HOME-BASED EEG NEUROFEEDBACK FOR THE TREATMENT OF NEUROPATHIC PAIN: A MIXED METHODS CASE REPORT

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Background and Rationale

- Neuropathic Pain (NP) is a common secondary complication following Spinal Cord Injury (SCI) and is largely refractory to current pharmacological and physical treatments.
- Current estimates suggest 67% of individuals experience post-SCI NP, with 27% at injury level and 35% below injury level[1].
- Neurophysiological studies utilising electroencephalography (EEG) have identified distinct patterns of brain activity associated with NP[2]. Individuals with SCI and chronic NP often exhibit suppressed EEG activity in the alpha frequency range (8-13 Hz) and abnormal activity in the theta (4-8 Hz) and beta (13-30 Hz) frequency bands[3].
- Electroencephalographic Neurofeedback (EEG-NFB) is a non-invasive neuromodulation technique that applies the principles of operant conditioning to facilitate self-regulation of EEG activity in areas of the brain associated with a particular disease, such as chronic NP.
- This case study describes a 44-year-old male with a 6-year history of chronic NP following a T5 ASIA B SCI, who trialled a home-based EEG-NFB intervention to treat the primary and secondary symptoms of chronic NP.
- Mixed methods were utilised to explore his response to treatment.

Methods

- The EEG-NFB training was performed using the Axon™ system, comprising a purpose-built EEG headset and proprietary tablet-based software app (Figure 1A).
- The App presents the user with a choice of 'games', e.g., a Jigsaw Game (Figure 1B).
- EEG activity was transmitted in real-time via Bluetooth to the app.
- In-game progress (e.g., completing a puzzle) was achieved when the participant upregulated his relative alpha power above the baseline threshold, established at the start of each session.
- Operant conditioning of the alpha band resulted from the visual reward of puzzle pieces moving into place and the auditory reward (bell ring) when activity was sustained above threshold for 750ms, encouraging enhanced neural firing within the target range.
- The participant completed 62 sessions over 10 weeks.
- In-app measures (pain/mood/sleep) were collected prior to each session.
- EEG power was analysed by calculating mean relative power values for each band (first five and last five sessions) from Week 0 to Week 10. Statistical significance was calculated using paired two sample t-test comparing means at Week 0 and Week 10.
- Qualitative data was collected via interview at Weeks 0, 6 and 10.

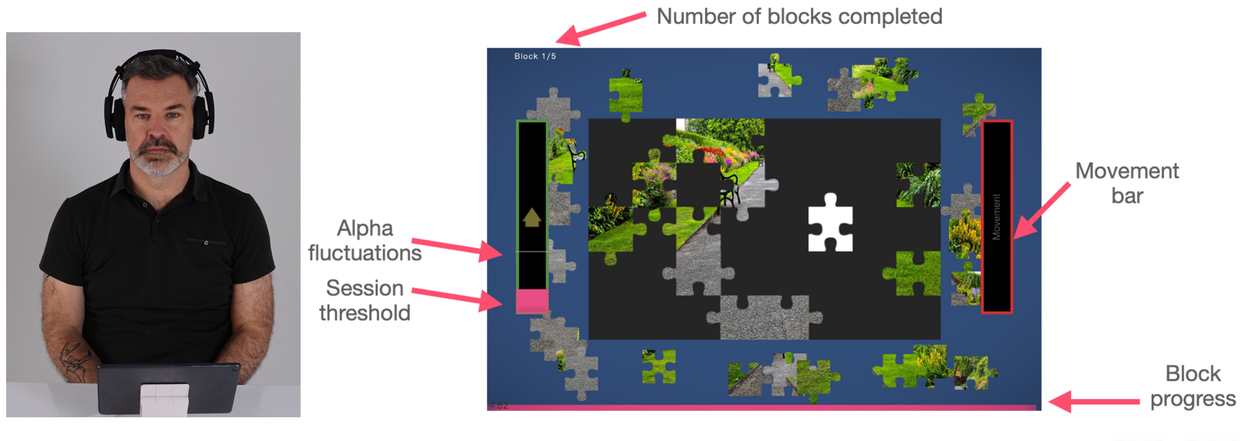

Figure 1: A: Axon neurofeedback system being demonstrated by a photographic model. B: Screenshot of one of the 'games' played by the participant

Results

- Pain scores showed an 83% reduction in pain at worst and an 80% reduction in average pain, pre to post intervention (Figure 2).
- Secondary measures of mood and sleep showed a 33% reduction in stress and a 60% increase in sleep quality.
- Resting-state relative alpha (t [4] = 5.18, $p = 0.007$), and theta (t [4] = 5.59, $p = 0.005$) activity was significantly upregulated.
- Resting-state relative high-beta activity was significantly downregulated (t [4] = 4.91, $p = 0.008$) (Figure 4).

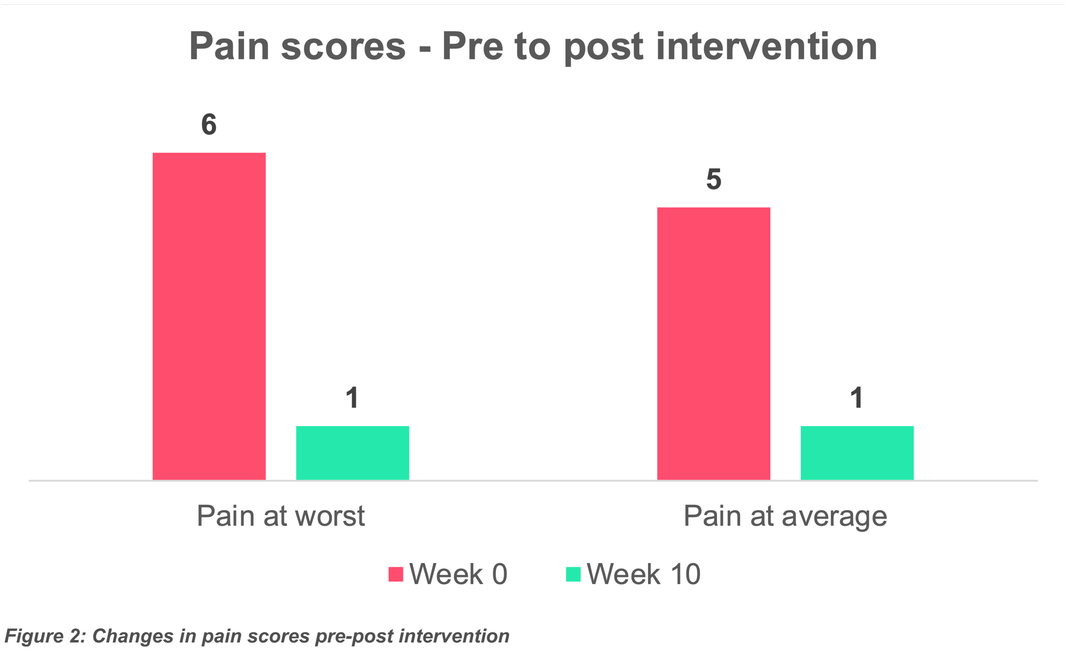

Figure 2: Changes in pain scores pre-post intervention

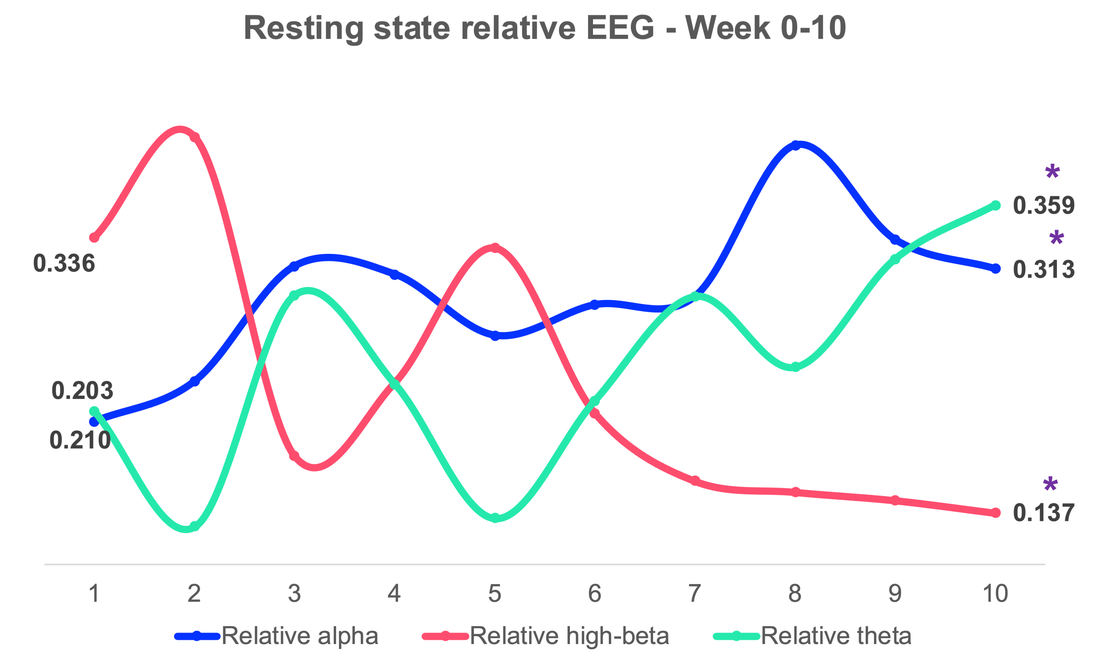

*Figure 3: Changes in relative EEG. * Denotes statistical significance p<0.05.*

Qualitative findings

- Patient interviews identified important concepts that developed during the intervention – control, confidence, quality of life and hope.
- At Week 0 he felt his pain was controlling his life and there was a loss of hope that it would change;

  "Each day was determined by my pain level. I wanted to get things done but with more bad days than good it wasn't always possible…..I struggled getting out of my house to make appointments. It was tough to accept this was how my life would be from now on."
- By Week 6, his experience of pain had changed, his confidence had increased, and his quality of life was improving;

  "I now fully understand the equipment…somewhere in the back of my mind I know my body is experiencing pain, but my brain is blocking it out. …I feel confident enough to look for full time employment and my social life has picked up."
- By Week 10, he reported a dramatic reduction in pain, and a return to normal life;

  "I'm now in full time employment, not just working from home - but with a fair amount of travel too. I rarely experience pain days anymore and even when I do I know they would have been of a much higher strength had I not used the equipment."

  "I consider myself as living a completely normal life … something I didn't think would ever be possible again."

Control

Confidence

Hope

Quality of life

Discussion and conclusion

- The participant's improvements in pain, mood and quality of life, alongside changes in resting state EEG support the existing body of research indicating alpha modulation as a mechanism for managing the symptoms of chronic NP.
- The qualitative findings support the quantitative data and illustrate the value of patient-centred experiential data.
- EEG NFB offers clinicians an important tool in the treatment of chronic NP, a condition with a paucity of effective non-pharmacological treatments.

References

1) Burke D, Fullen BM, Stokes D, Lennon O. Neuropathic pain prevalence following spinal cord injury: A systematic review and meta-analysis. *European Journal of Pain. 2017 Jan;21*(1):29-44.

2) Mussigmann T, Bardel B, Lefaucheur JP. Resting-state electroencephalography (EEG) biomarkers of chronic neuropathic pain. A systematic review. *Neuroimage. 2022;258:*119351.

3) Jensen MP, Sherlin LH, Gertz KJ, Braden AL, Kupper AE, Gianas A, et al. , Brain EEG activity correlates of chronic pain in persons with spinal cord injury: clinical implications. *Spinal Cord. 2013;51*(1):55-8.

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