Therapeutic potential of transcutaneous electrical spinal stimulation on upper extremity functions in cervical spinal cord injury

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Introduction

- Transcutaneous electrical stimulation is a non-invasive strategy to modulate spinal circuitry[1] and induce neuroplasticity
- Electrical neuromodulation of spinal networks below the injury facilitates volitional motor control in both lower[2,3] and upper[4,5,6] extremities

Goals:

- Determine the therapeutic potential of non-invasive spinal stimulation for functional restoration of hand and arm
- Quantify the sustained benefits to hand and arm function that persist beyond the period of spinal stimulation.

Methods

Subject:

- 62 y/o male, C3 central cord syndrome, ASIA D, 2 years post-injury

Interventions: 4-5 times/week

- Stimulation + physical therapy: 4 weeks (Figure 1)
- Physical therapy only: 4 weeks
- Stimulation + physical therapy: 1 weeks

Outcome Measures:

- Graded Redefined Assessment of Strength, Sensibility and Prehension (GRASSP) test
- International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI) assessment
- Hand strength

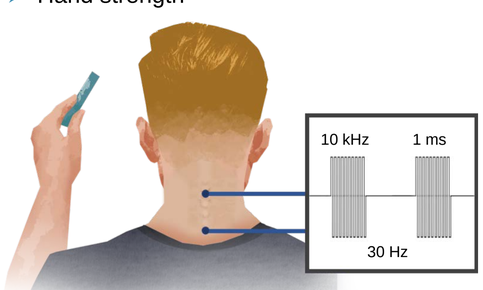

Figure 1. Transcutaneous stimulation via electrodes placed midline at C3-4 and C6-7 as cathodes. (Inset) Biphasic, rectangular, 1 ms pulses at a frequency of 30 Hz, filled with a carrier frequency of 10kHz. Stimulation intensity between 10 and 200mA.

Results

Transcutaneous stimulation improved arm and hand functions measured by GRASSP test

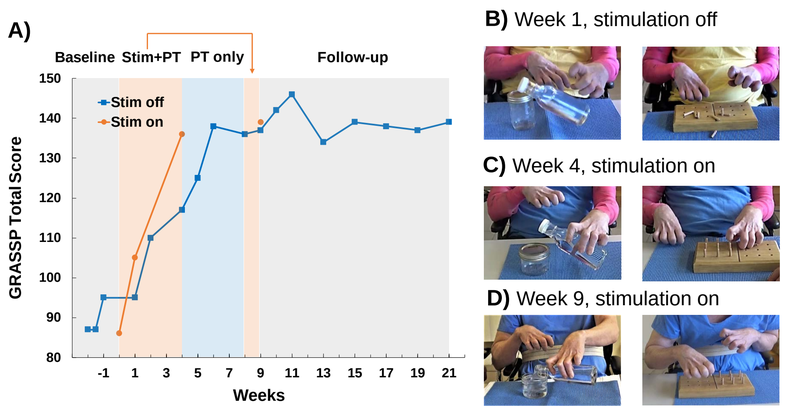

Figure 2. A) – GRASSP score increased 52 points following only 4 weeks of stimulation
B) – Water pouring (prehension) and 9 hole peg tasks (dexterity) were unsuccessful at the baseline and at first week when stimulation was off.
C) – After 4 weeks of stimulation, left hand prehension & dexterity improved dramatically
D) – One additional week of stimulation lead to further improvement in hand function.

Pinch force 2- to 7-fold greater after stimulation

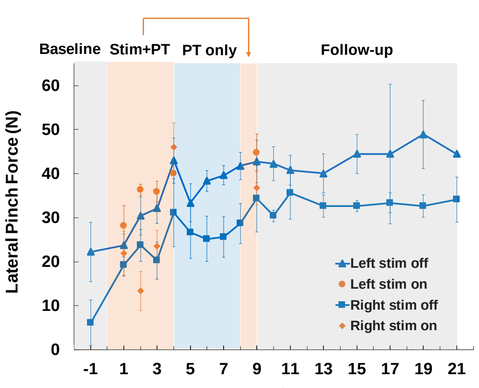

Figure 3. During stimulation treatment, lateral pinch force improved 2 and 7 fold in left and right hands, respectively. PT alone did not further improve pinch force, but the gains were maintained throughout the 3-month follow-up period.

Normal sensation returned to 8 dermatomes

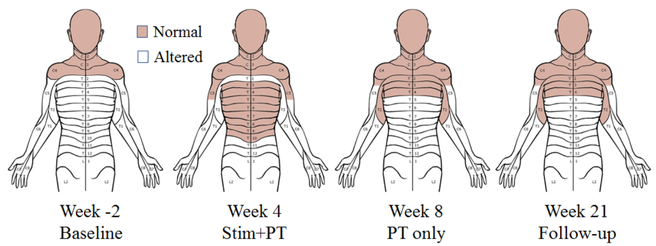

Figure 4. Following 4-weeks of stimulation, normal pin prick sensation expanded from C4 to T10 dermatome. After 4 weeks without stimulation, altered sensation returned below T4 (week 8 & 21).

Neurological level of improved one level caudally from C3 to C4 and was sustained following stimulation

Discussion

- Concurrent application of transcutaneous electrical spinal cord stimulation and PT restored strength, dexterity and sensation
- The magnitude of improvements exceeded previous reports of activity-dependent interventions after SCI

Conclusion

Our results provide evidence that non-invasive electrical spinal cord stimulation:

- Confers both immediate & sustained benefit
- Restores functional use of the hands after SCI

References

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