Abstract 520: Transcutaneous spinal cord stimulation for modulating micturition reflexes after spinal cord injury: Optimisation of electrode site and stimulation parameters

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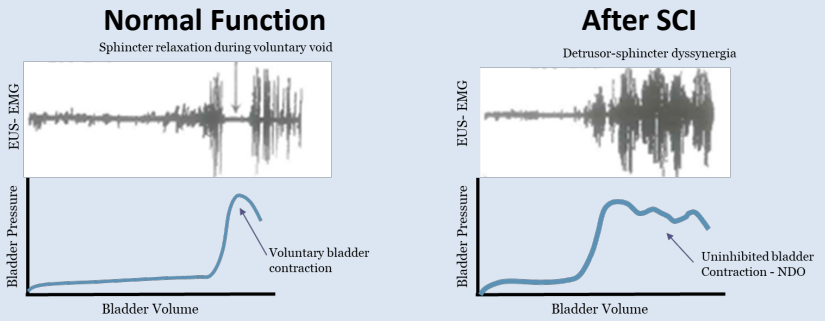
Introduction

Spinal Cord Injury (SCI) can result in neurogenic lower urinary tract dysfunction including neurogenic detrusor over-activity (NDO) and detrusor-sphincter dyssynergia (DSD). Restoration of bladder function is ranked as a high priority by people with SCI, and current management strategies are inadequate[1].



Recently, transcutaneous spinal cord stimulation (tSCS) has been applied to target restoration of bladder function. Demonstrating improvements in bladder capacity, reduction in NDO and DSD, and improving voiding efficiency. Applied at various electrode sites (lower thoracic and lumbosacral vertebrae), and stimulation parameters (Frequencies: 1-45Hz)[2,3]. Optimal electrode site and stimulation parameters to restore bladder function following SCI remains ambiguous.

Objectives

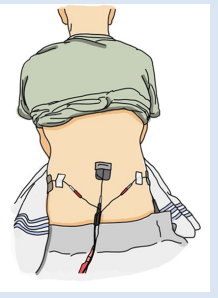
1. Optimisation of Stimulation Parameters and Electrode Position
   - Mapping of lower limb and sphincter responses
2. Investigate effect of tSCS on bladder function following optimisation
   - Facilitation of pelvic floor contraction and relaxation
   - Effect on bladder storage and voiding function

Methods

Ethical approval obtained from HRA Research Ethics Committee

Inclusion criteria: Participants with a supra-sacral SCI and proven NDO on most recent urodynamics

Exclusion criteria: Epilepsy, implanted devices, Botox previous 6 months



Optimisation of Electrode Site (visit 1)

DS7R Digitimer Device

Three individual pulses (monophasic, rectangular, cathodic, 1ms) delivered at each increasing amplitude (1, 5, 10, 15…mA).

Conducted at three electrode sites: Cathode + Anode

- T11-12 + iliac crest
- L1-2 + iliac crest
- T11-12 OR L1-2 + abdomen

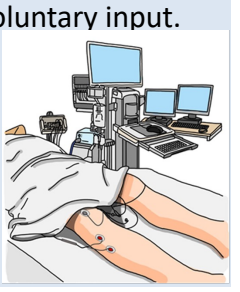
Recording electrodes (EMG): Tibilais Anterior (TA), Anal Sphincter Sensory threshold, and Motor Evoked Potential (MEP) responses monitored. Optimal electrode site selected based on MEP response and patient comfort.

Optimisation of Stimulation Parameters (visit 1)

Three x 5sec bursts of tSCS at optimal electrode site

Randomised frequency order: 1, 15, 30 Hz

During tSCS, voluntary pelvic floor contractions or no voluntary input.



Urodynamics with tSCS (visit 2)

Six cycles of urodynamics

- One control cycle at the start and end
- Two cycles at 30 or 15Hz tSCS during bladder filling
- Two cycles at 1 or 15Hz tSCS during voiding

Results

Participants

N= 6 (4 male and 2 female). Mean age 50 +/- 20 years old

Cervical (n=4) and thoracic (n=2) SCI; all incomplete

Stimulation thresholds and Optimal electrode site

Electrode Site (cathode, anode)	Mean Sensory Threshold (mA)	Mean Motor Threshold EAS (mA)	Mean Maximum Tolerated (mA)
T11-12, iliac crest	2.4	13.3	47.8
L1-2, iliac crest	2.4	25.0	50.0
T11-12, abdomen	2.7	25.0	41.7
L1-2, abdomen	1.9	5.0	61.3

Optimal electrode site based on MEP response and/or patient comfort:

- *T11-12 Iliac crest (n=2)*
- *L1-2 Abdomen (n=2)*
- *T11-12 Abdomen (n=1)*
- *L1-2 Iliac Crest (n=1)*

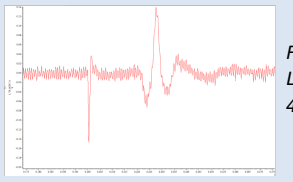


Figure 1: Example tSCS at L1-2, iliac crest, left TA MEP, 40mA

Pelvic floor contraction with tSCS

	Mean Percentage Change in EMG output (%)		
	1Hz	15Hz	30Hz
tSCS contraction vs control contraction	4	34	50
Mean tSCS contractions (x3) vs mean control contractions (x3)	-4	36	7
Final control contraction vs first control contraction	9	9	34

Table 2: Mean change in EMG output (%) comparing tSCS and control contractions at 1, 15 and 30Hz

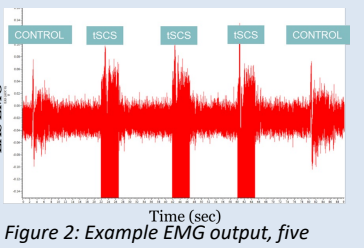


Figure 2: Example EMG output, five pelvic floor contractions, central three contractions with tSCS at 30Hz

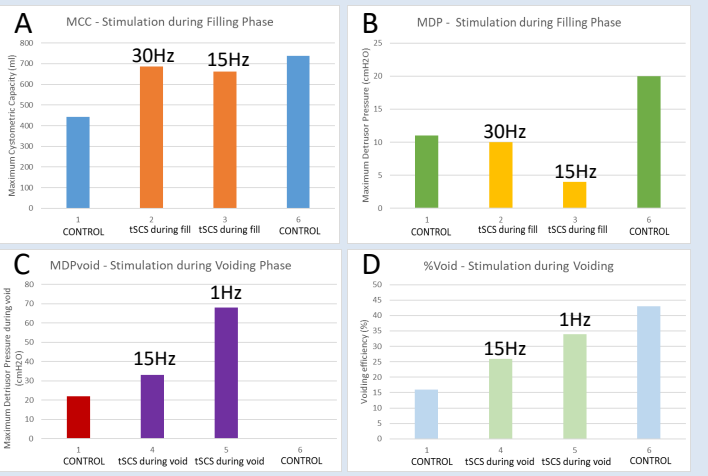


Figure 3: Participant 2, bladder capacity (MCC) (A) and detrusor pressure (MDP) (B) during filling with and without tSCS. Detrusor pressure during voiding (MDPvoid), and voiding efficiency (%void) with and without tSCS. Stimulation parameters: 20mA amplitude, 1ms pulse width at either 1, 15 or 30Hz.

Key findings and conclusions

- Optimal electrode site varied between participants
- tSCS facilitated voluntary pelvic floor contractions, with greatest increase in EMG output at 15Hz and 30Hz
- Response to tSCS during urodynamic filling and voiding differed between participants
- Trends showed that tSCS applied at 15 and 30Hz during bladder filling demonstrated improvements in bladder capacity and a reduction in detrusor pressure
- There was no clear trend in response to tSCS during voiding between participants

Individually tailored tSCS optimisation and application shows promise to improve bladder storage and facilitation of pelvic floor muscle function.

References

1. Anderson, K.D., 2004. Targeting recovery: priorities of the spinal cord-injured population. *Journal of neurotrauma*, *21*(10), pp.1371-1383.
2. Niu, T., Bennett, C.J., Keller, T.L., Leiter, J.C. and Lu, D.C., 2018. A proof-of-concept study of transcutaneous magnetic spinal cord stimulation for neurogenic bladder. *Scientific reports*, *8*(1), p.12549.
3. Gad, P.N., Kreydin, E., Zhong, H., Latack, K. and Edgerton, V.R., 2018. Non-invasive neuromodulation of spinal cord restores lower urinary tract function after paralysis. *Frontiers in neuroscience*, *12*, p.432.

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