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CASE REPORT: PAIN NEUROSCIENCE EDUCATION USING VIRTUAL REALITY

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ABSTRACT

This case study describes the delivery of pain neuroscience education (PNE) in conjunction with breathing and mindfulness strategies using virtual reality (VR) for a patient suffering from chronic neck pain. The patient was an 18-year-old high school girl, following a motor vehicle collision 10 months ago. The patient has previously not responded to massage, exercise and therapeutic modalities (ultrasound and electrical stimulation). Baseline assessment revealed pain ratings of 5/10 for neck pain and 6/10 for upper back pain (Numeric Pain Rating Scale - NPRS); a pain catastrophization score of 31 (Pain Catastrophization Scale - PCS), indicating “high” levels of catastrophising and a neck disability score of 21 (Neck Disability Index - NDI) indicating moderate disability. She underwent three sessions of PNE using VR, in combination with breathing and/or mindfulness. Pre- to post-treatment measurements showed reductions in neck and upper back pain, pain catastrophization, and positive shifts in pressure pain thresholds of the lower back. Overall NDI scores improved 29%. This case study indicates that VR-delivered PNE provides comparable results to what might be expected with therapist-delivered PNE and this combined approach warrants further investigation as a means to make PNE more accessible.

Ethical approval

Written patient consent was obtained to write this case study. Patient provided written consent for the use of her image in Figure 1.

Introduction

There is a global struggle with pain, especially chronic pain.¹ For example, 25.3 million adults in the United States are

suffering from daily chronic pain, adding an economic burden of \$560-635 billion dollars annually.¹ In physiotherapy (PT) pain neuroscience education (PNE) has emerged as an evidence-based educational approach, often used in conjunction with movement-based strategies to treat chronic pain.^{2,3} PNE is an educational strategy that teaches patients about the neurobiological processes involved in their pain experience and has strong evidence for treating chronic pain.^{2,4} Current evidence suggests that one-on-one, therapist led PNE results in superior outcomes compared to group PNE, yet group PNE has been shown to also yield positive outcomes and was superior from the perspective of cost-effectiveness to individualized one-on-one PNE.^{2,5} An emerging technology in healthcare education is virtual reality (VR),⁶ and to date a VR application of PNE has not been studied. Even though VR-led PNE has not been studied, it may potentially provide answers to current issues surrounding the clinical delivery of PNE including cost-effectiveness, patient engagement, adjunct and booster to clinician-led PNE, increased access to PNE in remote areas, patient-specific learning styles, decrease clinic distractions via full immersion into the virtual environment, etc.^{4,6-8} The aim of this case study was to describe the application and outcomes in a patient where PNE was delivered via VR and compare the results with previously reported therapist or group-led PNE sessions.

CASE DESCRIPTION

The patient is an 18-year-old high school female who was involved in a motor vehicle collision 10 months ago. Apart from being “shook up” from the accident, she denied any immediate symptoms at the accident site. She developed occipital and frontal headaches, and a gradual increase in neck and upper back pain over the following week, with no referral or neurological symptoms into her arms. She was seen by her primary care physician, who ordered a computerized tomography (CT) scan of her neck which showed no evidence of fracture. There was no evidence of a fracture. Over the course of the next 8 months she was seen intermittently by her physiotherapist, mainly utilising massage, range of motion exercises, therapeutic ultrasound, electrical stimulation and moist heat. During this period, her pain would fluctuate, but never really improve.

She reported that pain increased with stress, bending over, turning her head either way when driving and carrying a backpack. Pain was at its best when she was at rest. She was using over-the-counter anti-inflammatory medications (Ibuprofen) as needed. She worked part-time as a lifeguard during the summer, and was able to do so despite the pain. With the persistent pain, non-responsive to PT and difficulty with school activities (backpack, headaches interfering with studying, sitting long periods, etc.), she sought a second opinion from a PT clinic specialising in pain management.

PHYSIOTHERAPY INTERVENTION

The content of the PNE used a metaphorical alarm system

analogy to explain sensitization of the nervous system during a pain experience, leading to decreased pain thresholds for movement, emotions and activity, as part of the pain experience.^{9,10} The PNE session additionally explained, via the alarm metaphor, how various interventions including education, movement, sleep hygiene, breathing and mindfulness can decrease a sensitive alarm system and thus ease pain.^{9,10} The PNE was delivered via a VR system (BehaVR™), utilizing a headset and earphones (Figure 1). The VR sessions were delivered in a PT clinic. At the first session, the patient was familiarized with the VR headset, navigating the VR dashboard she was seeing as well as how to access each of the sessions utilizing a hand-held activator. The patient was seated in a private treatment room in a comfortable chair and the headset was placed on her head. The VR-led PNE sessions are uploaded via a wireless signal to the headset and the patient used a hand-held clicker to start, navigate and end her PNE session. The PT was not needed or in the room during the VR-led PNE. The software tracks the patient throughout the sessions, ensuring the patient fully completes each session. The VR system and software records duration of the session, pain ratings, satisfaction with the session as well as retention of knowledge from previous session (session 2 onward). The VR system provides a full 360-degree immersion including sound, as a means to provide a true sensory virtual environment.^{7,8}

Three sessions were delivered 1 week apart:

- Session 1 (15 minutes): Introduction to the sensitive alarm system, patient testimonial using PNE and breathing exercises.
- Session 2 (22 minutes): Recap of the sensitive alarm system, strategies to dampen down a sensitive alarm system (movement) and mindfulness session.

- Session 3 (26 minutes): Review of the sensitive alarm system, strategies to dampen down the alarm system (education and sleep hygiene) and a mindfulness session.

ASSESSMENTS

Upon initial assessment, the patient completed a review of systems form, demographic information and signed an informed consent form. Pain ratings for neck and upper back pain (Numeric Pain Rating Scale – NPR) (5/10 and 6/10 respectively), disability (Neck Disability Index – NDI) (21 – moderate disability) and pain catastrophisation (PCS) (31 – exceeding “high” level cut-off score) were recorded.¹¹ A detailed interview and physical examination screening was performed. To monitor the impact of the PNE VR formal measurements were taken prior to and immediately following PNE: Neck and upper back pain (NPRS), pain catastrophisation (PCS) and pressure pain thresholds (PPT) on the right upper trapezius, adjacent to the L3 spinous process and right hand web space.¹² Additionally, at each subsequent session NDI was completed. On a single question, “How likely are you to recommend this program to a friend or colleague?” utilizing a numeric rating scale (0 – not at all – 10 definitely) was used within the VR session to assess patient satisfaction.

RESULTS

The patient attended all three sessions. Results for the various outcome measures are found in Figure 2.

Overall NDI improved 29% and in each session neck pain dropped by 1 or more points after completion of PNE VR, thus meeting or exceeding minimal clinical important difference for chronic musculoskeletal pain (NPRS) of 1.0.¹³ In each session PNE VR had a positive influence on PCS, dropping

Figure 1 Clinical application of PNE VR



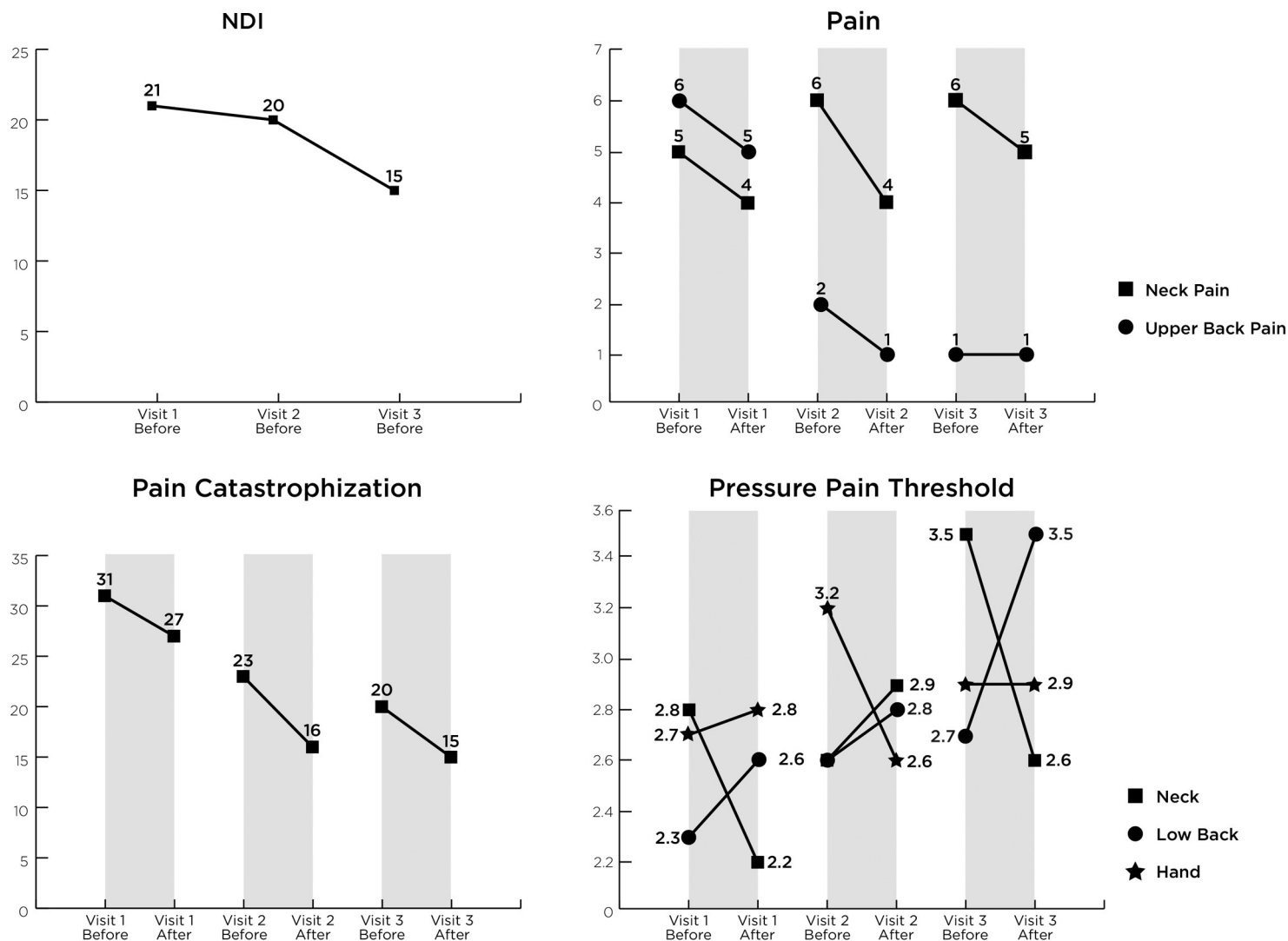


Figure 2 Results of PNE VR

PCS scores on average 5.3 points and overall PCS dropped below the “high threshold,” with a reduction of more than 50%.¹¹ The only PPT measurement that showed an increase was the low back, exceeding the proposed 15% needed for clinical importance,¹² while in contrast, PPT decreased for both the neck and web space. Throughout the VR sessions, the software reported a retention of the PNE information from one session to the next using the neurophysiology of pain questionnaire. The patient’s self-report satisfaction was high, scoring a perfect 10 in each of the 3 sessions.

DISCUSSION

This is the first documented study utilizing VR to deliver PNE. This case study design found a positive immediate change for both pain and PCS scores. Current PNE research points to reduction in PCS as likely one of the main mechanisms behind PNE success.^{2,14} This shift in pain catastrophization, altering threat appraisal is linked to activation of the endogenous release of opioids and cannabinoids.¹⁵ It is also important to notice in session 1, the PNE VR was able to lower the PCS score below the high threshold score of 30, which has been correlated to a higher likelihood of developing or maintaining chronic pain.¹¹ Even though on the lower margins of minimal clinical importance the PNE VR also eased pain from pre-

to immediate post treatment, concurring with current PNE research showing PNE to have a less robust effect on pain, yet function and psychometric measures (i.e., PCS) improve.² A surprising find was the lack of major shifts in PPT, yet these findings once again concur with current PNE research which is yet to show major shifts in PPT.^{2,16} These results, tentatively indicate that PNE VR can produce initial similar results to one-on-one (or group) PT-led PNE.^{2,5} It is important to note that the positive outcomes reported in this study cannot necessarily be contributed to PNE, since the VR sessions also included mindfulness and breathing activities. Furthermore, case studies can infer no causality and any changes seen could be due to multiple other factors that were not controlled for.

The question that arises, would be if VR could replace clinicians delivering PNE? Our group do not believe this is the case, nor the intent. Chronic pain is complex and the current interest in sub-grouping patients based on risk analysis, may provide an answer.¹⁷ For example, it could be argued that a complex patient case, i.e., central sensitization with numerous psychosocial issues, may indeed benefit more from a one-on-one personalized approach.¹⁰ This idea is substantiated by research focusing on therapeutic alliance, trust of the clinician and large-group PNE studies showing minimal effect, thus

implying a need for personalized care.¹⁸ In contrast, it could be argued that a patient presenting with a nociceptive dominant pain state and high levels of fear and/or catastrophization, could benefit just as much from PNE VR as PT delivered PNE.¹⁹ Finally, educational research has shown that a single PNE delivery session has limited efficacy and subsequent “booster” sessions improve knowledge retention. This identifies a potential avenue for the use of PNE VR in a clinical setting where return to the clinic may be difficult for the patient but access to a PNE VR system may be more easily accessible.²⁰

In summary, utilizing VR to deliver PNE is feasible within a PT practice. The current case resulted in both positive improvements in pain and a decrease in pain catastrophising. Future research should include a large case series and subsequent clinical trials to measure efficacy compared to other interventions.

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