted the research group. Two experienced independent physiotherapists screened accordingly to the inclusion criteria: aged between 20 and 75 years, experiencing nonspecific CLBP for ≥6 months, and having Spanish as a native language. The diagnosis was based on the presence of "pain experienced between the costal margins and the inferior gluteal folds"[2(p.30)] which is influenced by physical activities and postures, usually accompanied by painful limitation of motion, and frequently associated with referred pain.

Participants were excluded if they had a diagnosis of lumbar radiculopathy, were receiving any other treatment for their CLBP at the time of the study, or had pain because of tumors or infections, metastases, osteoporosis, inflammatory arthritis, or fractures. In addition, patients with known mental disorders diagnosed by a physician were excluded. Also, participants involved in compensation for work leave were not eligible to participate.[11,22]

Participants were informed about the nature of the study, and written informed consent was obtained from all participants prior to participation.

List of abbreviations:

CLBP	chronic low back pain
MCID	minimal clinically important difference
NPRS	numerical pain rating scale
PCS	Pain Catastrophizing Scale
PGIC	Patient Global Impression of Change
PNE	pain neurophysiology education
RMDQ	Roland-Morris Disability Questionnaire
TE	therapeutic exercise
TSK-11	Tampa Scale for Kinesiophobia

Procedure

Participants completed self-reported demographic information (sex and age) and a number of questionnaires as subsequently detailed. Participants were requested not to take analgesic medication 24 hours before each assessment.

Primary outcome measure: numerical pain rating scale

Pain intensity was evaluated using the numerical pain rating scale (NPRS) (0–10 with 0 representing no pain and 10 representing the worst pain).[23] Clinimetric properties of the NPRS are well established.[24] The NPRS's minimal clinically important difference (MCID) is 2 points. The NPRS was measured before treatment (baseline), immediately posttreatment, and at 1 and 3 months posttreatment.

Secondary outcome measures

Secondary outcome measures included the Roland-Morris Disability Questionnaire (RMDQ), Pain Catastrophizing Scale (PCS), Central Sensitization Inventory,[25] Tampa Scale for Kinesiophobia (TSK-11) (measured at baseline and at 1 and 3mo postintervention), and Patient Global Impression of Change (PGIC) (at 1 and 3mo postintervention). Finally, pressure pain thresholds and physical performance (finger-to-floor distance test) were measured by masked assessments conducted by 2 physiotherapists at baseline, posttreatment, and at 1-month follow-up.

Secondary outcome measure: disability

To measure the level of disability caused by CLBP, we used the Spanish version of the RMDQ (0–24, with 0 representing no disability and 24 representing the most disability), which has good internal consistency (Cronbach α=.83) and test-retest reliability (interclass correlation coefficient=.87).[26] Its MCID varies between 1 and 2 points in patients with minimal disability and 7 and 8 points in patients with severe disability.[27]

Secondary outcome measure: pain catastrophizing

The PCS was used to measure pain catastrophizing. Higher scores (range, 0–52) indicate higher pain catastrophizing. The Spanish version of the PCS has shown appropriate internal consistency, appropriate test-retest reliability, and sensitivity to change.[28]

Secondary outcome measure: kinesophobia

The Spanish version of the TSK-11 was used to measure fear of movement.[29] Higher scores indicate greater fear-avoidance behaviors. The minimal detectable change score for the TSK-11 is 5.6 points.[25] The TSK-11 has demonstrated acceptable internal consistency and validity.[30]

Secondary outcome measure: self-perception of improvement

The perception of improvement after treatment was assessed by the PGIC (range, 0–7).[31] Although this scale is recommended for patients with chronic pain, further research is needed regarding its consistency, validity, and reliability.[23]

Secondary outcome measure: physical performance

Physical performance outcomes were measured with the finger-to-floor distance test. The intra- and interreliability of this test is excellent (intraclass correlation coefficient = .99) in patients with low back pain.[32]

Secondary outcome measure: pressure pain thresholds

A standardized protocol for evaluating pressure pain thresholds was used.[33,34] The selected points were 5cm lateral to the spinous process of L3 and a remote distal point from the lumbar region (at 2cm from the lateral epicondyle). The pressure pain thresholds were measured using an analog Fisher algometer (Force Dial model FDK 40[a]) with a surface area of $1cm^2$. The MCID is $1.2kg/cm^2$.[35]

Randomization and blinding

Participants were randomly allocated in equal numbers to either PNE plus TE or TE only using the computer program Epidat version 3.1.[b] Allocation sequence was prepared by a researcher with no involvement in the study using a blocked randomization model. Allocation concealment was ensured using sequentially numbered opaque and sealed envelopes.

Interventions

In the first face-to-face session, both groups received a program of TE, but the PNE plus TE group received the TE after the PNE intervention. The second face-to-face session (TE or PNE plus TE) occurred 1 month later. During the following 3 months, all participants were instructed to complete the exercise program on a daily basis. Compliance with home exercises was assessed with a 5-point Likert-type scale to the question: How often have you done your home exercises?

One experienced physiotherapist supervised the TE for all participants, and another experienced physiotherapist provided the 2 sessions of PNE.

Therapeutic exercise

The TE program used in this study was a multimodal exercise program consisting of motor control exercises for the lumbar spine,[36] stretching,[37] and aerobic exercise (appendix 1).

In the first session, exercises were demonstrated to the participants, and then the participants performed the exercises independently. The physiotherapist corrected each participant individually as required to ensure correct technique and ensured that the participants were confident to perform their exercises alone at home every day during the 3-month period. During the second session (1mo after the first session), the physiotherapist confirmed their correct performance of the exercises again.

Pain neurophysiology education

The program used for PNE was based on prior research,[19] the book *Explain Pain*,[38] and Pain in Motion content (available at: www.paininmotion.be), and consisted of 2 educational sessions each lasting 30 to 50 minutes, which were provided to the participants in groups of 4 to 6 patients. The first session consisted of a verbal explanation with a visual presentation. During the class, all main concepts of the neurophysiology of pain were explained and discussed. At the end of the session, participants received a leaflet to reinforce the educational session content. At the follow-up session a month later, the main ideas of the first session were reinforced and any questions were answered.

Statistical analysis

Sample size

The required sample size was calculated using G*Power 3.0.18 Software,[39,c] based on an effect size of .25 for the primary outcome measure, pain intensity, with a correlation between repeated measurements assumed at 0.5. Given 4 measurements in the 2 groups, correction of sphericity was determined at 0.5. With a statistical power of .95 and an α level of .05, we estimated a sample size of 36 patients in total. Considering a possible loss to follow-up of 15%, the recruitment target was 44 patients.

Analysis

Statistical analyses were performed using SPSS 22.[d] The significance level was set at $P<.05$.

A contingency table was made to compare the results of the PGIC using Pearson chi-square test. The contingency coefficient was also calculated to determine the magnitude of this relation between groups. To compare both groups, the difference was calculated for each dependent variable by subtracting the pretest from the posttest measurement.

Treatment compliance for the home exercises was analyzed with a 5-point Likert scale using a contingency table and a chi-square test.

Normative distribution was evaluated using the Shapiro-Wilk test. Descriptive data included means and SDs.

Repeated-measures analysis of variance (pretest and posttest, and 1- and 3-mo follow-up) was used for normally distributed variables. In addition, Student t test was used to determine differences between group interventions. Effect sizes were calculated according to the formula $d=2t/\sqrt{g}$.

Results

The flow of participants through the study is depicted in figure 1. Fifty-six participants completed the study, and their data were used in the final analyses. All participants completed the interventions, including home exercises (fig 2). No statistically significant differences in baseline variables existed between groups (table 1). The raw scores and statistical significance for each measurement for both groups are shown in table 2.

As reflected in table 3 and figure 3, we found significant differences in the primary outcome measure, pain intensity, in the PNE plus TE group when compared with the TE group (NPRS score: −2.2; −2.93 to −1.28; $P<.001$), with a high effect size ($d=1.37$). According to figure 3, it is clear that pain intensity decreased in both groups, but the PNE plus TE group always had better results.

Regarding the secondary outcome measures, we found significant differences in the RMDQ score (−2.7; −3.9 to −1.4; $P<.001$; $d=1.15$), PCS score (−10.6; −13.1 to −8.06; $P<.001$; $d=2.23$), and TSK-11 (−8.5; −11.0 to −6.0; $P<.001$; $d=1.84$) between

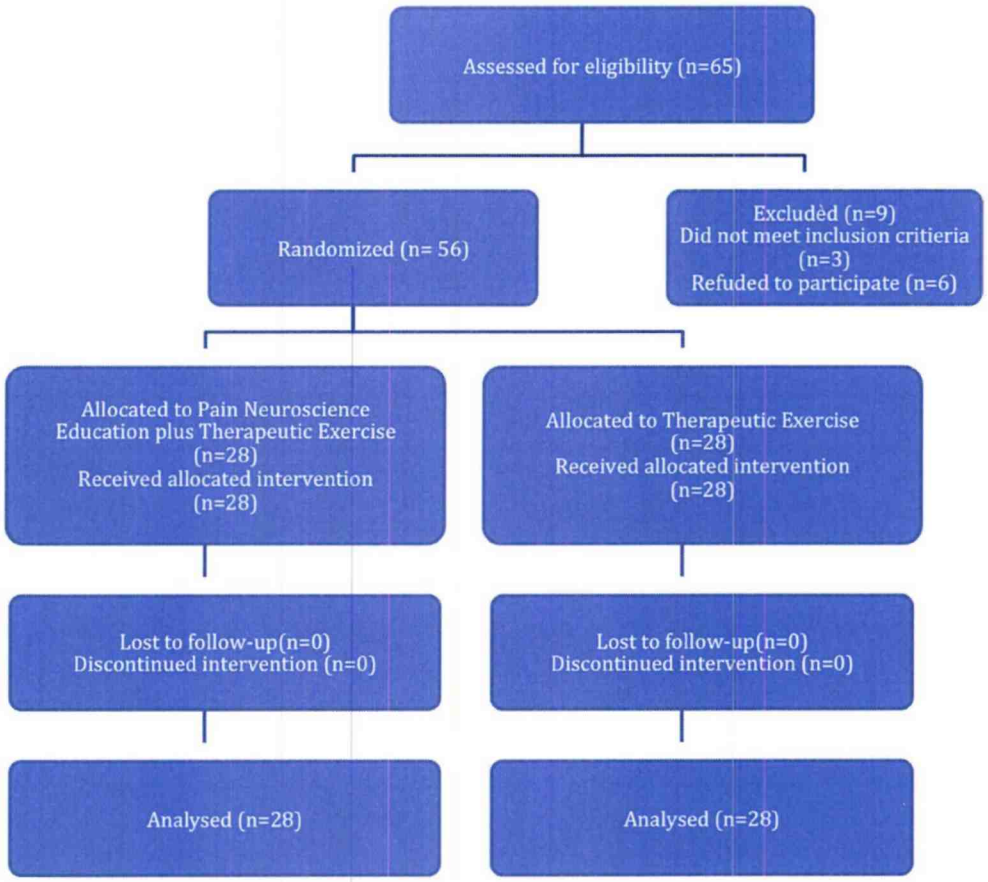

Fig 1 Participant selection flow diagram.

groups at 3-month follow-up with a high effect size. In the same way, we found significant differences between groups in lumbar pressure pain thresholds (score: 1.21; 1.00–1.41; $P<.001$; $d=3.24$) and in the finger-to-floor distance test (score: −2.6; −4.5 to −0.7; $P<.05$; $d=.75$). However, the differences in the elbow pressure pain thresholds were not significant (score: −0.0; −0.1 to 0.01; $P>.05$; $d=.03$). All differences were in favor of the PNE plus TE group (see table 3). The PGIC presented significant differences between groups at 3-month follow-up ($\chi^2_4=13.526$, $P<.05$) (fig 4). This relation was moderate ($C=.441$, $P<.005$).

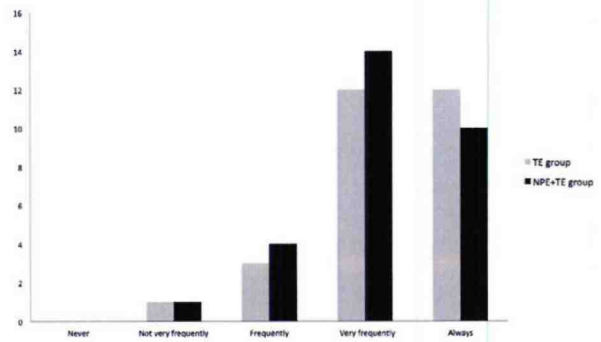

Fig 2 Compliance with home exercises.

Discussion

The results of this study reveal that combining PNE with TE produces significantly greater improvements in pain intensity, disability, psychosocial factors, and physical performance when compared with TE alone in patients with CLBP. These effects were maintained over a short-term follow-up period of 3 months.

Lumbar pain intensity

Although the intensity of lumbar pain decreased in both groups, a significantly greater improvement was observed for the PNE plus TE group at all time points. These results are similar to previous studies that used PNE alone,[11] PNE combined with other treatments,[17] or PNE combined with exercise.[10,12,40] The positive effects of this study are highly relevant because we used fewer group sessions of shorter duration compared with the 1-on-1 sessions in previous studies.[11,12,17,40] The decrease in NPRS scores observed in this study was superior to the results of Moseley.[17] Furthermore, the differences in pain intensity in this study were not only statistically significant but also clinically meaningful with an effect size of 1.37 at 3 months.[25,31]

Disability

Our findings that PNE plus TE resulted in significantly improved functioning based on the RMDQ (5.6 points) (see table 2) are

Table 1 Baseline characteristics

Characteristic	TE Group	PNE Plus TE Group	*P*
Sex (male/female), n	6/22	6/22	.85
Age (y)	49.2±10.5	44.9±9.6	.12
CSI (0–100)	57.7±6.0	57.8±6.7	.97
NPRS (0–10)	7.8±1.2	8.0±1.2	.93
PPT at spinal process of L3 (kg/cm^2)	3.0±0.6	2.8±0.6	.12
PPT at lateral epicondyle (kg/cm^2)	3.9±0.9	3.6±1.0	.39
FFD (cm)	12.2±4.8	12.5±5.5	.99
RMDQ (0–24)	12.7±1.5	12.0±1.5	.13
PCS (0–52)	32.2±5.1	34.1±7.5	.12
TSK-11 (11–44)	28.1±5.5	28.7±5.7	.63

NOTE. Values are mean ± SD or as otherwise indicated.
Abbreviations: CSI, Central Sensitization Inventory; FFD, finger-to-floor distance; PPT, pressure pain threshold.

similar to the results obtained by Moseley.[10] Interestingly, Ryan et al[12] found that using PNE alone had a better effect on the RMDQ than patients receiving PNE plus TE. Pires et al[40] found that PNE combined with aquatic exercises did not have a superior effect to PNE alone on patient function. This variation across studies likely relates to the type of exercises evaluated in combination with PNE. Only 6% of studies use a similar combination of exercises.[41]

Psychological factors

This study reveals a large decrease in pain catastrophizing (d=2.23) in patients receiving PNE plus TE (see table 3). This is in accordance with different studies in patients with CLBP[11,13,42] and studies performed in chronic fatigue,[18] fibromyalgia,[43] and lumbar radiculopathy.[44] However, other studies have not found significant differences between PNE and interventions when tested in other patient populations (eg, whiplash-associated disorders[19]).

The TSK-11 is not often evaluated as an outcome measure when evaluating the effects of PNE in patients with CLBP.[10-12,17] In a study that did include the TSK-11, Pires et al[40] did not find a significant difference in the degree of kinesiophobia after PNE versus a control group. In other disorders (whiplash,[19] low back pain in athletes,[45] musculoskeletal pain,[13] and chronic fatigue syndrome[18]) there are mixed results, with some studies showing a change in kinesiophobia after PNE and others not, which may be related to the nature of the condition being treated, with some conditions including low back pain being more susceptible to fear of movement.

The results for PGIC were also superior for the PNE plus TE group (see fig 4). However, the PGIC has not previously been used as an outcome measure after PNE; therefore, comparisons with previous studies cannot be made.

Physical performance

In this study we found greater improvement on the finger-to-floor test with PNE plus TE compared with TE. Previous work has shown improvements in physical parameters (straight leg raise test and finger-to-floor distance) with PNE, even without allowing participants to engage in physical activity during the study.[46]

Table 2 Raw scores and statistical significance for each measurement

Outcome and Group	Baseline	Posttreatment	1-mo Follow-Up	3-mo Follow-Up
NPRS				
TE group	7.8 (7.5–8.4)	7.1 (6.5–7.7)*	6.0 (5.4–6.6)*	4.8 (4.1–5.5)*
PNE plus TE group	7.9 (7.4–8.4)	5.3 (4.7–5.9)*	3.9 (3.2–4.6)*	2.7 (2.0–3.4)*
PPT SP-L3				
TE group	3.0 (2.7–3.2)	3.2 (3.0–3.5)†	3.6 (3.3–3.9)*	ND
PNE plus TE group	2.8 (2.5–3.0)	3.9 (3.6–4.3)*	4.6 (4.3–4.9)*	ND
PPT LE				
TE group	3.8 (3.5–4.2)	4.0 (3.6–4.3)	3.9 (3.6–4.3)	ND
PNE plus TE group	3.6 (3.2–4.0)	3.6 (3.2–4.0)†	3.7 (3.3–4.1)*	ND
FFD				
TE group	12.2 (10.3–14.0)	10.7 (9.1–12.4)†	8.6 (7.3–10.0)*	ND
PNE plus TE group	12.5 (10.4–14.6)	8.1 (6.3–9.9)*	6.3 (5.0–7.6)*	ND
RMDQ				
TE group	12.6 (12.1–13.1)		11.0 (10.3–11.6)†	9.8 (8.9–10.6)*
PNE plus TE group	12.0 (11.4–12.6)		8.5 (7.8–9.3)†	6.4 (5.5–7.2)*
PCS				
TE group	32.1 (30.2–34.1)		28.7 (26.6–30.8)†	26.9 (24.8–29.0)*
PNE plus TE group	34.1 (31.2–37.0)		22.2 (18.8–25.6)†	18.2 (15.4–21.0)*
TSK-11				
TE group	28.1 (26.0–30.2)		26.1 (24.1–28.0)†	24.1 (22.0–26.1)*
PNE plus TE group	28.7 (26.1–30.9)		20.1 (18.5–21.6)†	16.1 (15.2–16.9)*

NOTE. Data are given as mean (95% confidence interval).
Abbreviations: FFD, finger-to-floor distance; PPT LE, pressure pain threshold at lateral epicondyle; ND, no data; PPT SP L3, pressure pain threshold at spinous process of L3.
* Analysis of variance: statistically significant differences (P<.01).
† Analysis of variance: statistically significant differences (P<.05).

Table 3 Comparison between groups for NPRS, RMDQ, PCS, TSK-11, PPT, and FFD

Variable	Baseline	3-mo Follow-Up
NPRS (0–10)		
TE group	7.8 (7.5, 8.4)	4.8 (4.1, 5.5)
PNE plus TE group	7.9 (7.4, 8.4)	2.7 (2.0, 3.4)
Between-group difference in change score*	−2.2 (−2.93 to −1.28); <.001; 1.37	
RMDQ (0–24)		
TE group	12.6 (12.1, 13.1)	9.8 (8.9, 10.6)
PNE plus TE group	12.0 (11.4,12.6)	6.4 (5.5, 7.2)
Between-group difference in change score*	−2.7 (−3.9 to −1.4); <.001; 1.15	
PCS (0–52)		
TE group	32.1 (30.2, 34.1)	26.9 (24.8, 29.0)
PNE plus TE group	34.1 (31.2, 37.0)	18.2 (15.4, 21.0)
Between-group difference in change score*	−10.6 (−13.1 to −8.06); <.001; 2.23	
TSK-11 (11–44)		
TE group	28.1 (26.0, 30.2)	24.1 (22.0, 26.1)
PNE plus TE group	28.7 (26.1, 30.9)	16.1 (15.2, 16.9)
Between-group difference in change score*	−8.5 (−11.0 to −6.0); <.001; 1.84	
Variable	**Baseline**	**1-mo Follow-Up**
PPT at spinal process of L3		
TE group	3.0 (2.7, 3.2)	3.6 (3.3, 3.9)
PNE plus TE group	2.8 (2.5, 3.0)	4.6 (4.3, 4.9)
Between-group difference in change score*	1.21 (1.00 to 1.41); <.001; 3.24	
PPT at lateral epicondyle		
TE group	3.8 (3.5, 4.2)	3.9 (3.6, 4.3)
PNE plus TE group	3.6 (3.2, 4.0)	3.7 (3.3, 4.1)
Between-group difference in change score*	−0.0 (−0.1 to 0.01); >.05; .03	
FFD		
TE group	12.2 (10.3, 14.0)	8.6 (7.3, 10.0)
PNE plus TE group	12.5 (10.4, 14.6)	6.3 (5.0, 7.6)
Between-group difference in change score*	−2.6 (−4.5 to −0.7); <.05; .75	

NOTE. Values are mean ± SD. $d = 2t/\sqrt{g}$.
Abbreviations: FFD, finger-to-floor distance; PPT, pressure pain threshold.
* Values are mean difference (95% confidence interval); *P*; *d*.

Pressure pain threshold

Lumbar pain pressure thresholds increased in both groups after the intervention, but this increase was greater for the PNE plus TE group (d=3.24).

In the few studies of PNE in which pain pressure threshold was used as an outcome measure, none were performed in patients with CLBP. Mixed results were obtained in other patient populations with no changes observed after PNE in chronic fatigue syndrome,[18] but a significant increase in both local and widespread pain pressure thresholds was seen in patients with chronic whiplash.[19] The mechanisms underpinning the effects of PNE on the central nervous system are largely unknown. However, it is hypothesized that PNE targets the cognitive-emotional components of pain, decreases

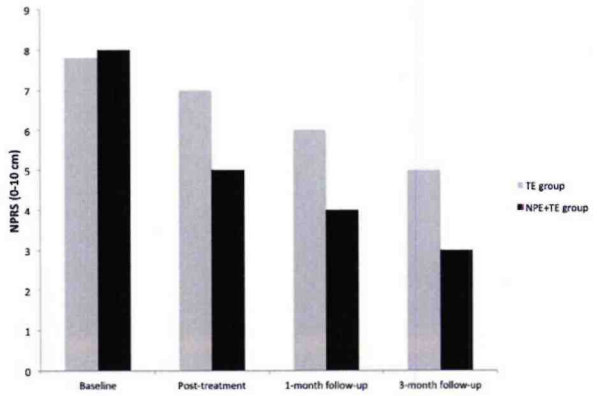

Fig 3 Absolute scores of NPRS for PNE plus TE group and TE group for each measurement.

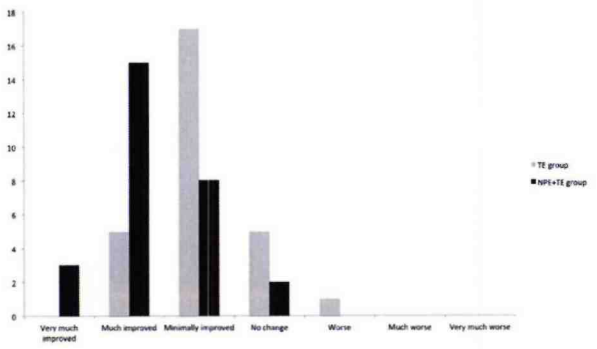

Fig 4 PGIC: differences between the TE group and PNE plus TE group at 3-month follow-up.

facilitating descending pain mechanisms,[13,47] and promotes activation of inhibitory descending pathways.[20]

Clinical implications

In this study, almost all outcomes were statistically and clinically improved in the PNE plus TE group compared with the TE group, with larger effect sizes demonstrated compared with those found for other CLBP treatments.[8] All participants in our study had high scores on the central sensitization inventory (57.79 points for the PNE plus TE group and 57.71 points for the TE group),[48] which may explain why they benefitted so significantly from PNE. Previous studies did not determine the presence of altered central pain mechanisms at baseline, and therefore could not establish that PNE was indicated for the treated patients.

Although we did not specifically evaluate the cost-effectiveness of the interventions, our study demonstrated significant improvement with a short intervention of only 2 group sessions, which appears to be as efficacious and likely more cost-effective than longer duration, 1-on-1 PNE treatment.

Providing PNE first appears to be important when combined with other physiotherapy treatments to avoid potential conflict between messages given to the patient (pain does not mean harm) and other physiotherapy techniques where pain guides the treatment.[49] In this study, PNE preceded TE in the PNE plus TE group. For all patients, TE was cognitively targeted and adapted to each individual.[50,51] However, a better understanding of their pain after PNE may have led to better coping strategies and greater effect of the TE in the group receiving both treatments.

Study limitations

A main limitation of this study is the absence of a control group that did not receive an intervention. This would have allowed us to compare results from both treatment groups with the natural history of CLBP. Second, because patients contacted the researcher to participate in the study, we cannot exclude selection bias. It is plausible that only very motivated patients participated, explaining the extremely high level of compliance. Moreover, compliance was assessed using a Likert scale, which may be a crude measure of completion of home exercises. Third, no sociodemographic factors with potential effect on the results (eg, educational background, occupation, socioeconomic status) were recorded. Finally, the effect of the intervention was only assessed at 3-month follow-up; therefore, future studies are necessary to study long-term effects of this combined intervention.

Conclusions

A program of PNE combined with TE is more effective in reducing pain, disability, and pain catastrophizing compared with TE alone in patients with CLBP.

Suppliers

a. Force Dial model FDK 40.
b. Epidat version 3.1.
c. G*Power 3.0.18; Universität Düsseldorf.
d. SPSS 22; SPSS.

Keywords

Exercise therapy; Low back pain; Neuroscience; Rehabilitation

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Acknowledgments

We thank Alcalá University, especially the Physiotherapy Department.

Appendix 1 TE Program

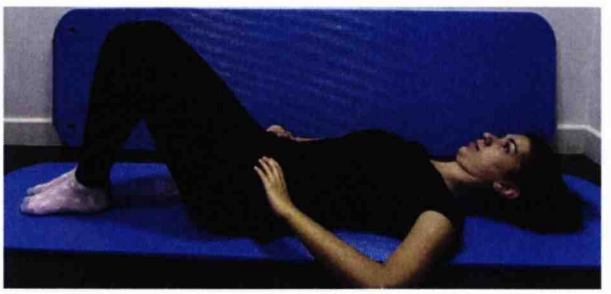
TE multimodal program based on motor control, stretching, and aerobic exercises.

Motor control exercises

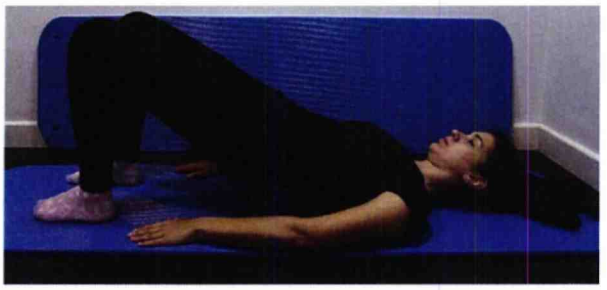
Repeat exercises twice a day, starting at level 1 (do not start next level until the previous one is done correctly).

Supine position

Level 1: isolated contraction of the transversus abdominis
Position: knees flexed, neutral pelvis.
Dose: 10 contractions of 10 seconds' duration each.
Instruction: place the fingers in the anterior superior iliac spine and slowly contract to try to pull them together.



Level 2: pelvic elevation with previous transversus abdominis contraction
Position: knees flexed, neutral pelvis.
Dose: 10 repetitions keeping the pelvis up for 5 seconds.
Instruction: previous contraction of transversus abdominis and descend in a controlled way.

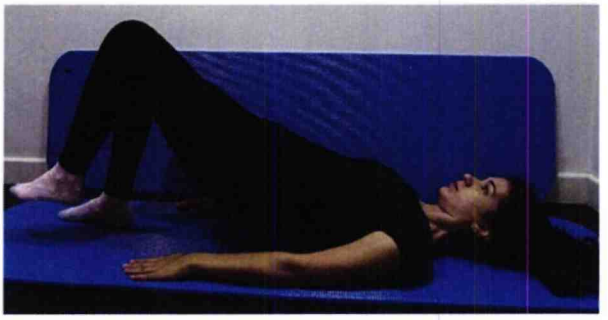


Level 3: progression: lift the foot 2cm from the ground while keeping the pelvis up

Position: knees flexed, up pelvis.

Dose: 10 repetitions (each time with 1 foot).

Instruction: keep transversus abdominis contraction throughout the exercise and descend in a controlled way.



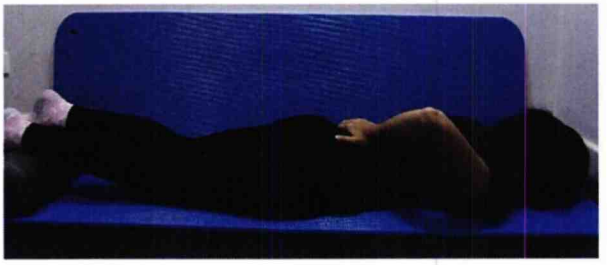
Prone position

Level 1: combined contraction of the transversus abdominis and multifidi

Position: knees flexed with the feet on a pillow, neutral pelvis, forearms and forehead resting on the mat.

Dose: 10 contractions of 10 seconds' duration each.

Instruction: think of moving the pelvis forward without actually moving it, place the fingers in the posterior superior iliac spine, and slowly contract to pull them together to feel the contraction of the multifidi muscles and then try to combine both.

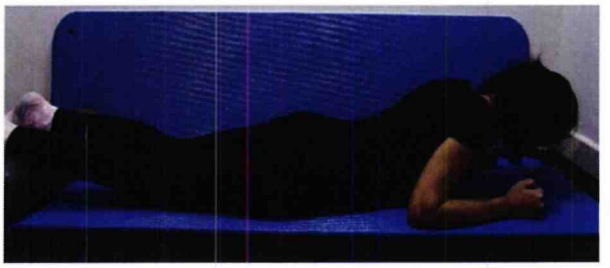


Level 2: head and shoulder lift on elbows

Position: the same as level 1.

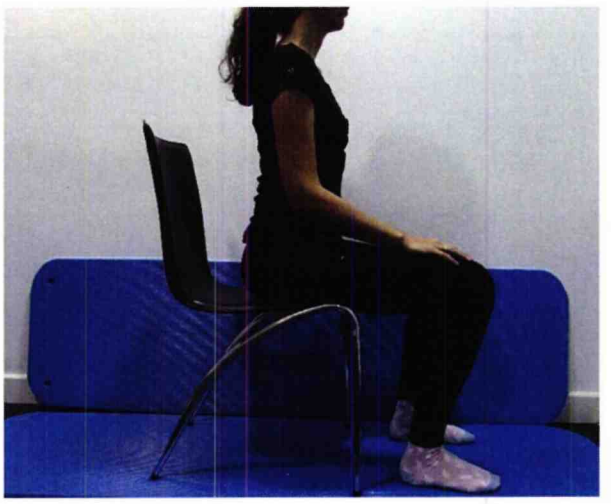
Dose: lift and hold for 5 seconds, 10 repetitions.

Instruction: keep the same contraction from the previous exercise and control it on the way down.



Seated

Postural correction in sitting: correct the posture keeping the feet on the floor in line with the hips, sitting on the ischiatic tuberosity (which they have felt with their hands), with the spine in neural position. Maintain this position using simultaneous contraction of the transversus and multifidi. Do this exercise as much as possible during daily activities.



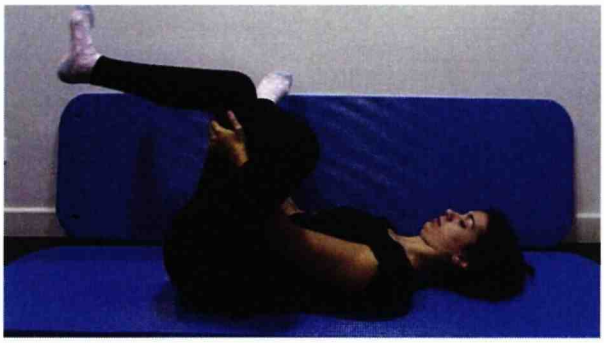
Stretching exercises

Three repetitions of 30 seconds' duration stretch (with 20 seconds rest between each repetition). Repeat stretching exercises twice a day after control motor exercises.

Starting at a point of slight muscle tension and increasing the range of motion into a tolerable muscle tension (without pain).

Piriformis stretch

In supine crook lying, place the lateral side of the foot over the contralateral knee and pull toward the chest with the hands.



Erector spine stretch

On the knees, sit on the heels, flex the trunk, and stretch the arms forward.

Aerobic exercise

Twenty- to 30-minute continuous walk at a plausible speed every day.

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