Pain Neuroscience Education Following Arthroscopic Rotator Cuff Repair for Patients With Rotator Cuff Tears

A Double-Blind Randomized Controlled Clinical Trial

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Objective: This trial examines the efficacy of the pain neuroscience education on clinical outcomes in patients with arthroscopic rotator cuff repair.

Design: A total of 36 participants undergoing arthroscopic rotator cuff repair were assigned to either the experimental group ($n = 18$) or control group ($n = 18$) in this randomized study. A 6-wk-long conventional physiotherapy program was administered for both groups. In addition, a pain neuroscience education protocol was administered for the experimental group for a whole period of 6 wks (1 session/week, 15–60 mins per session). The primary outcomes were to compare pretreatment and posttreatment scores of the experimental versus control groups on the pain and disability. Our secondary outcomes included the comparisons of scores on the catastrophizing, anxiety, depression, kinesiophobia, and quality of life. The participants were assessed both at baseline and posttreatment.

Results: The improvement in pain catastrophizing, anxiety, depression, and kinesiophobia was greater in the experimental group ($P < 0.05$). The improvement was similar in both groups in terms of the rest of outcome measures.

Conclusions: This study showed that the pain neuroscience education improved only psychological aspects of the chronic pain in arthroscopic rotator cuff repair. Therefore, adding pain neuroscience education to the conventional program might be useful to improve pain catastrophizing, anxiety, depression, and kinesiophobia in patients with arthroscopic rotator cuff repair.

Key Words: Pain, Rotator Cuff, Biopsychosocial, Neuroscience, Education

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What Is Known

- Educational strategy addressing neurophysiology and neurobiology of pain could have a positive effect on pain, disability, catastrophizing, and kinesiophobia. Therefore, emotional well-being and quality of life may improve especially if combined with exercises in patients with chronic pain.

What Is New

- Pain neuroscience education improves only psychological aspects of the chronic pain in arthroscopic rotator cuff repair (ARCR) rather than physical aspects. Therefore, adding pain neuroscience education to the conventional program might be useful to treat pain catastrophizing, anxiety, depression, and kinesiophobia in patients with ARCR.

Rotator-cuff tear (RCT) is a common complaint of shoulder pain and disability and one of the most common referrals to physiotherapy clinics.[1] Rotator-cuff tear reduces emotional well-being, health-related quality of life, and retention to work and increases the use of healthcare resources.[2] Various treatment options such as conservative and arthroscopic rotator cuff repair (ARCR) referring beneficial results exist for the management of RCT.[3] The rotator cuff has limited capabilities for healing without repair, yet conservative management often yields an acceptable outcome. As comparative evidence on treating RCT is inconclusive, a combined management is advocated as the treatment modality to RCT.[4]

Successful postoperative management after ARCR is dependent on several presurgical and postsurgical variables.[5] A number of studies have attempted to define those factors that could be relied upon to predict outcomes after ARCR.[6] There is a consensus that favorable results depend not only on the severity of the lesion or the number of degenerative changes but also on biophysiological factors.[5,6] Pain catastrophizing, pain-related anxiety, depressive feelings, diminished self-efficacy, and adverse life events are present to varying degrees in patients with ARCR.[5,6] Patients frequently develop poor affective and cognitive functions based on these factors. These cognitive-affective changes are related to an increase in pain catastrophizing, kinesiophobia, and disability.[7]

There is an ongoing body of research investigating the efficacy or effectiveness of the pain neuroscience education (PNE) in different pathologies, making it a potential adjunct treatment option.[8] Pain neuroscience education is a treatment

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strategy that focuses on teaching patients about key contributing factors in the generation of the experience of pain to influence their beliefs and behavior.[9] It consists of educational sessions describing the neurobiology and neurophysiology of chronic pain and pain processing, with a particular focus on the role of the central nervous system on chronic pain and deemphasizing anatomical issues. It promotes the patients' understanding of chronic pain and changes maladaptive thoughts and cognitions, which are important barriers to recovery.[8] There is evidence that an educational strategy addressing neurophysiology and neurobiology of pain could have a positive effect on pain, disability, catastrophizing, and kinesiophobia. Therefore, emotional well-being and quality of life may improve especially if combined with exercises in patients with chronic pain.[10]

Considering these principles, the PNE seems to be a potential action mechanism in patients with ARCR.[11,12] Therefore, we aimed to examine the efficacy of the PNE on clinical outcomes in patients with ARCR. The primary outcomes were to compare pretreatment and posttreatment scores of the experimental versus control groups on the pain and disability. Our secondary outcomes included the comparisons of scores on the catastrophizing, anxiety, depression, kinesiophobia, and quality of life. It was hypothesized that the PNE could be an effective approach for the intended features.

METHODS

Study Design

This double-blind, randomized, controlled clinical trial was registered with the Clinical Trials Registry (NCT05277077). The study protocol was approved by the local ethics committee (2022/281). Patients were informed about the study and obtained their written consent. The CONSORT guidelines were followed (See Supplementary Checklist, http://links.lww.com/PHM/C355).

Participants

The study population consisted of 36 patients with small and medium-sized RCT, who admitted to the orthopedics and traumatology outpatient clinic. All the patients were referred to the physiotherapy clinic after ARCR.

The inclusion criteria were as follows: being 18–65 yrs old; being diagnosed with an RCT not exceeding 3 cm based on magnetic resonance imaging and clinical continuity tests; history of ARCR; using a velpeau bandage up to postoperative 6th week, compliance to range of motion exercises including pendulum exercises, passive flexion and abduction stretching, and active cervical movements (completing the range of motion exercises with ≥80% compliance was an inclusion criterion. The compliance rate was obtained using routine diaries), and volunteering to participate in the study.[13]

Patients with diabetes mellitus; neurological problems; cervical disc herniation; visual, verbal, and/or cognitive defects; systemic inflammatory problems; trauma, contraindications for mobilization; former shoulder fractures and surgery; a history of adhesive capsulitis; and traumatic shoulder instability; patients who were in ≥stage 3 on the Goutallier system; and those who received a corticosteroid injection on the affected side within 6 wks before diagnosis were excluded.[13]

Randomization

A simple computer-generated randomization was carried out by a secretary who was not directly involved in the study. The allocation was concealed using consecutive numbered, sealed, and opaque envelopes. The participants were randomly assigned to either the experimental group (conventional treatment + PNE) or the control group (conventional treatment only).

Blinding

Given the nature of the study, it was not possible to blind the physiotherapist to the interventions. The patients were informed about the study being a comparison between two physiotherapy treatments. At the end of the study, to evaluate blinding, the blinded physiotherapist was asked whether each patient was allocated to the experimental or to the control group. Statistical analysis was also performed by a blinded researcher. The researcher did not have the knowledge of the groups (e.g., experimental group were assigned as group Y) when statistical analysis performed.

Interventions

Conventional Treatment Methods

Seven-year experienced physiotherapist administered the 6-wk-long treatment program (a total of 30 sessions, 5 d/wk, 90 mins per session) for both groups. This program was designed according to the current guideline.[3] Progressive strength and perturbation exercises were not included in our treatment program as these exercises are recommended only for individuals working in heavy jobs and athletes with frequent overhead sportive activities. Conventional program was given in Table 1.

Pain Neuroscience Education

In addition to the conventional treatment, a PNE protocol was administered for the experimental group for a whole period of 6 wks (1 session/week, 15–60 mins per session) by 3-yr experienced physiotherapist. The PNE sessions were conducted in line with international guidelines and covered the neurophysiology of pain (e.g., neuron and synapse), transition from acute to chronic pain, the nervous system ability to modulate the pain experience (e.g., descending nociceptive inhibition and facilitation, peripheral sensitization, and central sensitization).[8,14] The PNE aimed to reconceptualize patients' beliefs about pain, to increase their knowledge of pain and to decrease its threat. The theoretical information was complemented with pictures and diagrams based on previous procedures. A slide presentation (PowerPoint, Microsoft Corp., Redmond, WA) prepared by the instructor was used in all sessions. A booklet with the contents of each session and containing a mixture of text, figures, and activities to perform between sessions was developed for the study purpose and given to participants. Time devoted to PNE decreased from session 1 (60 mins) to session 6 (15 mins). The sessions were conducted in face-to-face, one-on-one sessions. A detailed description of the PNE protocol is presented in the study by Saracoglu et al. In addition to Saracoglu et al.' program, the 5th and 6th sessions continued as question and answers related to the former sessions.[15] The PNE sessions were designed according to the highlights shown in Table 2.

TABLE 1. Conventional treatment program

First 3 wks of the Program	Second 3 wks of the Program
Duration: The 90-mi-long training sessions were held 5 days per week, and each exercise was performed in 3 sets of 10 repetitions. A 1-min rest period was applied between sets and 2 mins between different exercises.	*Duration:* The 90-min-long training sessions were held 5 days per week, and each exercise was performed in 3 sets of 10 repetitions. A 1-min rest period was applied between sets and 2 mins between different exercises.
1. Cold-pack on the shoulder for 20 mins	1. Strength training using elastic band with the elbow in extension (long lever-arm)
2. 20 mins of Conventional TENS (60–120 Hz)	2. Arm elevation to keep the supraspinatus activation level below 50%
3. 3 mins of soft tissue massage for deltoid and biceps muscles	3. Rolling a ball on the wall
4. Scapula and glenohumeral joint mobilizations	4. High-medium-low intensity scapular rowing
5. Towel sliding and duster slide exercises on the wall in standing position	5. External rotation in prone and side lying positions holding a free weight equal to 25% of maximal voluntary muscle contraction (calculation based on the 1-maximum repetition of the unaffected side)
6. Wand-assisted bilateral shoulder elevation up to 120°	6. Internal rotation in prone and side lying positions holding the same weight
7. External rotation in increasing abduction angles	7. Resistance training with the elastic band in throwing and forward punching
8. Internal rotation in abduction, horizontal adduction and functional internal rotation exercises (hand dorsum on lumbar spine and gradually higher)	
9. Strengthening exercises in the supine and side lying positions with the elbow in flexion (to shorten the lever-arm)	
10. Finger ladder exercises	
11. Activation of deltoid, rotator cuff, and scapular muscles at chest level as the degree of active elevation increases	
12. anterior elevation using an elastic band in the supine position	
13. Strength training in "Full Can" (thumb up) position with 0.5 kg weight	
14. Closed kinetic chain trainings in static quadrupedal position	
15. Isometric exercises of the periscapular muscles, deltoid and trapezius	
16. Posterior capsule stretching	

Outcome Measures

Demographic characteristics of the participants were recorded. While pain and disability were our primary outcomes, catastrophizing, anxiety, depression, kinesiophobia, and quality of life constituted our secondary outcomes. Visual analog scale (VAS)[16] was used to assess pretreatment and posttreatment pain severity. Shoulder Pain and Disability Index[17] and the Disabilities of the Arm, Shoulder and Hand Questionnaire[18] were used to assess functionality. The participants were evaluated with the following reliable, valid, and culturally adapted tests and tools in terms of catastrophizing, anxiety, depression, kinesiophobia, and quality of life: Pain Catastrophizing Scale,[19] Hospital Anxiety and Depression Scale,[20] Tampa-Scale of Kinesiophobia,[21] and 12-Item Short-Form Health Survey.[22] Measurements were performed twice, before (postoperative 6th week) and after (postoperative 12th week) 6-wk-long physiotherapy program (conventional treatment + pain neuroscience education or conventional treatment only).

TABLE 2. Highlights related to the PNE sessions

1	Pain is an output of the brain, %100 of the time.
2	Pain is a perception, and the brain regulates all experiences of the pain.
3	Pain does not equal the amount of tissue damage.
4	The issue may not be in the tissue.
5	Your pain may be coming from a sensitive "alarm" system, not from the body area that hurts.
6	Pain is influenced by multiple factors such as thoughts, activity, stress, etc.
7	Acute pain serves a useful protective function to warn of danger of injury.
8	Chronic pain results from a hypersensitive nervous system and usually no longer warns of damage.

Sample Size

With reference to Zhang et al. results of the VAS scores after 6 wks of treatment and using G*Power Software (Version 3.1.9.2, Düsseldorf University, Düsseldorf, Germany), the minimum required sample size was calculated as 32 participants for the anticipated effect size of 0.44 with the probability level of 0.05 and statistical power level of 80% [*F* test (analysis of variance): repeated measures, between factors].[23] Considering a dropout rate of 10%, 36 participants were recruited.

Statistical Analysis

The IBM® SPSS® Statistics for Windows software (ver. 22.0; IBM Corp., NY) was used for statistical analysis. Descriptive statistics were expressed as mean ± standard deviation (mean ± SD) for continuous variables, and ratios (%) for categorical variables. Basic parameters of the groups were compared using independent samples *t* test and χ^2 test. Paired-sample *t* test was used to determine within-group differences before and after the treatment. Two-way repeated measures analysis of variance in mixed design [independent factor: group (experimental vs. control group); repeated factor: time (pretreatment vs. posttreatment)] was used to compare clinical outcomes in terms of time-dependent variation and group*time interactions. Partial eta square was calculated to classify effect size (ηp^2) [($\eta p^2 = 0.0099$, small effect size), ($\eta p^2 = 0.0588$, medium effect size), ($\eta p^2 = 0.1379$, large effect size)].[24] The Bonferroni post-hoc test was used for significant differences

detected for time variation or group*time interaction. Statistical significance was set at $P < 0.05$.

RESULTS

Thirty-six participants equally distributed between experimental (49.9 ± 11.2 yrs, 11 females, 29.1 ± 5.4 kg/m^2) and control groups (51.9 ± 8.7 yrs, 10 females, 30.3 ± 6.3 kg/m^2) were recruited between April 2022 and November 2022. However, four participants, two from the experimental group and two control, dropped out, and therefore equally distributed 32 participants were included in the analysis. The study flowchart was presented in Figure 1. All demographics were similar between groups (Table 3). There was no difference between the groups in terms of baseline clinical outcomes ($P > 0.05$, Table 4).

Comparison of the outcome measurements within (experimental: Fig. 2, control: Figure 3) and between the groups (Fig. 4) were shown in Table 4. There were significant within-group differences with large effect sizes for both experimental (all $P < 0.001$, ηp^2_{range} = 0.51–0.81) and control groups (all $P < 0.02$, ηp^2_{range} = 0.51–0.81) in terms of pain and disability as primer outcome measurements. However, pain and disability did not differ between study groups (P_{range} = 0.10–0.85, ηp^2_{range} = 0.001–0.09).

There were significant within-group differences with large effect sizes for the experimental group in terms of pain catastrophizing, anxiety, depression, and kinesiophobia as seconder outcome measurements (all $P < 0.01$, ηp^2_{range} = 0.21–0.36), while there was not any significant within-group differences for the control group (P_{range} = 0.30–0.80). For the between group difference in pain catastrophizing, anxiety, depression, and kinesiophobia, the experimental group was significantly better than control group with medium to large effect sizes (P_{range} = 0.01–0.04, ηp^2_{range} = 0.13–0.20). Lastly, there were significant within-group differences with large effect sizes ($P < 0.001$, $\eta p^2 = 0.51$) for the experimental and control groups in terms of the physical component of the quality of life, but no between group difference ($P = 0.16$, $\eta p^2 = 0.07$). For the mental component of the quality of life, there was no either within ($P = 0.98$, $\eta p^2 = 0.000$) or between group ($P = 0.93$, $\eta p^2 = 0.000$) difference.

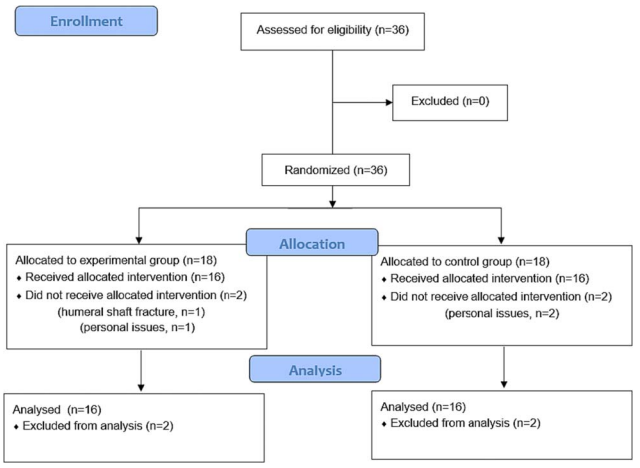

FIGURE 1. The study flowchart and details of adherence to treatment.

TABLE 3. Participant characteristics. The experimental group (conventional treatment + pain neuroscience education) vs the control group (conventional treatment only)

Demographics	Experimental (n = 18)	Control (n = 18)	P
Age (yrs)	49.9 ± 11.2	51.9 ± 8.7	0.55
Sex (female: male)	11: 7	10: 8	0.74
Body mass (kg)	79.1 ± 12.0	82.2 ± 11.2	0.43
Height (cm)	165.3 ± 8.2	165.7 ± 9.3	0.91
Body mass index (kg/m^2)	29.1 ± 5.4	30.3 ± 6.3	0.56
Dominant side (right: left)	17: 1	16: 2	0.55
Injured side (right: left)	12: 6	13: 5	0.72
Anteroposterior tear size (mm)	17.3 ± 2.2	17.6 ± 1.8	0.68
Mediolateral tear size (mm)	12.4 ± 1.9	12.3 ± 2.4	0.94
Goutallier classification (1–4)			0.09
1	13 (72%)	8 (44%)	
2	5 (28%)	10 (56%)	
Education level			0.46
Primary school	10 (55%)	13 (72%)	
Secondary school	3 (17%)	3 (17%)	
High school	3 (17%)	2 (11%)	
University	2 (11%)	0 (0%)	

Mean ± SD values for the continuous variables. P values for differences in means between groups calculated using independent t test or Mann-Whitney U test based on normal distributions, and χ^2 was used for categorical variables.

DISCUSSION

We conducted this randomized controlled trial to investigate the efficacy of the PNE on clinical outcomes in patients undergoing ARCR in order to provide evidence-based adjunct intervention option for clinicians seeking to manage chronic pain in RCT. We found that the PNE had no effect on pain and disability. Although psychological clinical outcomes such as pain catastrophizing, anxiety, depression, and kinesiophobia were not at clinically meaningful levels in baseline assessment, PNE still improved these outcomes significantly after intervention. Similarly, physical component of the quality of life was improved in both groups regardless of whether the PNE applied or not. Lastly, there was not any improvement in the mental component of the quality of life in both groups.

Our findings revealed that PNE had no direct effect on pain intensity and disability levels. These outcomes are in line with previous studies that have reported unsatisfactory results on the efficacy of PNE in directly reducing pain and functional limitations.[25–27] Ponce-Fuentes et al. conducted a randomized clinical trial in 29 patients with ARCR to compare effectiveness of the PNE versus biomedical education both in addition to the standard exercise program.[12] They found that either the PNE or biomedical education is equally effective in improving rest pain and disability, except for pain at movement in favor of the PNE group.[12] We found similar results as the PNE had no effect on pain and disability as both groups were improved with large effect sizes regardless of whether the PNE applied or not. The only difference was in pain intensity during activity, which could be resulted from the content and difference of treatment dosage between two studies as we applied five session instead

TABLE 4. Comparison of the outcome measurements between and within the groups

	Experimental (n = 16)				Control (n = 16)						
Outcome Measures	**Pretreatment**	**Posttreatment**	**Mean Differences (95% CI)**	P^a	**Pretreatment**	**Posttreatment**	**Mean Differences (95% CI)**	P^a	P^b	**Time P^c (ηp^3)**	**Group*Time P^c (ηp^3)**
VAS rest	3.5 ± 2.8	0.44 ± 0.63	3.1 (1.7–4.5)	<0.001	3.4 ± 2.9	0.56 ± 0.81	2.9 (1.4–4.4)	<0.001	0.95	<0.001 (0.56)	0.85 (0.001)
VAS activity	6.3 ± 2.4	3.3 ± 1.5	3.0 (1.7–4.3)	<0.001	6.2 ± 2.4	1.8 ± 1.7	4.4 (3.2–5.7)	<0.001	0.98	<0.001 (0.73)	0.10 (0.09)
VAS night	5.7 ± 3.4	1.3 ± 1.8	4.4 (2.6–6.2)	<0.001	4.5 ± 3.9	1.9 ± 3.1	2.6 (0.6–4.6)	0.02	0.33	<0.001 (0.51)	0.16 (0.07)
DASH	60.7 ± 13.2	30.0 ± 15.5	30.6 (22.4–38.9)	<0.001	60.1 ± 19.7	25.4 ± 15.8	34.7 (25.6–43.8)	<0.001	0.87	<0.001 (0.81)	0.48 (0.02)
SPADI	73.9 ± 33.1	25.1 ± 21.6	48.8 (34.4–63.1)	<0.001	82.0 ± 35.3	44.1 ± 24.5	37.9 (17.0–58.8)	0.002	0.22	<0.001 (0.64)	0.37 (0.03)
PCS	24.8 ± 13.1	8.4 ± 13.3	16.4 (9.9–23.0)	<0.001	15.5 ± 15.7	12.2 ± 15.8	3.3 (−4.7 to 11.3)	0.39	0.23	<0.001 (0.36)	0.01 (0.20)
HADS total	17.9 ± 10.8	5.6 ± 6.5	12.3 (6.6–17.9)	<0.001	10.8 ± 10.9	8.8 ± 10.3	2.0 (−4.1 to 8.1)	0.50	0.21	<0.001 (0.31)	0.01 (0.19)
HADS anxiety	8.6 ± 5.2	3.4 ± 4.4	5.2 (2.3–8.0)	0.001	5.9 ± 5.7	5.6 ± 5.8	0.38 (−2.7 to 3.5)	0.80	0.32	0.01 (0.21)	0.02 (0.17)
HADS depression	9.3 ± 6.4	2.2 ± 2.5	7.1 (3.7–10.4)	<0.001	4.8 ± 6.1	3.2 ± 5.0	1.6 (−2.2 to 5.5)	0.39	0.18	0.001 (0.30)	0.03 (0.15)
TSK	48.7 ± 9.4	28.9 ± 12.7	19.8 (12.0–27.6)	<0.001	38.9 ± 14.5	33.1 ± 19.5	5.8 (−5.6 to 17.2)	0.30	0.17	<0.001 (0.34)	0.04 (0.13)
SF-12 physical	31.8 ± 4.0	39.5 ± 5.5	−7.7 (−10.9 to −4.5)	<0.001	34.2 ± 7.3	38.8 ± 5.7	−4.5 (−7.9 to −1.1)	0.01	0.14	<0.001 (0.51)	0.16 (0.07)
SF-12 mental	45.3 ± 6.3	45.5 ± 8.5	−0.22 (−6.3 to 5.8)	0.94	41.7 ± 6.2	41.6 ± 7.0	0.11 (−4.8 to 5.0)	0.96	0.20	0.98 (0.000)	0.93 (0.000)

The experimental group (conventional treatment + pain neuroscience education) versus the control group (conventional treatment only).

[a]P = paired-sample t test.

[b]P = between group comparison at baseline, independent samples t test.

[c]P = two-way repeated measures ANOVA in mixed design.

DASH, Disabilities of the Arm, Shoulder and Hand Questionnaire; HADS, Hospital Anxiety and Depression Scale; PCS, Pain Catastrophizing Scale; SF-12, 12-Item Short-Form Health Survey; SPADI, Shoulder Pain and Disability Index; TSK, Tampa-Scale of Kinesiophobia.

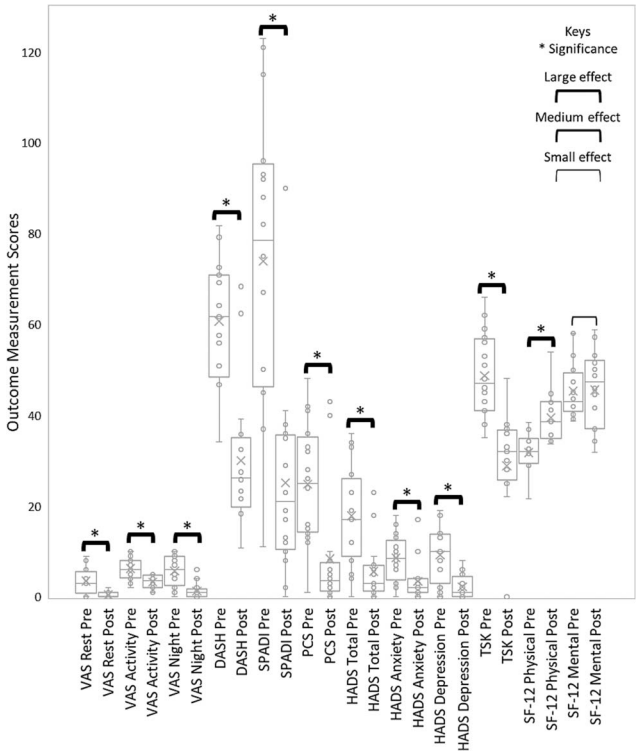

FIGURE 2. Pretreatment and posttreatment comparison of the outcome measurements for the experimental group (conventional treatment + pain neuroscience education). DASH, Disabilities of the Arm, Shoulder and Hand Questionnaire; SPADI, Shoulder Pain and Disability Index; PCS, Pain Catastrophizing Scale; HADS, Hospital Anxiety and Depression Scale; TSK, Tampa-Scale of Kinesiophobia; SF-12, 12-Item Short-Form Health Survey. The boxes represent the comparison of outcome measures before and after treatment for the experimental group. Whiskers represent the partial eta square, which was used to classify effect size (ηp^2). The effect size was classified as small ($\eta p^2 = 0.0099$), medium ($\eta p^2 = 0.0588$), and large ($\eta p^2 = 0.1379$).

of three and our program also included TENS and cold pack. Kim and Lee also investigated the effects of additional PNE on a rehabilitation protocol in 34 patients after ARCR.[11] Their rehabilitation protocol was shorter than our study but very similar (five times a week, for 4 wks, 115 mins per session including physical agents, manual therapy, and exercises).[11] They also did not find any improvement in pain and disability.[11] Another study investigated the effect of PNE versus usual preoperative education for 120 patients about to undergo total knee arthroplasty.[14] Similar to our findings, there was not any improvement in physical aspects of the chronic pain. The lack of significant change in pain and disability could be attributed to the multifactorial structure of chronic pain, which involves various underlying mechanisms and patient-specific factors. The pain intensity is linked to behavioral, psychological, and social factors. It is important to individualize explanations of these factors to the patient's context in patients with ARCR, as their influence could vary. We did not measure the preoperative pain scores of the participants. Because ARCR was the main treatment for the patients, a significant reduction in postoperative pain could be expected regardless of the group. The absence of differences between the treatment and control groups may be explained by this fact. Furthermore, the use of a unidimensional scale such as VAS for pain assessment instead of multidimensional pain assessment tools allowed for a biological assessment of pain. Multidimensional instruments could enhance the power and comprehensiveness of the analysis in terms of other domains of the pain. Moreover, PNE might require more extended or targeted interventions to have a pronounced effect on pain and disability outcomes.

We found that the adding a PNE training to the treatment program had no superior effect on quality of life subgroups, including physical and mental components measured by SF-12 compared to the conventional treatment solely. Current results seem consistent with the literature. It was suggested that the PNE does not improve the quality of life in patients with ARCR.[12] Physical component of the quality of life was improved in both groups regardless of whether the PNE applied or not, but this improvement was not detectable in terms of between-group comparison in our study. This could be attributed to factors beyond the specific intervention, such as the natural course of chronic pain conditions, changes in lifestyle or activity levels, or the influence of other nonspecific therapeutic effects. There was no significant improvement in the mental component of the SF-12 in either the experimental or control group. This finding is consistent with previous study

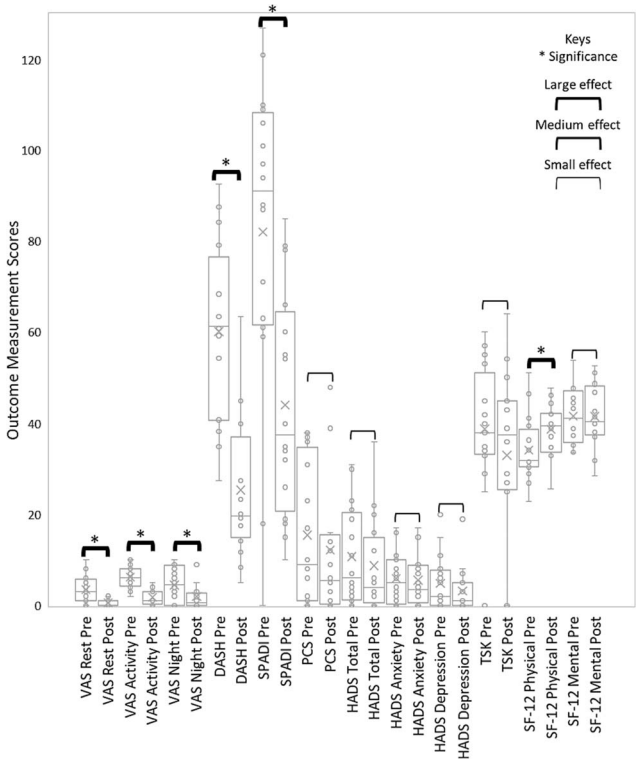

FIGURE 3. Pretreatment and posttreatment comparison of the outcome measurements for the control group (conventional treatment only). DASH, Disabilities of the Arm, Shoulder and Hand Questionnaire; SPADI, Shoulder Pain and Disability Index; PCS, Pain Catastrophizing Scale; HADS, Hospital Anxiety and Depression Scale; TSK, Tampa-Scale of Kinesiophobia; SF-12, 12-Item Short-Form Health Survey. The boxes represent the comparison of outcome measures before and after treatment for the control group. Whiskers represent the partial eta square, which was used to classify effect size (ηp^2). The effect size was classified as small ($\eta p^2 = 0.0099$), medium ($\eta p^2 = 0.0588$), and large ($\eta p^2 = 0.1379$).

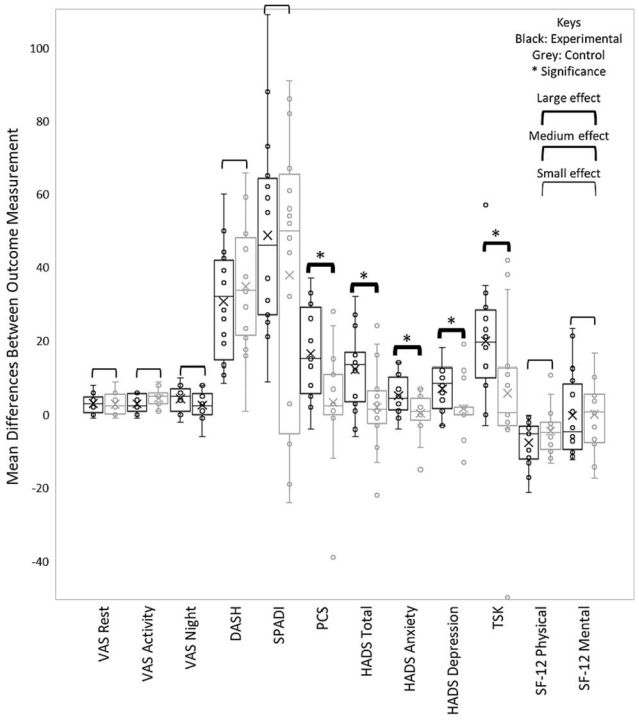

FIGURE 4. Between-group comparison of the outcome measurements. The experimental group (conventional treatment + pain neuroscience education) versus the control group (conventional treatment only). DASH, Disabilities of the Arm, Shoulder and Hand Questionnaire; SPADI, Shoulder Pain and Disability Index; PCS, Pain Catastrophizing Scale; HADS, Hospital Anxiety and Depression Scale; TSK, Tampa-Scale of Kinesiophobia; SF-12, 12-Item Short-Form Health Survey. The boxes represent the comparison of outcome measures before and after treatment for the between-group differences. Whiskers represent the partial eta square, which was used to classify effect size (ηp2). The effect size was classified as small (ηp2 = 0.0099), medium (ηp2 = 0.0588), and large (ηp2 = 0.1379).

suggesting that mental well-being may be more resistant to change with interventions, including PNE.[12] Addressing mental health aspects in chronic pain management often requires a comprehensive and multimodal approach that integrates various therapeutic modalities, including psychotherapy and mindfulness-based interventions.[12]

The implementation of PNE in patients undergoing ARCR has shown promising results, particularly in terms of pain catastrophizing, anxiety, depression, and kinesiophobia. In terms of psychological aspects of the chronic pain, our results were contradictory to other controlled trials,[8,10] but in line with systematic review study conducted by Siddall et al.[28] Their findings suggest that combining PNE and exercise in the management of chronic musculoskeletal pain results in greater short-term improvements in kinesiophobia and pain catastrophizing relative to exercise alone.[28] However, Louw et al. reported no difference in pain catastrophizing, but there was a detectable improvement in kinesiophobia for patients about to undergo total knee arthroplasty.[14] Similarly, another study reported that PNE in addition to a rehabilitation protocol did not improve pain catastrophizing and kinesiophobia (TSK harm and TSK total), except the TSK avoidance showed a significant difference between groups in patients with ARCR.[11] Although the study by Louw et al. had a very different setting, the one by Kim and Lee had a very similar setting to this study. The main difference was the duration of the treatment. However, in contrast, our findings were completely different as we found that the PNE improved pain catastrophizing, anxiety, depression, and total kinesiophobia score with medium to large effect sizes, and conventional treatment alone had no effect on any of these outcomes. Characteristics of the participants between two studies were also very similar, except body mass index and surgery procedure.[11] However, there is no clear explanation whether body mass index could explain this difference. In addition to this, we excluded the participants undergoing capsular release and biceps tenodesis from the study protocol. They also reported that either PNE or biomedical education is equally effective in improving pain catastrophizing and kinesiophobia in patients with ARCR, which contradict to our results.[12] However, their control group included a general biomedical education, which might explain the difference from our study. Because our control group was conventional treatment alone and they might decrease the effect of the PNE with another education in the control group. On the other hand, the results from systematic reviews were similar to our findings showing positive effect of the PNE in psychological aspects of the chronic pain in the musculoskeletal disorders.[1,8,10] By addressing maladaptive beliefs, negative cognitive patterns, and fear-avoidance behaviors associated with pain, PNE can facilitate patients to develop healthier coping strategies and improve their emotional well-being. The observed improvements in these domains are important, as psychological factors play a critical role in the overall experience of chronic pain and its management. Therefore, adding a PNE session to a traditional rehabilitation program might be useful to improve pain catastrophizing, anxiety, depression, and kinesiophobia.

One of the possible limitations was that we did not specifically measure the health literacy level.[29] Pain neuroscience education is a health-related education and might require high education level. However, it was reported that it had no clinical meaningful differences in effectiveness of PNE in terms of education level.[30] Pain neuroscience education was effective on psychological aspects, although general education level was similar and low (>50% primary school, <12% university) between groups. On the basis of aforementioned study and participants' low educational status, it seems that PNE is effective in improving several aspects of chronic pain regardless of educational status and health literacy. The main limitation was the absence of long-term follow-up, which should be addressed.

CONCLUSIONS

In conclusion, this trial showed that the PNE improved only psychological aspects of the chronic pain in ARCR rather than physical aspects. Thus, the PNE could be a useful adjunct intervention option to improve pain catastrophizing, anxiety, depression, and kinesiophobia in patients with ARCR. Therefore, we suggest adding PNE to a traditional treatment protocol for clinicians seeking to manage chronic pain in patient with ARCR.

REFERENCES

1. Yamaguchi K, Ditsios K, Middleton WD, et al: The demographic and morphological features of rotator cuff disease. A comparison of asymptomatic and symptomatic shoulders. *J Bone Jt Surg Am* 2006;88:1699–704

2. Osborne JD, Gowda AL, Wiater B, et al: Rotator cuff rehabilitation: current theories and practice. *Phys Sportsmed* 2016;44:85–92
3. Thigpen CA, Shaffer MA, Gaunt BW, et al: The American Society of Shoulder and Elbow Therapists' consensus statement on rehabilitation following arthroscopic rotator cuff repair. *J Shoulder Elbow Surg* 2016;25:521–35
4. Ryösä A, Laimi K, Äärimaa V, et al: Surgery or conservative treatment for rotator cuff tear: a meta-analysis. *Disabil Rehabil* 2017;39:1357–63
5. Kim SC, Shim SB, Kim WJ, et al: Preoperative rotator cuff tendon integrity, tear size, and muscle atrophy and fatty infiltration are associated with structural outcomes of arthroscopic revision rotator cuff repair. *Knee Surg Sports Traumatol Arthrosc* 2022;30:2029–38
6. Zhao J, Luo M, Pan J, et al: Risk factors affecting rotator cuff retear after arthroscopic repair: a meta-analysis and systematic review. *J Shoulder Elbow Surg* 2021;30:2660–70
7. Kennedy P, Joshi R, Dhawan A: The effect of psychosocial factors on outcomes in patients with rotator cuff tears: a systematic review. *Arthroscopy* 2019;35:2698–706
8. Louw A, Zimney K, Puentedura EJ, et al: The efficacy of pain neuroscience education on musculoskeletal pain: a systematic review of the literature. *Physiother Theory Pract* 2016;32:332–55
9. Wijma AJ, van Wilgen CP, Meeus M, et al: Clinical biopsychosocial physiotherapy assessment of patients with chronic pain: the first step in pain neuroscience education. *Physiother Theory Pract* 2016;32:368–84
10. Louw A, Diener I, Butler DS, et al: The effect of neuroscience education on pain, disability, anxiety, and stress in chronic musculoskeletal pain. *Arch Phys Med Rehabil* 2011;92:2041–56
11. Kim H, Lee S: The efficacy of pain neuroscience education on active rehabilitation following arthroscopic rotator cuff repair: a CONSORT-compliant prospective randomized single-blind controlled trial. *Brain Sci* 2022;12:764
12. Ponce-Fuentes F, Cuyul-Vasquez I, Bustos-Medina L, et al: Effects of pain neuroscience education and rehabilitation following arthroscopic rotator cuff repair. a randomized clinical trial. *Physiother Theory Pract* 2023;39:1861–70
13. Moosmayer S, Lund G, Seljom US, et al: At a 10-year follow-up, tendon repair is superior to physiotherapy in the treatment of small and medium-sized rotator cuff tears. *J Bone Jt Surg Am* 2019;101:1050–60
14. Louw A, Zimney K, Reed J, et al: Immediate preoperative outcomes of pain neuroscience education for patients undergoing total knee arthroplasty: a case series. *Physiother Theory Pract* 2019;35:543–53
15. Saracoglu I, Arik MI, Afsar E, et al: The effectiveness of pain neuroscience education combined with manual therapy and home exercise for chronic low back pain: a single-blind randomized controlled trial. *Physiother Theory Pract* 2022;38:868–78
16. Karartı C, Basat HÇ, Özsoy İ, et al: Biopsychosocial approach in identifying risk factors of kinesiophobia in persons with subacromial pain syndrome and developing a clinical prediction tool. *Indian J Orthop* 2023;57:124–36
17. Bumin G, Tüzün EH, Tonga E: The Shoulder Pain and Disability Index (SPADI): cross-cultural adaptation, reliability, and validity of the Turkish version. *J Back Musculoskelet Rehabil* 2008;21:57–62
18. Düger T, Yakut E, Öksüz Ç, et al: Kol, omuz ve el sorunları (disabilities of the arm, shoulder and hand-DASH) anketi Türkçe uyarlamasının güvenirliği ve geçerliği. *Fiz Rehabil* 2006;17: 99–107
19. Süren M, Okan I, Gökbakan AM, et al: Factors associated with the pain catastrophizing scale and validation in a sample of the Turkish population. *Turk J Med Sci* 2014;44:104–8
20. Aydemir Ö, Güvenir T, Küey L, et al: Hospital Anxiety and Depression Scale Turkish form: validation and reliability study. *Türk Psikiyatr Der* 1997;8:280e287
21. Yilmaz ÖT, Yakut Y, Uygur F, et al: Tampa Kinezyofobi Ölçeği'nin Türkçe versiyonu ve test-tekrar test güvenirliği. *Fiz Rehabil* 2011;22:44–9
22. Soylu C, Kütük B: SF-12 Yaşam Kalitesi Ölçeği'nin Türkçe formunun güvenirlik ve geçerlik çalışması. *Türk Psikiyatr Derg* Published online 2021
23. Zhang M, Zhou J, Zhang Y, et al: Influence of scapula training exercises on shoulder joint function after surgery for rotator cuff injury. *Med Sci Monit* 2020;26:e925758
24. Ozsoy G, Ilcin N, Ozsoy I, et al: The effects of myofascial release technique combined with core stabilization exercise in elderly with non-specific low back pain: a randomized controlled, single-blind study. *Clin Interv Aging* 2019;14:1729–40
25. Watson JA, Ryan CG, Cooper L, et al: Pain neuroscience education for adults with chronic musculoskeletal pain: a mixed-methods systematic review and meta-analysis. *J Pain* 2019;20: 1140.e1–1140.e22
26. Rabiei P, Sheikhi B, Letafatkar A: Examining the influence of pain neuroscience education followed by a Pilates exercises program in individuals with knee osteoarthritis: a pilot randomized controlled trial. *Arthritis Res Ther* 2023;25:94
27. Andias R, Neto M, Silva AG: The effects of pain neuroscience education and exercise on pain, muscle endurance, catastrophizing and anxiety in adolescents with chronic idiopathic neck pain: a school-based pilot, randomized and controlled study. *Physiother Theory Pract* 2018; 34:682–91
28. Siddall B, Ram A, Jones MD, et al: Short-term impact of combining pain neuroscience education with exercise for chronic musculoskeletal pain: a systematic review and meta-analysis. *Pain* 2022;163:e20–30
29. Marques ES, Meziat NAD, Ferreira PD, et al: Group pain neuroscience education combined with supervised exercises reduces pain and improves function of Brazilian women with central sensitisation and a low level of education: a single-subject study. *Eur J Physiother* 2019;21: 224–32
30. Bilterys T, Kregel J, Nijs J, et al: Influence of education level on the effectiveness of pain neuroscience education: a secondary analysis of a randomized controlled trial. *Musculoskelet Sci Pract* 2022;57:102494