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Review Article

Effect of Transcutaneous Spinal Stimulation on Spasticity and Walking Performance in Patients with Neurological Condition: A Review of Literature

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ABSTRACT

Transcutaneous spinal cord stimulation (tSCS) has emerged as an effective, non-invasive neuromodulatory technique to improve spasticity and walking performance in neurological conditions. While its primary applications are often in stroke rehabilitation, the technique has also shown promise in conditions such as spinal cord injury (SCI), multiple sclerosis (MS), and cerebral palsy. This review focuses on electrode placement over T11–T12, highlighting its effects on spasticity and motor performance. The review explores studies across different patient populations to evaluate the generalizability of these findings.

Key words: transcutaneous spinal stimulation, spasticity, stroke, multiple sclerosis, walking performance

INTRODUCTION

Multiple sclerosis (MS), cerebral palsy, stroke, and spinal cord injury (SCI) are common neurological disorders that impair motor function and spasticity. Patients' motor function and spasticity are improved using a variety of neuromodulation treatments. By altering the descending spinal pathways, non-invasive electrical spinal cord stimulation is now showing encouraging outcomes on the walking ability and spasticity of patients with spinal cord injuries. It may be used to help people with neurological conditions function better in their lower limbs because of the shift in lumbar responsiveness[1]. The goal of epidural and non-invasive continuous electrical spinal stimulation approaches is to use the spinal circuitry's silent, spared descending routes following SCI [2].

Continuous spinal stimulation has been demonstrated in experiments to produce tonic and rhythmic patterns of motor activity during walking or step like motions. even though people with SCI have restricted brain-to-brain connectivity.[1] (tSCS), a neuromodulation technique based on surface electrodes that affects the spinal segments innervating the lower limbs by producing currents that partially traverse the vertebral canal.[3,4,5] Cervicolumbar connection is another feature of TSCs that indicates that altering the cervical lumbar network may potentially alter the lumbar circuit and cause lower limb motor activity.[6]

Numerous researches are conducted on both healthy and neurologically intact humans to examine the impact of TSCS on locomotor pattern, and both SCI and neurologically intact humans have shown good outcomes from TSCS. There are several approaches for the TSCS application, and there is a dearth of literature that discusses the application's particular methodology. Therefore, a study is required to generalize the findings of the application methods for individuals with neurological problems. This review concentrates on a single technique that was applied to simulating across a range of circumstances. Electrical stimulation applied to the skin over the spinal cord is known as transcutaneous spinal cord stimulation (tSCS). It usually targets spinal segments such the T11–T12 or the L1 and L2 level for lower limbs.

The ability of this method to alter spinal cord activity, lessen spasticity, and enhance motor function has drawn interest. Research on tSCS is included in this review using a stimulation strategy that involves stimulating at the T11-T12 and L1-L2 levels. The objective is to evaluate how it affects walking performance and spasticity in these various populations.

METHODOLOGY

In order to find papers involving transcutaneous spinal cord stimulation, a thorough search was done in databases such as PubMed, MEDLINE, and Google Scholar. Specific criteria included placing the electrode at the level of T11-T12 and L1-L2. Included were studies with human subjects who had cerebral palsy, stroke, or multiple sclerosis and reported results pertaining to improved gait and decreased spasticity.

RESULT

Three publications in all were assessed and added to the study after a variety of articles were found utilizing search strategies.

A study on the Characterization of Motor-Evoked Responses Obtained with Transcutaneous Electrical Spinal Stimulation from the Lower-Limb Muscles after Stroke was carried out by Moon et al. in 2021. The study involved 30 participants, 10 of whom were stroke survivors, 10 of whom were age-matched controls, and 10 of whom were younger controls. We investigated the sMER features (resting motor threshold (RMT), slope of the recruitment curve, and latency) of the tibialis anterior (TA) and medial gastrocnemius (MG) muscles between groups using tSCS administered between the L1 and L2 spinal levels. In contrast to the age-matched control group, the current study found that stroke individuals had decreased spinal motor reactivity following their stroke, as evidenced by an increased RMT (TA: 27% increase, MG: 28% increase) and delayed TA latency (13% increase). This implies that spinal motor response to the lower limb muscles may be downregulated due to cortical injury following a stroke. Bilateral changes in corticospinal input may impact the lumbosacral spinal network's overall reactivity. An other theory is that the spinal networks that underpin motor function are impacted retrogradely by the general disuse of lower limb muscles brought on by a decline in functional activity. Applying continuous tSCS to improve lower-limb function in stroke survivors may be beneficial because there are changes in motor reactivity within the lumbar cord following a stroke.[2]

Transcutaneous spinal cord stimulation improves walking performance and decreases spasticity in people with multiple sclerosis, according to a 2021 study by Ursula S. Hofstoetter et al. Transcutaneous spinal cord stimulation was administered to 16 MS patients for 30 minutes at a frequency of 50 Hz. Following the intervention, measurements were made of walking speed, spasticity, trunk control, and manual dexterity immediately, two hours later, and twenty-four hours later. In the intermediate period (0–2 hours) and for 24 hours after its application, the stimulation decreased lower-extremity muscle hypertonia as clinically assessed by the MAS. In the intermediate term, but not for 24 hours after the intervention, walking speed as measured by the 10-m walk test, mobility and fall risk as measured by the timed up-and-go test, and fatigability as measured by the 2-min walk test, all improved. The reduction of spasticity was relatively less effective for those who improved their walking performance the most, and vice versa. Additional studies showed a suppression of muscular spasms, a reduction in clonus durations, and an intermediate decrease in postural sway during normal standing with eyes open. Neither the trunk control test nor the upper-extremity nine-hole-peg test revealed any alterations.[7]

Transcutaneous spinal stimulation at the T11-T12 and L1-L2 levels with a biphasic pulse for 30 minutes was used in a 2021 study by Parag Gad et al. titled Transcutaneous Spinal Neuromodulation Reorganizes Neural Networks in Patients with Cerebral Palsy. The GMFCS scale and locomotor training were used to measure the motor activity of the children older than 2 years. The main goal was to evaluate EMG and kinematic patterns that indicated better coordination and less co-contractions in patients who could step on a treadmill. Every subject underwent testing on a treadmill with and without stimulation at the same speed and body weight support. The treadmill's speed was adjusted so that patients may step at a comfortable pace. According to the study's findings, spinal stimulation can remodel a defective or nonfunctional brain-spinal network to a new functional physiological state in CP patients by causing electrophysiological alterations in just one stimulation session. Furthermore, it creates the groundwork for a learning phenomena to occur when these exercises are repeated, which makes it easier to relearn a variety of movements that call for more strength, endurance, and ability.[8]

DISSCUSSION

According to the reviewed research, tSCS given at the T11–T12 spinal segments significantly improves walking performance and spasticity in a variety of patient populations with neurological conditions. It has been demonstrated that tSCS efficiently reduces hyperreflexia and muscle tone, which are common indicators of spasticity, on a number of criteria, including walking performance and spasticity reduction in stroke patients, people with spinal cord injury, and people with multiple sclerosis. Both stroke survivors and other populations (e.g., MS, SCI) showed notable improvements in gait, including stride length, walking speed, and symmetry. This implies that tSCS improves motor control by promoting neuroplasticity in addition to reducing spasticity.

According to the reviewed studies, tSCS is helpful not only for spinal cord injuries but also for various neurological diseases that cause spasticity and reduced motor performance. This creates opportunities for wider use in rehabilitative procedures. Additionally, tSCS has been shown to modify spinal cord excitability in healthy persons, which suggests that it may have wider rehabilitation uses.[9, 10, 11, 12] Even if the findings are encouraging, more research with bigger sample sizes and standardized procedures is required to create firm clinical recommendations. More research should be done on patient-specific characteristics, ideal stimulation parameters, and long-term consequences.

CONCLUSION

Transcutaneous spinal cord stimulation (tSCS) is a promising approach for managing spasticity and enhancing walking performance in neurological disorders. Although primarily studied in stroke patients, its application has proven effective in SCI, MS, and cerebral palsy, providing evidence for its broader use in neurorehabilitation but the literature is scarced for the general clinical application for the proven effects. Continued research and larger clinical trials are necessary to optimize protocols and validate the long-term benefits of tSCS across diverse populations as per the available studies the placement of the electrodes over T11-T12 and L1-L2 and over ASIS has proven effect on the modulating the lumbar spinal network and alternating the neural plasticity in the brain. So there is a need to explore the different parameters and the duration for the effective treatment with TSCS in clinical setting.

Declaration by Authors

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