



Original experimental

Pain reduction due to novel sensory-motor training in Complex Regional Pain Syndrome I – A pilot study



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H I G H L I G H T S

- Proof-of-principle successfully implemented home-based sensory-motor training in CRPS.
- Home-based sensory-motor self-training leads to a significant reduction pain.
- Pain reduction is correlated with reduction in pain disability and depression.

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Background and aims: Patients suffering from Complex Regional Pain Syndrome (CRPS) of the upper limb show a changed cortical representation of the affected hand. The lip area invades the former hand area contralateral to the affected hand. This change in cortical representation is correlated to the intensity of ongoing pain in patients with CRPS. Further studies revealed that restoration of the original representation coincides with a decrease of pain. Sensory-motor training protocols can increase and/or relocate cortical somatosensory and motor representation areas of the fingers, as shown, for example, in Braille reading individuals and professional violin players. Further, there is evidence that sensory-motor discrimination training has a beneficial effect on both the intensity of pain and the mislocalization of sensory-motor cortical areas in CRPS patients. Based on these propositions, we developed a novel sensory-motor self-training paradigm for CRPS patients to use in a home-based manner.

Methods: Ten CRPS patients performed the sensory-motor training for 2 weeks. The training consists of a braille-like haptic task with different training modes (bi-manual, speed and memory training). During the training, as well as 1 week before and after, patients were asked to fill out pain diaries. Furthermore, measures of impairment were acquired at baseline and post training.

Results: Patients showed significant pain reduction after the 2 week training period. The overall disability as well as the depression scores showed a trend to improve after the 2 week training. The reduction in pain was correlated with the total amount of training performed.

Abbreviations: CES-D, Center for Epidemiological Studies – Depression Scale; CRPS, Complex Regional Pain Syndrome; M1, Primary motor cortex; PDI, Pain Disability Index; PT, Physical Therapy; S1, Primary sensory cortex; ST, Sensory-motor Training; tDCS, Transcranial Direct Current Stimulation; TMS, Transcranial Magnetic Stimulation; VAS, Visual Analogue Scale.

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Conclusions: This is a first proof of principle study of a novel sensory-motor self-training protocol to reduce pain in CRPS patients. The more consistent the patients trained the larger the pain reduction. Sensory-motor training, which can be performed on a regular basis at home might provide a novel interventional strategy to improve symptoms of CRPS.

Implications: Although a larger study needs to be conducted to confirm our findings, including long-term follow-up, the results show, that a sensory-motor home-based training is a strategy worth exploring further for the reduction of pain as well as high frequency training for patients with CRPS.

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1. Introduction

Complex Regional Pain Syndrome (CRPS) is a chronic pain condition typically affecting one limb, often after minor injury or trauma to that extremity. It is associated with poor quality of life, and considerable healthcare and societal costs with limited success from current treatment strategies [1]. While pain is the main symptom (93% [2]), other symptoms include impairments in sensory and motor performance [3], as well as changes in body perception [4] and tactile acuity [5]. Unfortunately, despite the availability of analgesic medications, no treatment has been found that benefits the majority of individuals with CRPS [6]. As multimodal, interdisciplinary therapy seems to be the most effective treatment, a large part of this approach is physical therapy (PT) to regain mobility. Graded motor imagery may be effective [6], however, therapies in clinical environments are time and cost intensive and achieve only limited treatment frequency. Thus, a cost-effective approach with a high therapy density, in form of a daily training over the course of several weeks or even months, requires self-training at home.

The pathophysiological mechanisms of CRPS are not completely understood [3,7]. Yet, evidence suggests that maladaptive neuroplastic cortical changes, especially in the sensory-motor cortex, may play a role in the development and maintenance of chronic neuropathic pain [8]. Changes in cortical representation and body representation in the primary somatosensory (S1) [9] and motor (M1) [10] cortex in the form of shrinkage of the hand representation were identified in CRPS patients [11–13]. The amount of these neuroplastic changes are correlated with the intensity of ongoing pain [14,15]. Furthermore, restoring the original representation of the hand has been shown to be associated with reduction in pain levels [16].

Sensory-motor training in healthy subjects has been demonstrated to be associated with neuroplastic mechanisms leading to changes in cortical representation, such as an increase of the somatosensory or motor cortical maps (e.g. [17,18]). Learning paradigms, e.g. working with Braille characters, led to enlarged cortical representation of the reading finger [19]. Several studies from Moseley et al. [5,20] demonstrated beneficial effects of sensory discrimination training on pain in CRPS patients. In this study, a tactile discrimination training was compared to tactile stimulation. Whereas the tactile stimulation did not have any effect on pain or two point discrimination, the tactile discrimination training had beneficial effects on both [5]. In a further study, they found an additional beneficial effect when the tactile discrimination training was combined with a mirror training [20]. In further studies, higher pain levels were associated with lower tactile acuity [21] as well as body scheme disturbances [22].

Taken together, this evidence clearly suggests that sensory-motor training can functionally alter cortical representation areas which may result in a decrease in pain.

Our novel sensory-motor self-training (ST) protocol is developed to be used by the CRPS patients in their home environment. The ST is comparable to Braille reading where patients are trying to identify patterns by touch.

The idea behind this treatment is that impairments in the motor and sensory domain will be positively influenced by non-painful tactile differentiation training of the affected hand, with subsequent decrease of pain, enhanced use and mobility of the affected limb. As the fear of pain leads the patients to reduce or even avoid movements of their painful limb, it was crucial to develop a training that can achieve high training density without inducing pain. Thus, we hypothesized in the present study that home-based ST of the hand in patients suffering from CRPS at the upper extremity will lead to a reduction of CRPS symptoms.

2. Materials and methods

2.1. Participants

Ten CRPS I (according to Budapest criteria [23,24]) patients (3 male; age, mean \pm standard deviation 58.4 ± 11.23) participated in the protocol after giving their informed consent (see Table 1). All of them were right-handed according to the Edinburgh handedness inventory [25]. Four subjects were affected on the left, six on the right upper limb. Quantitative sensory testing was reported comparing the affected with the unaffected hand (Table 1). The protocol used is the one used by the German Research Network on Neuropathic Pain (DFNS) [26,27]. The mean pain duration was 42.7 ± 79.7 months with a minimum of 2 months pain duration and a maximum of 264 months (22 years). Written informed consent was obtained from all subjects according to the Declaration of Helsinki (www.wma.net/en/30publications) and with approval from the local Ethics Committee of the Medical Faculty of the University of Tuebingen.

2.2. Sensory-motor training (ST)

2.2.1. ST training

The ST was developed by our pain research labgroup at the Medical Psychology in Tuebingen (Fig. 1). The ST is based on the concept of meaningful perceptual discrimination training (pattern recognition). We used Duroplastic discs (diameter 5 cm) with small embedded metallic spheres (diameter 15 mm). The spheres are elevated on the disc, such that they can be recognized by moving a fingertip over them. The shapes we used are one dot, two dots, three dots in a row, a triangle, a square and an arrow (Fig. 1D).

The training was constructed with two different degrees of difficulty, which are represented by different distances between the metallic spheres: “easier” shapes with 5 mm distance and “more difficult” ones with 2.5 mm distance (Fig. 1E).

All CRPS patients were asked if they experienced an increase in ongoing pain during the sensory-motor sessions. No CRPS participant reported an increase in ongoing pain. Furthermore, the movements of the ST are feasible even with reduced strength and may therefore help the patients in regaining function in the affected hand. Recent studies indicated that passive movement training does not improve task performance, cortical organization or CRPS symptoms [13].

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