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Effect of Sacral Nerve Stimulation on Detrusor Overactivity among Spinal Cord Injury

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Abstract

Spinal cord injury (SCI) remains a leading cause of long-term disability, with a significant proportion of patients developing bladder dysfunction. According to the National Spinal Cord Injury Statistical Center, approximately 40 new cases per million people are reported annually, with over 80% experiencing some degree of bladder impairment. Emerging evidence suggests that sacral nerve stimulation (SNS) may be beneficial in managing such dysfunctions. This pilot study aimed to examine the effects of sacral nerve stimulation on detrusor overactivity in individuals with SCI Fifteen post-SCI patients were recruited from Saveetha Institute of Medical and Technical Sciences for a 4-week intervention. Pre- and post-treatment assessments were conducted using the Overactive Bladder Symptom Score (OABSS). Patients received transcutaneous sacral nerve stimulation twice daily for four weeks. Statistical analysis revealed a significant reduction in OABSS scores post-intervention ($p < 0.001$), indicating improved bladder control. The findings support the therapeutic efficacy of sacral nerve stimulation in reducing detrusor overactivity among SCI patients.

Keywords

Detrusor overactivity, Overactivity bladder, Spinal cord injury, sacral nerve stimulation, overactive bladder symptoms score.

Introduction

A spinal cord injury (SCI) refers to damage resulting from an insult that partially or completely impairs the function of the spinal cord. It affects critical systems including sensory, motor, and autonomic functions. SCI remains a major global health concern and one of the leading causes of long-term disability. In recent years, SCI has been associated with high morbidity and mortality rates. In the United States alone, approximately 8,000–10,000 individuals sustain traumatic SCIs annually. Beyond the personal health implications, SCI imposes significant socioeconomic burdens on patients, healthcare systems, and society at large.

Primary SCI occurs through four main mechanisms: impact with transient deformation, persistent mechanical tension, loss of structural continuity, and transection. Secondary injury mechanisms include excitotoxicity, calcium-mediated damage, fluid imbalance, immune cell infiltration, neuronal cell death, mitochondrial dysfunction, and other pathophysiological

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processes (Dumont et al., 2001). SCI can result from trauma, such as vehicular accidents or falls, or from non-traumatic causes, such as vascular occlusion or infection.

Among the most common urological complications of SCI are urinary tract infections (UTIs), deterioration of the upper and lower urinary tracts, and the formation of bladder or renal calculi. According to the National Spinal Cord Injury Statistical Center, approximately 40 new cases per million individuals are reported each year, with over 80% of affected persons experiencing some degree of bladder dysfunction (Al Taweel et al., 2015).

Detrusor overactivity is defined by involuntary detrusor contractions during the bladder filling phase, occurring either spontaneously or in response to provocation. In contrast, detrusor sphincter dyssynergia (DSD) is characterized by detrusor contraction accompanied by involuntary urethral and/or periurethral striated muscle activity. Neurogenic bladder dysfunction following SCI represents a significant medical and psychosocial issue, with limited effective long-term treatment options.

Following suprasacral SCI, cerebral control over the sacral micturition reflex is disrupted, resulting in the development of neurogenic detrusor overactivity (NDO) and/or DSD in most patients (Al Taweel et al., 2005; Abrams et al., 2002). The initial pharmacological approach often includes oral anticholinergic agents such as oxybutynin and tolterodine, typically administered in conjunction with clean intermittent self-catheterization to reduce post-void residual urine. However, drug tolerance and adverse effects frequently limit long-term efficacy. When standard treatments are ineffective, alternative therapies may include oral α-adrenoceptor antagonists, intravesical capsaicin or resiniferatoxin instillations (Hesch et al., 2007), intradetrusor botulinum toxin injections (Schurch et al., 2000), bladder augmentation cystoplasty (Quek et al., 2003), and detrusor deafferentation (Hohenfellner et al., 2001).

NDO is typically associated with suprasacral SCI and is accompanied by motor and sensory impairments below the lesion site (Al Taweel et al., 2015). To assess bladder function and formulate management strategies, most SCI patients undergo filling cystometry, which evaluates bladder pressure and volume during the filling phase. In this study, filling cystometry was performed at a non-physiological filling rate using a Dantec Etude urodynamic device. A double-lumen 8F catheter was inserted transurethrally to measure cystometric capacity (CC) and leak point pressure (Pves LPP) during involuntary detrusor contractions—defined as non-inhibitable contractions that may cause incontinence (Moslavac et al., 2008).

The prevalence and incidence of neurogenic overactive bladder (nOAB) remain uncertain. A review of the literature found survey-based data on nOAB, urinary incontinence (UI), and detrusor overactivity (DO) among individuals with SCI, Parkinson's disease (PD) (Winge et al., 2006), cerebrovascular disorders, and spina bifida (van Gool et al., 2001; Ruffion et al., 2013).

The Overactive Bladder Symptom Score (OABSS) is a validated tool for quantifying the severity of OAB symptoms through a composite score. The OABSS includes four questions addressing daytime frequency (2 points), nocturia (3 points), urgency (5 points), and urgency incontinence (5 points), with a total score ranging from 0 to 15. Higher scores indicate greater symptom severity (Chuang et al., 2018). The OABSS has also been evaluated for its sensitivity to change and its minimal clinically important change (MCIC) threshold (Gotoh et al., 2019).
Sacral nerve stimulation, particularly targeting the S3 spinal nerve, has been successfully used to treat various non-neurogenic lower urinary tract disorders, including OAB (Doherty et al.,

2019). This modality represents a promising therapeutic option when conservative measures fail, offering potential improvements in bladder function and quality of life for patients with refractory symptoms.

Methodology

Participants and selection criteria:
Inclusive criteria:

- GENDER: Both male and female
- AGE GROUP: 20 years and above.
- Patients with bladder dysfunction.

Exclusive criteria:

- Subjects with recent surgeries or injuries
- Subjects with infections.

This was a pilot study in which 20 patients with post-spinal cord injury were chosen based on sample selection. Fifteen samples were collected from the neuro IP and physiotherapy OPD. The study was conducted at Saveetha Medical College and Hospital. The study included both men and women with bladder dysfunction. They were examined using a score for overactive bladder symptoms. The detailed treatment procedure was explained to the patients. The patients were made to feel comfortable with the procedure after an explanation. The demographic details are collected with the patient's permission, and a consent form for treatment is also provided. Transcutaneous electrical nerve stimulation was used to stimulate the sacral nerve for 4 weeks, with 2 sessions per day. The electrodes were placed over the sacral foramen, with the patient lying prone and the intensity was given up to the patient’s tolerance.

Results and Discussion

A group of 15 participants is being used as a test group for the study. The data’s mean and standard deviation were determined. The paired t-test was used to compare the values in between sacral nerve stimulation. The frequency of urination was compared using the overactive bladder symptoms score. A p-value slightly lower than 0.001 was deemed relevant. With a p-value of <0.001, the data obtained are statistically significant between the pre-test and post-test, as indicated by the results of the statistical analysis of the quantitative data. Sacral nerve stimulation has been shown to aid patients suffering from urinary incontinence after a spinal cord injury. The test was evaluated by using overactive bladder symptoms score outcome measures, and progress has been observed in all tests.

Table 1. Shows the comparison of pre-test and post-test values

	Mean	**SD**	**W-value**	**Z-value**	**P-value**
Pre-Test	10.00	13.00	-120.000	-3.430	<0.001
Post-Test	5.00	6.00			

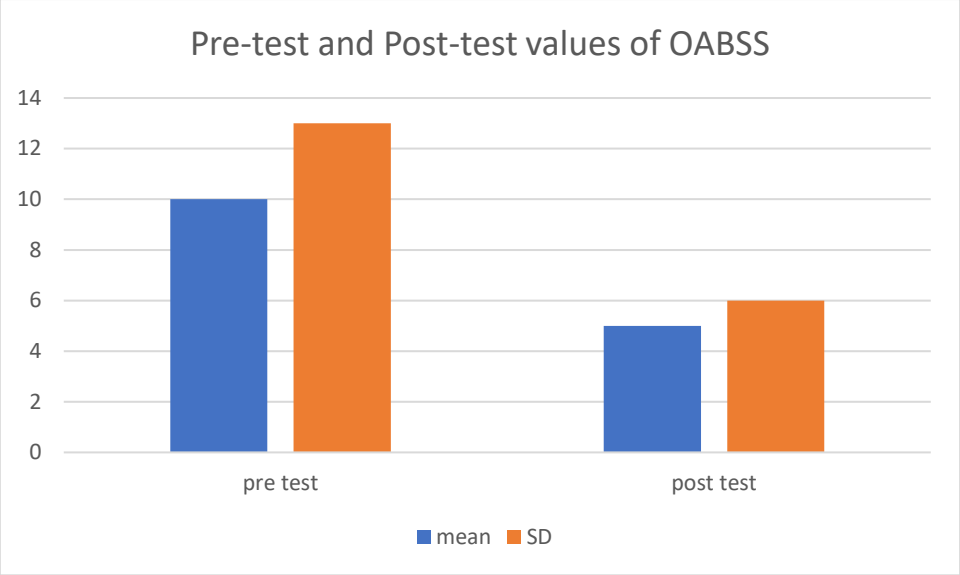

Figure 1. Shows the pre-test and post-test values of the overactive bladder symptoms score

The study assessed the impact of sacral nerve stimulation on detrusor hyperactivity in patients with spinal cord injury and found a significant reduction in bladder dysfunction. A total of 15 participants (7 males and 8 females), aged 20 years and above, underwent sacral nerve stimulation therapy for 30 minutes on alternate days over a period of 4 weeks. The effectiveness of transcutaneous sacral nerve stimulation in reducing detrusor overactivity was analyzed using a paired *t*-test, which yielded statistically significant results ($p < 0.001$).

Sacral nerve stimulation (SNS) is employed to restore voluntary control over abnormal sensations and involuntary responses in the lower urinary tract. It functions by modulating sacral afferent pathways and altering reflex activities and central brain mechanisms associated with urinary control. The stimulator delivers electrical impulses to the sacral nerves, resulting in neuronal depolarization and the generation of action potentials that propagate along the axons. These impulses influence the central nervous system, facilitating the reorganization and potential regeneration of bladder control mechanisms via stimulation of cutaneous sensory nerves in the sacral nerve roots (Malde et al., 2017).

In 2001, Kamm et al. reported that sacral nerve stimulation could effectively treat fecal incontinence, particularly urge-related fecal incontinence that occurs alongside urinary urgency. Their findings confirmed that SNS has a beneficial impact on striated sphincter function.

Shalom et al. (2014) observed that individuals with detrusor overactivity exhibited significantly elevated baseline urinary nerve growth factor (uNGF) levels. Seventeen participants diagnosed with detrusor overactivity underwent percutaneous nerve evaluation (PNE) and were reassessed at the end of the intervention period. The study demonstrated a significant improvement in quality-of-life scores following PNE, along with a notable decrease in uNGF levels.

Siddiqui et al. (2010) conducted an observational study that supported the effectiveness of SNS in managing overactive bladder (OAB) symptoms in women. Their findings indicated that the use of tined leads resulted in fewer adverse effects compared to non-tined leads. However, they emphasized the need for high-quality research to further validate these results

and to investigate the long-term outcomes of SNS, including its effectiveness, impact on quality of life, and comparison with alternative treatment options. The study acknowledged several limitations, including a short intervention period, a small sample size, and the absence of follow-up data. Future research should incorporate larger sample sizes and extended study durations to enhance the validity of the findings. Additionally, further investigation into the effectiveness of alternative rehabilitative interventions, such as functional electrical stimulation, on the overall functional recovery of spinal cord injury patients is recommended (Suganthirababu et al., 2023).

Conclusion

The study concluded that sacral nerve stimulation has provided a greater relief for patient suffering from incontinence after spinal cord injury.

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