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RESEARCH ARTICLE

ACTIVITY BASED THERAPY AND SURFACE SPINAL STIMULATION FOR RECOVERY OF WALKING IN INDIVIDUAL WITH TRAUMATIC INCOMPLETE SPINAL CORD INJURY: A CASE REPORT

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ABSTRACT

Objective: To examine the effects of Activity Based Therapy (ABT) and Surface Spinal Stimulation on neurologic function, walking ability and functional independence.
Design: Single Subject Case Study.
Setting: Outpatient Private Physiotherapy and Rehabilitation Clinic.
Participant: Volunteer subject with Spinal Cord Injury, Motor Incomplete ASIA grade C.
Interventions: A total of 12 hours/week of ABT for 24 weeks including developmental sequencing, resistance training, repetitive patterned motor activity and task specific loco motor training. This was accompanied with thrice weekly, 45minutes session of Surface Spinal Stimulation.
Main outcome measures: Neurologic function ASIA (International standards for Neurological Classification of Spinal Cord Injury), Hoffmans Reflex, Somato Sensory Evoked Potential (SSEP), Walking Index for Spinal Cord Injury –II, SCI-FAI, Spinal Cord Injury Independence Measure (SCIM-III).
Results: Some observable changes in the neural pathways, improvement in ASIA score of lower limb by 2 points on right side and by 1 point on left side. There was no change in level of WISCI-II and improvement of 5 points on SCI-FAI and of 9 points on SCIM-III.
Conclusion: Both SSS and ABT have a positive effect on the neurologic function; walking ability and functional independence of the individual with Motor Incomplete ASIA grade C SCI. However, there must be further investigations into this field to determine a specific protocol of ABT and a particular spectrum of SSS optimal for individuals with SCI.

INTRODUCTION

Background

A traumatic Spinal Cord Injury (SCI) is a lesion of neural elements of the spinal cord that can result in any degree of sensory and motor deficit, autonomic or bowel dysfunction. The general prognosis for regaining ambulatory function after a traumatic SCI ranges from 3% in initially complete SCI patients (according to the Standard Classification of the American Spinal Injury Association ASIA A (Wirz *et al.*, 2011) to 95% in very incomplete lesions (ASIA D)[1] It is reported that for patients with a motor complete and sensory incomplete SCI (ASIA B) the chance to become ambulatory is 50%. A major goal for many patients after SCI is to recover the ability to walk[1]. It is crucial that rehabilitation strives to maximize locomotor ability and functional recovery after SCI. Experimental evidence of improvement in stepping and motor control after activity-based training in animal models and human SCI has been translated into clinical neurorehabilitation.

There are three interventions that have been proven successful in modulating the physiological state of the spinal circuits associated with successful postural and locomotor activity. The first intervention involves the modulation of the locomotor circuits through activity-dependent mechanisms. Several studies have shown that the spinal cord learns to perform the task that it practices[2]. A second intervention involves modulation of the locomotor circuits pharmacologically. A third intervention is the modulation of the physiological state of the spinal circuitry via Epidural Stimulation. It seems highly probable that the chronic stimulation techniques presently used to suppress pain and spasticity can be readily adapted to facilitate postural and locomotor control[2].

Activity-based interventions or therapies include any therapy activity, or intervention, that is focused on improving muscle function and sensory perception below the level of injury, and not simply accommodation or compensation for the paralysis and sensory loss due to the spinal cord injury (SCI), in order to improve overall function after SCI[3].

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Surface Spinal Stimulation is non-invasive form of electrical stimulation delivered at the T 10 –L1 vertebral level with the adhesive electrodes placed para-vertebrally on each side of spine 5 cm apart. Electrodes are self-adhesive in nature rectangular 4.5 cm * 9 cm in size. The electrical stimulations had an amplitude modulated Alternating Current (AC), with a carrier frequency of 2500 Hz, modulated to "beat" frequency of 20Hz and stimulation amplitude was raised to elicit sensory stimulation[4].

This case study is an attempt to highlight the effect of ABT on neurologic function, walking ability and functional independence in individual with traumatic incomplete SCI.

METHOD

Participation of human subject was approved by an institutional review board before the initiation of the study. Patient was explained in detail about the purpose and methods of this study. Informed consent was obtained from the participant.

The participant was a young male of 25 years age, with no cognitive deficit and any other neurological ailment. The participant was not undergoing any exercise regimen past three months and was taking no medications but has completed the initial rehabilitation after the injury. The individual was suffering from traumatic Spinal Cord injury (level L1) past 2.5 years. He was hit by a tree branch in a cyclone.

The participant underwent basic examination, ASIA grading, Hoffmans Reflex, Somato Sensory Evoked Potential (SSEP),Walking Index for Spinal Cord Injury –II, SCI-FAI and Spinal Cord Injury Independence Measure(SCIM-III) as baseline assessment. Patient had flaccidity in crural group of muscle of left limb. In rest of the muscles of the left lower limb and right limb there was no increase in muscle tone according to Modified Ashworth scale.

The participant underwent a thrice weekly, 24 week protocol of activity based therapy and thrice weekly session of Surface Spinal Stimulation of 45 minutes. Both of these interventions were delivered on the same day. The exercises for the participant were designed according to the principles of activity based therapy (Appendix A). Exercises were determined according to the requirement of the participant. Each session of ABT lasted for 4hours. It also included locomotor training using Body weight support treadmill training (BWSTT) for 30 minutes in each ABT session. In this procedure a portion of the patient's body weight is supported while the patient is assisted to walk on a motorized treadmill with the goal of providing normal kinematic and temporal cues during walking. BWSTT is based on practicing a normal physiologic gait pattern, with attention to the ideal kinematic and temporal aspects of gait[5].

This study followed the guidelines from previous study on ABT[3]depicting the principles:

Phase I/II: Reactivation/Reorganisation and development/stabilization Phase:

Stimulate the nervous system with active assisted exercises and use developmental sequencing to develop joint stabilization

Phase III: Strength: Initiate eccentric and concentric muscle contractions through positional movement or stimulation.

Phase IV: Function and co-ordination-Improve co-ordinated movement through all planes of movement and motion. Most exercises are performed in load bearing position. Mainly free standing.

Phase V: Gait training- Focus on proper gait mechanics and the ability to move over ground in multiple planes of motion.
Surface spinal stimulation was delivered (45 minutes session) to the patient three times a week along with ABT on alternate days.

RESULTS

The participant underwent a 24 week program of ABT and SSS. The following section depicts the effect of same on neurologic function, walking ability and functional independence. Table 1 determines the effect of activity based therapy and Surface Spinal Stimulation on neurologic function, walking ability and functional independence.

Table 1 Effect of activity based therapy and Surface Spinal Stimulation on neurologic function, walking ability and functional independence.

Time frame	AIS score (25 + 25) Right LEMS	Left LEMS	WISCI-II (20 levels)	SCI-FAI (39)	SCIM-III (100)
Week 1	7	6	9	24	70
Week 12	9	7	9	28	73
Week 24	9	7	9	29	79

Electrophysiological measures can provide information that complements clinical assessments. The present study utilized H reflex (Posterior Tibial Nerve) and SSEP (Posterior Tibial Nerve and Common Peroneal Nerve) bilaterally for the subject to determine the effect of interventions on the integrity of impulse transmission of somato-sensory nerve fibres through parts of the spinal (mainly dorsal column) and peripheral (peripheral nerve, plexus) nervous system can be tested. And the purpose of H reflex was to determine the function of afferent, spinal-segmental and efferent pathways. Below the Table 2, represents the recordings of SSEP at 24 weeks. During the week 1, week 12 and week 24 H reflex was non-elicit able SSEP was elicit able. Some observable changes were seen in SSEP at 24 weeks.

Table 2 Parameters of Somato-sensory evoked potential at 24 week.

Variable	Latency→	N8	N22	P37	N45
SSEP (CPN)	Right Limb	0.75 ms	5.38ms	15.12ms	24.75ms
	Left Limb	0.88 ms	4.88 ms	11.25ms	15ms
Variable	**Latency→**	**N8**	**N22**	**P37**	**N45**
SSEP (PTN)	Right Limb	3.75ms	5.12ms	11.25ms	15ms
	Left Limb	3.75ms	7.5ms	11.25ms	15ms

DISCUSSION

The above case study was designed keeping in view the concepts of neural control of locomotion that underlie the activity-based therapy which include (a) the level of automaticity of the spinal cord networks; (b) the importance of sensory input to the spinal cord automaticity; (c) neuromodulation of the physiologic state and the learning capacity of the spinal cord locomotor circuitry; and (d) the role of descending pathways in the control of locomotion. Also the present study utilized Surface Spinal Stimulation. Research studies in animals and humans that have found that retraining after SCI using the intrinsic physiologic properties of the nervous system can facilitate the recovery of function[6]. The purpose of the interventions was to modulate the spinal neural circuitry for gaining functional changes. We observed that after 24 weeks of intervention (ABT+SSS) there were some observable changes in the neural pathways, from no clinical sign of nerve activity we reached a point whereby there were recordable electrophysiological parameters indicating activity in neural circuit. Also, there was improvement in ASIA score of lower limb by 2 points on right side and by 1 point on left side. There was no change in level of WISCI-II and improvement of 5 points on SCI-FAI and of 9 points on SCIM-III.

Physical activity has been linked with improved outcome following CNS trauma. It has been well-documented for more than 20 year that cats with a completely transacted spinal cord can be trained to step or stand on a treadmill[7]. This phenomenon occurs because of the "retraining" of the spinal cord networks responsible for the alternating pattern of flexion and extension. Referred to central pattern generators (CPGs), the CPGs for hind limb stepping are located within the lower thoracic and upper-mid lumbar regions of the spinal cord in mice, rats, and cats[8]. These studies show that the spinal cord integrates supraspinal and afferent information and with repetitive practice can improve motor output. Keeping in vision these facts the present study attempted to tap the neural circuitry with ABT and SSS as interventions. Recovery of function after spinal cord injury depends on a complex interaction between severity of injury and type and intensity of training and modulation of the spinal circuitry. The use dependent features of the spinal circuitry seem to be of paramount importance when the injury is incomplete.

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