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ORIGINAL RESEARCH

Comparison the Effect of Pain Neuroscience and Pain Biomechanics Education on Neck Pain and Fear of Movement in Patients with Chronic Nonspecific Neck Pain During the COVID-19 Pandemic

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ABSTRACT

Introduction: Self-management education is the basis of any intervention for persons with chronic musculoskeletal pain. Given the biopsychosocial nature of chronic musculoskeletal pain, an educational approach based on the biopsychosocial model would seem to be an appropriate educational model for the treatment of these people during coronavirus disease 2019 (COVID-19). The aim of this study was to compare the effect of pain neuroscience education (PNE) and pain biomechanics education, using online and face-to-face sessions on pain and fear of movement, in people with chronic nonspecific neck pain during COVID-19.

Methods: In this multicenter assessor-blinded randomized controlled trial, 80 patients (both male and female) with chronic nonspecific neck pain (based on the inclusion criteria of the study) participated in educational sessions (face-to-face and online) from the beginning September until the end of October 2021. The participants were randomly divided into two groups (through the selection of numbers from 1 to 80, hidden in a box), with one group receiving PNE (treatment group) and the other group receiving pain biomechanics education (control group). Pain and fear of movement before and after the intervention were measured on the Numerical Pain Rating Scale and the Tampa Scale of Kinesiophobia, respectively. A 2×2 variance analysis (treatment group $\times$ time) with a mixed-model design was applied to statistically analyze the data.

Results: No significant change in pain ($P = 0.23$) was observed between the two groups ($P = 0.24$, Cohen's $d = 0.17$, 95% confidence interval [CI] − 0.21 to 0.35), while changes in the fear of movement variable were reported to be significant ($P = 0.04$, Cohen's $d = 0.34$, 95% CI 0.11–0.51), in favor of PNE. Intra-group change was seen only in the PNE group for the fear of movement variable ($P = 0.04$; 14.28%↓).

Conclusion: In our study population PNE did not affect the pain index, leading to the conclusion that PNE should not be used as the only treatment, but possibly in combination with other active/passive therapy to enhance the results for patients with nonspecific chronic neck pain. Moreover, online treatment may help clinicians to increase their interaction with patients during COVID-19 lockdown.

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Keywords: Nonspecific neck pain; Pain; Kinesiophobia; Pain neuroscience education

Key Summary Points

Why carry out this study?

Self-management education is the basis of any intervention for patients with chronic nontraumatic neck pain.

This study aimed to compare the effect of pain neuroscience education (PNE) and pain biomechanics education using online and face-to-face sessions on pain and fear of movement in personse with chronic nontraumatic neck pain in COVID-19 lockdown.

What was learned from this study?

PNE might be used in combination with other therapy to enhance the results for patients with nonspecific chronic neck pain.

PNE might be useful to address fear of movement in people with chronic nontraumatic neck pain during COVID-19 lockdown.

Online treatment may help clinicians to boost their work with chronic musculoskeletal pain during the period of lockdown due to COVID-19.

INTRODUCTION

Neck pain affects between 12.1% and 71.5% of the world's population and is debilitating in more than 10% of cases [1]. In 70% of patients, there is no defined diagnosis of neck pain based on the structure involved, and in most cases no specific cause for neck pain has been reported; these cases are known as nonspecific neck pain [2]. Neck pain mainly affects adults and is associated with decreased quality of life, physical activity and mental health [3]. In most patients who experience neck pain, the pain recurs in the early years of the condition (in most cases the first year) [4]. Neck pain can be considered a social problem that has a significant impact on the condition of patients, family and work place as well as the national health system [4].

In chronic pain rehabilitation, it is essential to address factors such as the actual pain, the patient's beliefs and attitudes toward pain, such as the fear of pain and the avoidance of fear beliefs and how to manage chronic pain [5]. Therefore, patients at moderate or high risk of musculoskeletal pain require a supervised, personal exercise program [5, 6] which, if necessary, has cognitive-behavioral components [7, 8].

Given the biopsychosocial nature of chronic musculoskeletal pain, it seems that the educational approach based on the biopsychosocial model is an appropriate educational model for the treatment of these people. Various psychological issues and serious health concerns during the imposed quarantine/lockdown caused by coronavirus disease 2019 (COVID-19) have driven many changes in the treatment and exercise programs of these patients [9]. Although periods of quarantine are considered the best option to prevent the spreading of the infection, such isolation periods make substantial changes in people's lifestyle and become a serious issue in patients' healthcare [10]. Specifically, physiotherapy services for people with chronic neck pain were substantially reduced during COVID-19 [11].

If patients feel that pain is directly related to tissue injury or damage, they are more likely to have less control over the management of that pain [12]. The strategy to improve patients' autonomous motivation by increasing pain self-efficacy and therapeutic alliance is called pain neuroscience education (PNE) [13].

PNE is an educational method used by healthcare professionals to help patients understand the biology, physiology and psychosocial factors affecting their pain experience [12–14] and align them with defective cognitions and beliefs related to pain and recurrent disability [13]. It has been shown that PNE has positive effects on pain, [13] disability [11–13]

and psychosocial factors, [13]. The proposed mechanism of PNE is based on a change in the patient's perception and experience of pain [15]. The basic message is that pain indicates a perceived need to protect body tissues, not an injury or disease [16]. Allowing the patients to tell their story is one of the fundamental components in PNE which may result in more pain reconceptualization [17]. It has been reported that more research is needed to explore the standardization, reproducibility and effectiveness of applying PNE for pain reconceptualization in patients with musculoskeletal pain [18].

Previous studies of PNE have focused on patients with chronic low back pain [13, 19], chronic fatigue syndromes [15], fibromyalgia [20], both neck and low back pain [21] and chronic whiplash pain (14), as well as those undergoing surgery for lumbar radiculopathy [22]; however, studies patients with idiopathic chronic neck pain are lacking. Although neck pain is the second most common type of chronic pain, studies of PNE in patients with neck pain have been limited to patients with chronic whiplash-related neck disorders [21]. Also, online programs are now considered to be viable new solutions to encourage patients to use their own ability to manage their condition independently [22].

Based on the results and gaps of previous studies, this study aimed to compare the effect of PNE and pain biomechanics education using online and face-to-face sessions on pain and fear of movement in persons with chronic non-specific neck pain during COVID-19. We hypothesized that applying PNE would produce superior results primarily in pain and secondary in fear of movement compared to pain biomechanics education. If online pain education is able reduce pain and fear of movement in patients with chronic pain during COVID-19, clinicians are provided with an opportunity to help such patients overcome their conditions without the necessity of coming to a clinic. Moreover, online treatment during the period of lockdown due to COVID-19 might provide yet another means to reduce rapid spread of infection, to overcome psychological issues and patient's concerns, to provide clinicians with the opportunity not to restrict their work and to reduce annual health costs for both patients and healthcare services.

METHODS

This study is a multicenter, blinded-assessor randomized controlled trial (RCT). This RCT was conducted in accordance with the ethical standards of the Helsinki Declaration of 1964 and its later amendments. Kharazmi University Sports Science Research Ethics Committee approved the study protocol (IR.KHU.Rec.1400.013), following which the research protocol prospectively was registered in the Iranian clinical trial system (IRCT20150503022068N5). All participants provided informed consent to participate in the study.

For about 2 months (from the beginning of September to to end of October 2021, we circulated flyers in universities, university hospitals, and primary cares in the search for eligible patients with chronic nontraumatic neck pain to participate in the study. Ultimately, we selected 80 patients (both male and female; age range: 8–65 years old) from a statistical population of 140 persons who had been diagnosed with chronic nontraumatic neck pain by physicians who were not in the research team. All information on demographic characteristics and inclusion and exclusion criteria were collected through an online questionnaire filled out by the patients. All eligible patients were examined by physicians according to criteria to ensure that the selection process was performed in accordance with inclusion and exclusion criteria.

Inclusion criteria included men and women aged 18–65 years, Visual Analog Scale (VAS) score (range: 1–10) > 3 and < 8 in the last 24 h, history of neck pain (at least 12 weeks and 3 days a week), referral to medical centers to treat neck pain and no initiation of treatment or medication. The exclusion criteria included pregnancy, dissatisfaction with participation in research for any reason, lack of regular participation in training sessions (3 consecutive sessions), patients with spinal osteoporosis, a history of spinal tumors, participation in

training courses for the treatment of neck pain in the last 3 years, having criteria for referral to surgery (such as severe discopathy of the cervical vertebrae), having any fractures and surgery in the cervical spine in the last 3 years, injury during interventions and neck pain due to whiplash [23].

After the informed consent form was signed by the patients, the baseline data were collected by an assessor blinded to the group allocations. The patient was informed that they could leave the study at any time. After the initial evaluation, patients were randomly assigned to the PNE group (as an experimental group) or to the pain biomechanics education group (as a control group) by selecting numbers from 1 to 80 (hidden in a box; pre-prepared and packaged in sealed envelopes by an independent person).

The randomization sequence was not disclosed until patients completed their baseline assessments. The statistician and the assessor were blind to group allocation. Patients were not blind to the intervention, but did not know which group was the treatment therapy. The two groups in the study were monitored by a physiotherapist (with 15 years of experience) and a corrective movement instructor.

Patients in each group were excluded from the study if they had severe pain (score > 8 on the Numerical Pain Rating Scale [NPRS-11)] and did not attend three sessions. The number of falls in each group is reported in Fig. 1.

Sample Size Estimation

The sample size estimated to be needed for this research, based on the criteria for entering the research purposefully using G*Power 3.1.7 software and considering 80% (1 - β error probability) and α equal to 0.05 and the average effect size, was about 36 patients. Ultimately, 40 patients were assigned to each group (80 patients in total), including a 10% loss during the study.

Outcome Measures

Pre-test and post-tests of pain and fear of movement were performed, and the results assessed using the Numerical Pain Rating Scale (NPRS-11) and the Tampa Scale of Kinesiophobia (TSK), respectively.

The Primary Outcome: NPRS-11

The NPRS-11, an 11-point scale for self-reporting of pain, was used by patients to report pain. This is the most common scale used to report pain. The patient chooses a number between 0 and 10 that best shows the severity of their pain, with 0 indicating no pain and 10 indicating the most severe or worst pain. The validity of the NPRS scale in people with chronic pain is reported to be 0.95–0.86 [4]. The minimum detectable change (MDC) reported from the NPRS-11 is 2 points [24].

The Secondary Outcome: TSK

Kinesiophobia is a fear of movement caused by pain or re-injury that can be assessed based on the results of the TSK. The TSK questionnaire consists of 11 items, each of which contains 4 Likert options that range from strongly disagree to strongly agree. High TSK values indicate a high degree of fear of pain and movement. According to cutoff scores, a reduction of at least 4 points on the TSK maximizes the probability of correctly identifying a significant reduction in fear of movement [25]. The validity of the TSK Persian questionnaire has been verified, and the Cronbach's alpha level of this questionnaire was 0.82, indicating a good reliability [26]. Another study reported a minimal important change (MIC) value of 5.5 for the TSK, with an area under the curve of 0.996, a sensitivity of 95% and a specificity of 97% [27].

Interventions

All sessions of PNE for patients in the experimental group were performed by one of the study researchers who studied seven training sessions under the supervision of a physiotherapist. The principles of PNE were discussed by two of the leading researchers, and the educational materials, goals, agenda and activities of each session were presented and reviewed by the researchers. For post-session assessments, the participants in both groups were asked how

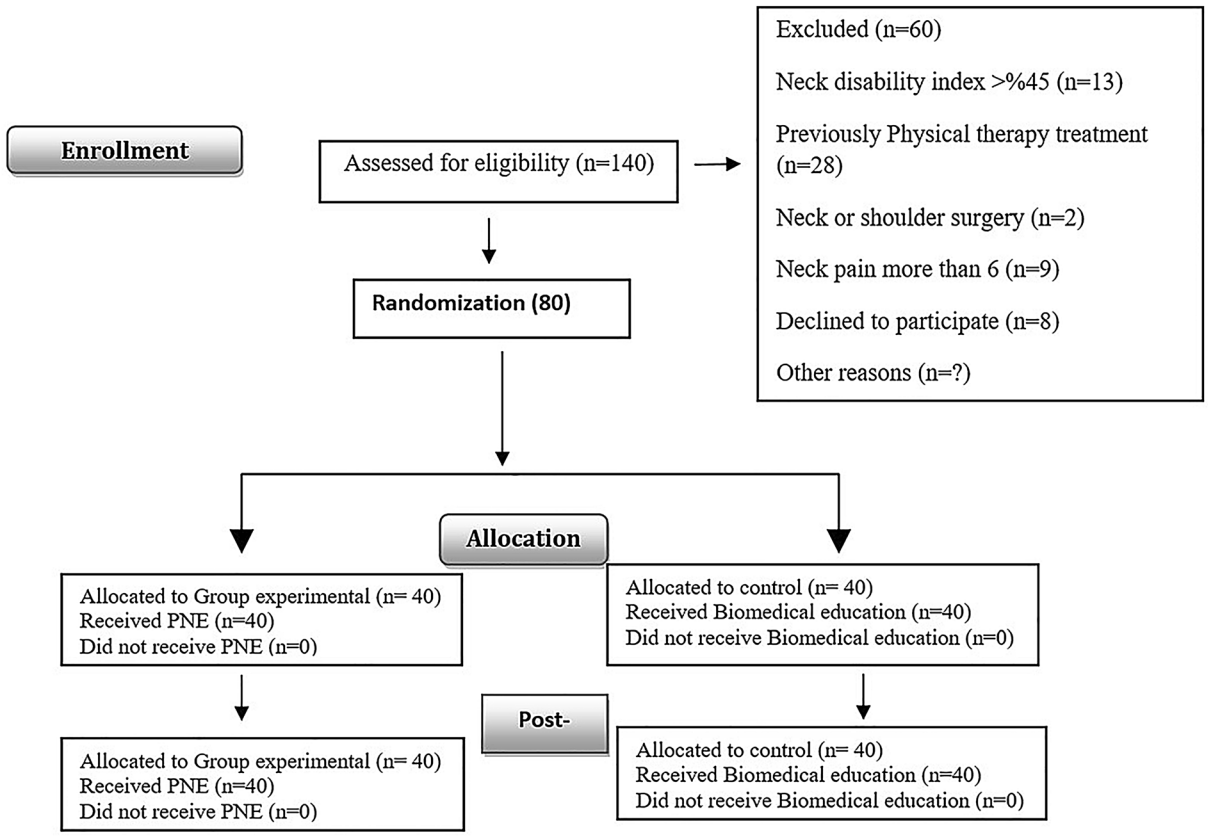

Fig. 1 Flow chart of patient enrollment. *PNE* Pain neuroscience education

they were satisfied with the face-to-face and online sessions; these questions were rated with scores ranging from 4 (strongly agree) to 0 (totally disagree), with higher scores indicating greater adherence.

PNE Protocol in the Experimental Group

For all patients in the experimental group, three introductory training sessions over a 2-week period were held to teach pain management approaches by researchers. The first session was a group session (duration: 30–60 min) with a maximum of six participants in each group. The second session, held in the form of e-learning, explained the same PowerPoint that was displayed during the first session. After each clip, participants were asked to complete a questionnaire, and their understanding and comments on the descriptions were assessed. The third session consisted of a 30-min one-on-one conversation that focused on the patients' personal needs: the questions in the second session questionnaire were analyzed and the use of this information in the patient's daily life was discussed [21].

The objectives and approaches of learning PNE in the experimental group were to reduce the severity of pain and fear of movement, increase patients 'awareness of pain and recognize pain [21]. All patients' questions about on neuroscience were answered online.

PNE Protocol in the Control Group

The biomedical content on pain, with a focus on neck biomechanics, was based on clinical guidelines and previous studies [28, 29] The questions in the online session were also related to the patient's understanding and opinions on

education; these included, as examples: "Which activities or movements cause you pain?"; "Do you know the importance of ergonomics?"; "What can you do to improve your posture at work?". In the third session, the therapist and the patient discussed the answers by relating the questions to the educational material.

Statistical Analysis

The Smirnov–Kolmogorov test was used to evaluate the normality of data distribution. Based on the research procedures, data were presented as mean ± standard deviation (SD). A 2×2 variance analysis (treatment group × time) was conducted with a mixed-model analysis design. For each variable, the percentage of change was calculated compared with baseline. All analyses were performed in SPSS software version 26 (SPSS IBM Corp., Armonk, NY, USA) at an alpha level of 0.05. The magnitude of the difference between groups was interpreted based on the effect size (Cohen's *d*), with $d \leq 0.5$ indicating a small effect size, $d = 0.5$–0.8 a moderate effect size and $d > 0.8$ a large effect size [30].

RESULTS

Eighty patients with chronic nonspecific neck pain participated in this study (See Fig. 1). The demographic characteristics of the patients, including sex, pain intensity, pain duration, weight, height and level of education, are presented in Table 1. The two groups (experimental treatment and control) were comparable at baseline, with no significant difference ($P > 0.05$) in the demographic and clinical variables between the groups. No undesirable or adverse event or dropout was reported. There was 100% adherence to all two interventions.

Information on dependent variables in the experimental and control groups is presented in Table 2.

A significant interaction between group and time ($P < 0.001$) was found for kinesiophobia ($P > 0.05$; Table 2). This result indicates that the changes in this outcome score were not equal between the two groups after the intervention.

Table 1 Demographic characteristics and baseline data of the patients participating in the study

Demographic characteristics	Control group (PNE group)	Experimental group (pain biomechanics education group)	*P*
Age (years)	44.5 ± 6.4	43.2 ± 7.6	0.21
Weight (kg)	57.3 ± 7.2	53.4 ± 7.6	0.32
Height (m)	1.54 ± 0.06	1.52 ± 0.07	0.41
Sex, *n* femal (%)	22 (55)	19 (47.5)	0.34
Pain duration (months)	4.6 ± 2.3	4.9 ± 2.8	0.44
Pain (Min–Max) (Visual Analog Scale score)	3–7	4–7	-
Educational level (*n*)			
Diploma	14	12	-
Undergraduate	16	13	-
Master degree and higher	10	15	-

Values are presented as the mean ± standard deviation (SD) unless indicated otherwise
PNE Pain neuroscience education

Following up on this interaction showed that there was no significant difference between the groups at baseline. However, the mean kinesiophobia score of the groups improved after intervention.

According to the results presented in Table 2, after the implementation of the PNE protocol, patients in the experimental group showed no changes in pain ($P = 0.23$) from baseline, while significant changes in the fear of movement were reported ($P = 0.04$).

The between-group comparison showed a significant difference between experimental and control groups in Cohen's *d* for the kinesiophobia variable (0.34; 95% confidence interval [CI] 0.11–0.51), $P = 0.04$), but not in Cohen's *d* for the pain variable (0.17; 95% CI -

Table 2 Between- and within-group changes in pain and kinesiophobia

Variable	Groups	Time point (mean ± SD)		Within-group changes		Relative changes to baseline	Between-group changes		
		Baseline	Post-test	Cohen's *d*	*P*		Changes relative to time	*P*	Cohen's *d* (95% CI)
Pain	NPRS	6.3 ± 0.4	5.0 ± 0.4	0.21	0.23	20.63%↓	$F = 2.21$	0.24	0.17 (- 0.21 to 0.35)
	Control	6.4 ± 0.5	5.6 ± 0.3	0.18	0.43	12.5%↓	$P = 0.13$		
Kinesiophobia	PNE	18.2 ± 3.0	15.6 ± 3.2	0.23	**0.04***	14.28%↓	$F = 13.01$	0.04¥	0.34 (0.11–0.51)
	Control	18.4 ± 2.9	17.7 ± 4.8	0.17	0.39	3.8%↓	$P = 0.04$		

CI Confidence interval, *d* effect size, NPRS Numerical Pain Rating Scale
*Significant within-group changes
¥Significant between-group changes

0.21 to 0.35, $P = 0.24$). No adverse side effects were reported in either group.

DISCUSSION

The quarantine and lockdown limitations imposed by COVID-19 reduced social and public life to a minimum. In this context, online treatment strategies offer one of the best options to treat patients who do not have easy access to therapists as well as patients who live long distances from healthcare facilities [31]. Online physiotherapy recommendations could be an inexpensive alternative to conventional physiotherapy, but its quality relative to routine face-to-face physiotherapy must be evaluated by researchers [32].

The aim of this study was to compare the effect of PNE and pain biomechanics education on pain and fear of movement in patients with chronic nonspecific neck pain who were living under the social limitations imposed by the COVID-19 pandemic, in both online and face-to-face sessions. The results of this RCT showed that after the implementation of the PNE protocol, the changes observed in pain ($P = 0.23$) reported by the experimental group were not significant, while changes in the fear of movement variable ($P = 0.04$) were significant. Also, inter-group changes were significant for the variable of fear of movement.

Regarding fear of movement, the PNE group showed significant reduction compared to the biomechanical education group. Both groups showed pre-test TSK scores that were around the cutoff for indicating fear of movement; however, only the PNE group showed decreases (small to moderate effect sizes; Cohen's $d = 0.34$) [30]. As the minimally important change cutoff for TSK is 5.5 [27], the observed changes in TSK could not be considered to be clinical meaningful after three sessions of applying PNE. Changes in kinesiophobia in the short term for the present study (↓0.34) are not greater than that of Malfliet et al. [21] (↓5.42), Tegner et al. [19] (↓5.73) and Wood and Hendrick [33] (↓4.72). Our results revealed PNE has an effect of − 14.28% on kinesiophobia in the short term, which is slightly more than the − 13.55% reported in previous review [29].

In a clinical trial study, Malfliet et al. [21] investigated the effect of combining PNE and online support on improving disability, catastrophic pain, fear of movement and perception of disease in patients with musculoskeletal pain (back pain and neck pain). The treatment group did not show a significant change in pain index, but significant interactions were observed regarding patients' fear of movement [21]. Also,

in a meta-analysis study that examined the effects of pain education on chronic musculoskeletal pain, the results showed a low clinical association between pain education and reduction of pain in the short and medium term; in contrast, for fear of movement (short term) and catastrophic (medium term), these authors reported positive clinical association results [17].

Our results showed that education-only approaches of PNE could not change pain intensity, which is in accordance the the results reported in a systematic review [12]. Previous studies examining PNE combined with active or passive therapy [13, 15, 20, 34] have reported an improvement in pain, which was not observed in our study. It should be noted that in these previous studies, the study population comprised patients with neck pain from whiplash or patient populations with different musculoskeletal pain, in contrast to our study population.

The goal of PNE is to change patients' perceptions of what pain is, how pain works and the biological processes associated with pain [35]. The basic message hoped to be delivered through PNE is that pain is a sign to protect body tissue and is not necessarily a sign of injury or disease [12]. The patient who is provided with PNE is more likely to develop coping strategies and behaviors that lead to a lower fear of movement and better functioning in their daily lives [16].

PNE focuses on describing increased spinal excitability induced after peripheral noxious input that was spatially restricted and explaining increased pain perception after injury and pain perception [36]. This feeling of vulnerability to painful injury or re-injury may result in kinesiophobia or fear of movement [35]. It has been suggested that knowledge through PNE may be an effective strategy to provide people with chronic pain with the knowledge to manage kinesiophobia or fear of movement and related disability, ultimately improving treatment outcomes [37].

The different results of the PNE studies mentioned above may be due the inclusion of patients with low back pain and other chronic musculoskeletal pain (low back pain, neck pain and fibromyalgia). In addition, it can be hypothesized that the dose, context and style of content delivery are all problems related to the therapeutic effectiveness of PNE. As suggested by Watson et al. [17], the effect of different doses of PNE on different patients with different musculoskeletal pain should be further investigated. These same authors stated that clinicians must have a common understanding of the subject to provide adequate PNE to patients [17]. Research has shown that some specialists do not have sufficient knowledge of pain neuroscience, which is an obstacle to adequately educating the patient on pain [17].

PNE changes the cognition and perception of pain by redefining pain. Due to this re-conceptualization, patients may acquire different perspectives on activities and movements that they feared prior to the education, possibly resulting in a re-evaluation of negative thoughts on pain. As a consequence of this re-evaluation, they also acquire a better perception of movement when in pain [12]. All of these effects may lead to the patient paying less attention to pain. These positive effects of PNE are important because patients may find themselves less incapacitated, which leads to increased activity. Given the importance of physical activity in the treatment of nonspecific neck pain, [16], PNE may become an essential part of nonspecific neck pain interventions.

The results of the present study show a significant effect of PNE on the fear of movement index in a sufficiently large sample of people with nonspecific neck pain; as such they can make an important contribution to the body of literature on the treatment of patients with chronic nonspecific neck pain. However, the lack of significance of the effect of the protocol on the pain index suggests that future research should be conducted on changes in the intervention or characteristics of the providers (occupation, work experience, postgraduate hours, age and gender). The lack of significance of PNE in the pain index on patients may be due to the insufficient number of sessions and the lack of individual education sessions. Also, some patients may need more than three sessions of education because not all patients are ready to accept new beliefs on pain and may need more

time. Therefore, in the clinical field, the therapist must make sure that the education program is designed for the individual patient.

Further research should also consider including a long-term follow-up to see if the positive results of PNE persist over time. In addition, this study focused only on self-reported questionnaires, but further research should also consider objective outcome measures for pain and performance. Finally, this study provides evidence that face-to-face education alongside online training can be used in an educational setting. However, since there was no control group receiving the education without the online component, future research may focus on the best therapies for providing PNE by comparing different approaches.

CONCLUSION

The results of this RCT showed that face-to-face PNE and online support help to improve the fear of movement in patients with chronic nonspecific neck pain during the limitations to healthcare due to COVID-19. In our study, PNE did not affect the pain index, leading us to suggest that PNE should not be used as the only treatment; rather, PNE might become a key element in a comprehensive active rehabilitation program. Also, the results of pain biomechanics education showed that this training does not affect the improvement of any of the variables of pain and fear of movement. Future studies should compare PNE with online exercises, as well as PNE with face-to-face exercises, and consider the cost-effectiveness of such programs.

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Author Contributions. AL, YS, MH and ZK initially conceptualized and designed the study. AL, ZK, MH and YS provided methodological advice for the design of the study. The manuscript was written by AL and ZK and was reviewed by all authors. AL designed the statistical analysis. All authors provided critical revisions to the report and final approval of the manuscript. The principles of pain neuroscience education were presented and discussed by AL, YS and MH. Materials, goals, agenda and activities of each session were presented and reviewed by AL, ZK, YS and MH.

Disclosures. Zohre Khosrokiani, Amir Letafatkar, Malihe Hadadnezhad, Yahya Sokhanguei declare that they have no conflict of interest.

Compliance with Ethics Guidelines. This study is a multicenter, blinded-assessor randomized controlled trial. This randomized controlled trial (RCT) complies with the ethical standards of the Helsinki Declaration. First, Kharazmi University Sports Science Research Ethics Committee approved the study protocol (IR.KHU.Rec.1400.013) and then the research protocol prospectively was registered in the Iranian clinical trial system with the code of IRCT20150503022068N5. All participants provided informed consent to participate in the study.

Data Availability. The datasets generated during and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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