The Effects of Pain Neuroscience Education on Pain in a Healthy Population

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ABSTRACT
Background and Purpose: Pain neuroscience education (PNE) can improve pain understanding in people with pain. This study investigated a single session of PNE on pain knowledge, fear-avoidance beliefs, and pressure pain threshold in a healthy population.

Methods: Twenty-five healthy participants (mean age 23.5 ± 3.3 years) were randomized into a PNE group or a control group. Outcomes included pressure pain threshold using a pressure algometer, fear-avoidance beliefs (Fear-Avoidance Beliefs Questionnaire [FABQ]), and pain knowledge (Revised Neurophysiology of Pain Questionnaire [RNPQ]).

Findings: The PNE group demonstrated a significant increase in quadriceps pressure pain threshold (p=0.050, η²=0.163) and a significant improvement in pain knowledge (p=0.004, η²=0.324). A nonsignificant decrease in fear-avoidance beliefs was seen in the PNE group with a moderate to large effect size (p=0.081, η²=0.132).

Clinical Relevance: Improving pain understanding in healthy individuals may lower the risk of experiencing chronic pain. Conclusion: Pain neuroscience education can improve understanding of pain in healthy individuals.

Key Words: acute pain, pain science, pressure algometry, pressure pain threshold

INTRODUCTION
The understanding and treatment of acute and chronic pain have evolved rapidly in the past decade. It has shifted away from a biomedical paradigm that emphasizes tissue abnormality and pathology as a chief determinant of pain, to a new understanding that the pain experience is complex and multifactorial. This evolved understanding incorporates not only biological tissues but also considers the psychological and social aspects that affect the perception of pain in the brain. This perceptual component of pain has recently come to the forefront of literature regarding patients in chronic pain and the overall pain experience.¹⁻³

In patients with chronic pain, there is often an absence of biological tissue pathology despite the presence of continued symp-

toms. A large body of literature¹⁻³ supports the effect of psychological factors on perceived pain in these patients. Through examination of the hypothalamic-pituitary axis during periods of stress, compounded with symptom clusters, it has been demonstrated that the stress response in the brain can amplify or even manifest symptoms in patients suffering from chronic pain, despite the absence of acute tissue damage.⁴ This psychological component of pain has been shown to not only influence the perception of pain in these patients but also serves as a viable strategy for treatment as pain neuroscience education (PNE). This treatment approach aims to alter a patient’s beliefs about their pain experience.⁵⁻⁷ While the use of PNE in patients suffering from persistent pain across a multitude of diagnoses is well documented in the literature,⁸⁻¹⁰ a gap exists for the utility of PNE in patients experiencing acute bouts of pain, both from diagnosable pathologies and idiopathic causes.

This gap in pain research, largely due to the lack of funding, is becoming a growing problem for the American health care system. Currently, chronic pain accounts for an estimated total annual cost of $560-635 billion, with $261-300 billion coming from health care costs and $299-335 billion coming from the lost productivity of workers who are experiencing chronic pain.¹⁰ The literature does not account for the fact that most patients with chronic pain began with an acute bout of diagnosable or idiopathic pain, which for one reason or another did not properly resolve and developed into a persistent pain experience. This cycle leads to a considerable financial burden on both the health care system and the general economy.

Aside from treating patients with acute pain prior to it becoming chronic, there are options in managing chronic pain that may reduce the health care burden while simultaneously improving patient outcomes. Currently, research shows that over one-third of patients with chronic pain receive analgesic drugs or injections as a first option to manage chronic pain.¹¹ While this treatment may address the symptoms involved in the chronic pain experience, it does little to manage the underlying cause or improve long-term outcomes, ultimately resulting in frequent usage of the health care system and the concomitant necessity for high-cost pharmaceuticals. A possible option to subvert the extensive cost of pharmaceutical intervention is the introduction of education-based therapy for patients experiencing chronic pain. A meta-analysis by Losina et al that investigated pain management in osteoarthritis found that only 11% of studies examined the effects of behavioral interventions with a comparative 69% investigating pharmaceutical interventions.¹² In efforts to address this deficit and reduce the financial burden of individuals suffering from chronic pain, PNE may be an effective intervention for administration to healthy individuals during an episode of acute pain. Hence, the purpose of this study was to examine the effects of a PNE session on pain tolerance, pain knowledge, and beliefs about pain in healthy individuals. It was hypothesized that various positive effects on pain tolerance level, pain knowledge, and beliefs about pain would occur after a brief session of PNE.

METHODS
Study Design
All procedures were approved by the University of Central Florida Institutional Review Board. Individuals were initially screened for eligibility via a phone screening, and those deemed eligible were scheduled for the first of 2 sessions. During session 1, participants completed baseline questionnaires (further described in “questionnaires” subsection), underwent pressure pain threshold (PPT) testing, and were randomized by the same researcher (JM) into either a PNE group or a control group. The PNE group participated in a 10- to 15-minute educational session about pain at the end of session 1. Session 2 took place one week after session 1. Participants were encouraged to schedule the 1-week follow-up at the same time as session 1 to control for confounding variables. Participants in the PNE group could ask any questions regarding the education they received during session 1. Both groups completed pain knowledge/belief questionnaires...
and PPT was assessed. All procedures in each session were performed in the same two classroom locations at the University of Central Florida.

Participants
Participants were recruited from the community through flyers and word of mouth. Participants were excluded if they were under 18 years of age, previously received PNE at any point, recorded a score greater than 2/10 on the Numeric Pain Rating Scale, or if they described their health status as “fair” or “poor.” Participants were deemed healthy and eligible for the study when self-reporting general health status as “good” or “excellent.” Forty-three individuals were screened with 18 being deemed ineligible due to exclusion criteria. Twenty-five healthy individuals qualified for and participated in the study (Figure 1). All participants were made aware of the study procedures and signed written consent forms prior to participation.

Questionnaires
Screening questionnaire: A custom questionnaire was created and administered over the phone to assess eligibility for the study. The questionnaire screened for the following eligibility criteria: age, health status (poor, fair, good, excellent), pain level, and exposure to PNE.

General questionnaire: A custom questionnaire was created and administered during session 1 to collect the following: sex, ethnicity, prior pain experience, weekly physical activity, and sleep parameters.

Assessment of pain knowledge and beliefs about pain: This assessment used a combination of questionnaires including the Fear-Avoidance Beliefs Questionnaire (FABQ) and the Revised Neurophysiology of Pain Questionnaire (RNPQ) to assess pain knowledge and beliefs, using a numeric rating scale and true or false questions related to the pain assessment, knowledge, and beliefs of the participants.

Experimental Pain Outcome
Pressure algometry has been proven to be an effective way to determine an individual’s PPT and has demonstrated high levels of intrarater reliability on various anatomical landmarks in individuals with and without pain.14-16 A handheld digital algometer (PAIN TESTTM FPX, Wagner Instruments, Greenwich, CT) with a linear response force of 0 to 100 pounds of force (lbf) and a 1cm² round rubber covered tip was used to determine PPT at the anatomical sites used by Cruz-Almedia et al.17 This included the upper trapezius, quadriceps, and extensor carpi radialis on the dominant side of the participant after a trial on the webbing of the dorsum of the hand between the second and third digits. The average of 3 trials at each location was used for data collection, with rest periods between trials dictated by the participant. Pressure pain threshold force with the pressure algometer was applied at a rate of 1 pound of pressure per second. The following instruction was given to the participant: “I’m going to apply pressure to your muscle. I want you to tell me the moment the sensation changes from comfortable pressure to slightly unpleasant pain.” Slow pressure was applied until the participant said “now.” The researcher conducting the PPT assessment was blinded to groups of the participants. The location of the pressure was determined via the methods described as follows:

Upper trapezius procedure: The participant was in a seated position and a downward force was applied approximately to the midpoint between the seventh cervical vertebrae (C7) and the acromion along the upper trapezius muscle.

Quadriceps procedure: The participant was in a seated position with their feet on the floor and knees bent at 90°. A downward force was applied approximately halfway between the hip crease and the superior portion of the patella.

Extensor carpi radialis (ECR) procedure: The participant was in a seated position with their arm resting on a table with the elbow bent at 90°. The examiner palpated the belly of the ECR, and a downward force was applied.

Administration of PNE
Each participant in the intervention group went through a 10- to 15-minute educational intervention delivered by the same researcher using material in the book, Why Do I Hurt? by Louw.18 Main themes of this book have previously been used and its efficacy has been well-documented in numerous studies.2,8,19,20 The main themes of the book include the role of everyone’s ‘alarm system,’ tissue healing, central sensitization, and strategies for bringing nerve sensitivity back down to normal. Various images, metaphors, and examples were used to improve the understanding of the information. The format was conversational, and the participants were encouraged to ask questions throughout. The presentation did not specifically target any content requested in the questionnaires.

Statistical Analyses
To determine the overall effect of the PNE session, 5 separate one-way analyses of covariance (ANCOVAs) were used to examine the adjusted posttest quadriceps PPT, upper trapezius PPT, extensor carpi radialis PPT, and PPT was assessed. All procedures in each session were performed in the same two classroom locations at the University of Central Florida.

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The grouping was the independent variable and included 2 levels, intervention and control. The pretest and posttest values were used as the covariate and dependent variable, respectively. Prior to performing each ANCOVA, the homogeneity of slopes assumption was assessed via performing a regression analysis. Bonferroni-corrected post hoc pairwise comparisons were then used to examine the between-group differences. An alpha level of 0.05 was used to determine statistical significance. The ANCOVA's partial eta squared ($\eta^2$) statistic was calculated and values of 0.01, 0.06, and 0.14 corresponded to small, moderate, and large differences, respectively.

**RESULTS**
Participants (N=25) were randomized into intervention (n=13) and control (n=12) groups. Characteristics of the groups were similar and displayed in Table 1.

**Fear-Avoidance Beliefs**
Concerning changes in FABQ scores, the ANCOVA revealed that, although there was a difference in scores between groups, the difference was not statistically significant ($p=0.081$); however, a moderate to large effect size was noted ($\eta^2=0.132$). The FABQ was scored out of 96 points, with a higher score being associated with more fear-avoidance behaviors exhibited. The difference in mean postintervention scores was 13.08 points out of 96 for the intervention group and 17.33 points for the control group, with a lower score representing decreased fear-avoidance beliefs with activity (Figure 2). Figure 2 displays individual participant changes on the FABQ from baseline to 1-week postintervention. As dictated by the blue line, a decrease in mean score on the FABQ and overall fear-avoidance beliefs from baseline to post-intervention is seen in the PNE group (Figure 2A), but not in the control group (Figure 2B).

**Pain Knowledge**
The ANCOVA for the RNPQ scores showed a significant difference in scores between the control group and intervention group ($p=0.004$) and a large effect size ($\eta^2=0.324$). After adjusting for other variables, participants in the intervention group answered 7.752 questions correctly (out of 13 questions), while the control group answered 5.435 questions correctly after the intervention (Figure 3). Figure 3 displays individual participant changes on the RNPQ from baseline to 1-week postintervention. As dictated by the blue line, a decrease in mean score on the RNPQ and overall pain knowledge from baseline to post-intervention is seen in the PNE group (Figure 3A), but not in the control group (Figure 3B).

**Pressure Pain Threshold**
The ANCOVAs for the 3 different muscles tested during PPT revealed that the quadriceps testing site had the most meaningful difference between the groups with a large effect size ($p=0.050$, $\eta^2=0.163$). Force (14.04
Figure 3. Individual Participant Changes on the RNPQ from Baseline to 1-week Postintervention

**A**

**Pain Neuroscience Education Group**

Baseline 1-week Postintervention

**B**

**Control Group**

Baseline 1-week Postintervention

pounds) was needed to evoke discomfort in the intervention group, while only 10.78 pounds of force was needed for the control group (Figure 4). There were no significant differences between the groups for the upper trapezius (p=0.121, \( \eta^2=0.106 \)) or the extensor carpi radialis PPT scores (p=0.358, \( \eta^2=0.039 \)). Figure 4 displays individual participant changes in PPTs for the quadriceps muscle group from baseline to 1-week postintervention. As dictated by the blue line, an increase in mean PPT and overall pain tolerance from baseline to postintervention is seen in the PNE group (Figure 4A), but not in the control group (Figure 4B).

**Other Associations**

Bivariate correlations were examined to determine any existing relationships among the data collected from the baseline questionnaires and PPT results. These variables included PPT average scores for each muscle group, the FABQ and RNPQ scores, age of the participants, their average weekly minutes of exercise, average hours of sleep per night, average minutes it takes to fall asleep, and the change scores for the FABQ, RNPQ, and PPT testing. Upon analysis, no significant relationships were found among any of the variables in question.

**DISCUSSION**

It has previously been demonstrated that the application of PNE may decrease pain levels in individuals with chronic pain,\(^{8,26-27}\) however, few studies have investigated its usage on individuals without pain.\(^{5}\) The shortest duration of documented PNE sessions in current literature is 30 minutes,\(^{8,28-30}\) thus, this study is one of the first to find positive effects from a shorter, 10- to 15-minute, educational session. The current study reflects the potential use of a shorter session of PNE for individuals without pain.

It was hypothesized that various positive effects, including improved pain tolerance levels as well as pain knowledge and beliefs, would occur after administration of PNE in the healthy population. The results support that pain knowledge, PPT levels, and fear-avoidance beliefs were improved in a group that received a single 10- to 15-minute PNE session, compared to a control group.

A finding from this study that is consistent with current literature\(^{5,20,31,32}\) is the increase in pain knowledge after receiving a PNE session. The RNPQ was used to assess the level of pain knowledge. At baseline, the intervention group recorded an average score of 5.38 correct responses and the control group recorded an average score of 4.92 correct responses out of 13 questions. After administration of PNE, the intervention group’s average score was 7.85 correct responses (2.47-point increase), while the control group’s average score was 5.33 correct responses (0.41-point increase). This reinforces the belief that a short educational PNE session is powerful enough to make a statistically significant difference in an individual's knowledge of pain.

While there was not a statistically significant difference in the FABQ scores of participants in the PNE group when compared to the control group, a large effect size was observed from 10 to 15 minutes of PNE. This large effect size suggests that there may be merit to providing certain patients with short bouts of PNE to achieve a large effect on fear-avoidance beliefs.

Also, of important note, the quadriceps muscle group showed a statistically significant improvement in PPT in the PNE group when compared to the control group. This improvement is not only statistically significant, but it also demonstrated a large effect size. However, this muscle group was the only one to demonstrate a statistically significant change in PPT following PNE. Whether this was truly due to a change in pain perception or random chance should be further evaluated in future studies.

This study had a few inherent limitations that must be mentioned. To begin with, the sample size was relatively small (N=25) and for that reason, sampling not only has a greater chance of being affected by a potential outlier but also makes it difficult to generalize the results to the general healthy, young adult population at large. Additionally, there was low heterogeneity within the sample; most participants were selected from the first-year
cohort at the University of Central Florida’s Doctor of Physical Therapy program and, thus, more likely share many common traits. If a greater number of participants were used from the general population outside of health-related fields, the results may have been different. Furthermore, there was difficulty in standardizing the rate of application of the pressure algometer during testing. This limitation was reduced by having just one researcher apply all the algometer pressure measures after completing numerous practice repetitions at 1 pound of force per second.

In summary, the results of this study demonstrate that a single 10- to 15-minute bout of PNE can lead to improvements in pain knowledge and PPT, with potential improvements in fear-avoidance beliefs. These improvements may be useful in decreasing the number of patients that transition from acute to chronic pain, thus decreasing the future financial burden of individuals at risk of acquiring chronic pain. Future directions should be aimed to examine long-term results of this short educational intervention, as this study focused on short-term results of 1 week. Furthermore, analyzing the effects of multiple educational sessions may be warranted since that may have an increased effect on overall learning and retention. Other forms of acute pain stimuli should also be incorporated into future acute pain studies to determine potential differences in effects.

REFERENCES


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