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Effectiveness of FES Assisted Intensive Locomotor Training on Walking in Patient with Pott's Paraplegia: A Single Case Study

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Abstract: ***Background: Pott's disease caused by mycobacterium tuberculosis is serious form of spinal cord infection leading to subsequent neurologic compromise. In these patients the basic rehabilitation approaches would minimize the assistance of other people. Interventions for walking may enable improvement due to the processes of neuroplasticity. Repetitive retraining of walking after SCI would promote gait restoration through "central pattern generator", responsible for rhythmic oscillations of lower limbs. Activation of paralyzed lower limbs during locomotion is facilitated through flexor withdrawal response using FES. Hence, this study is done to show the effectiveness of FES assisted locomotor training intensively to promote early independent walking in Pott's Paraplegic patients. Methodology: Intense locomotor training with conventional therapy was given for 4 hours per day for 6 days per week for 12 weeks. For the evaluation of walking ability in Pott's paraplegic patient, pre and post post-intervention measures were taken using WISCI-II scale and 10MWT. Results: It showed increase in the level of independence in terms of improvement in the WISCI II level 1 to level 19, along with change in the Walking velocity. Conclusion: FES assisted Intensive gait training leads to early walking ability in pott's paraplegic patients.***

Keywords: POTT'S PARAPLEGIA, FES, GAIT, WISCI-II, 10MWT

1. Introduction

Pott's disease is a form of spondylodiscitis caused by mycobacterium tuberculosis. Pott's paraplegia was described by Sir Percivall Pott in the eighteenth century. Infections of the spine and infections of the spinal cord and surrounding structures can directly or indirectly cause damage to the spinal cord with subsequent neurologic compromise. The patients whether surgically or conservatively treated had a lot of neurological, motor, and sensory disturbances. In these patients the basic rehabilitation approaches during early, pre-operation, post-operation period and in the Rehabilitation centre and home environment will increase the independence of patients in daily living activities and minimize the assistance of other people. **[1]**

Restoration of walking has consistently ranked high in priority for the individual with SCI, their families, and their health care providers. **[2]** Riggins MS et al did a study in 2011 on The relationship between quality of life and change in mobility 1 year postinjury in individuals with spinal cord injury which indicate that patients who primarily focus on walking after SCI, but never attain it, have a lower quality of life, higher dependence and more depression at 1 year after SCI than their counterparts who master independence from a seated position.**[3]** In addition, patients' expectations about walking can prompt them to forgo standard rehabilitation while pursuing programs that focus primarily on gait. **[4]**

A number of studies have suggested that interventions for walking may enable improvement after a SCI due to the processes of neuroplasticity. **[5]** Retraining of walking after incomplete spinal cord injury (SCI) has largely focused on mass practice with repetitive stepping on a treadmill or over ground. **[6]**

Hip extension position and load are 2 examples of sensory input specific to the task of walking that contribute to the inherent mechanisms in the neural axis generating stepping. These sensory signals are interpreted by a network of spinal interneurons, often referred to as a "central pattern generator" (CPG), which combine with descending supraspinal input in order to control walking. The pattern of locomotion is attributed to the CPG, which promotes the rhythmic oscillations of the extremities. Thus, it is intuitive to develop rehabilitative strategies that emphasize the provision of hip extension and load, as well as other sensory elements contributing to the control of walking. A complete ensemble of sensory information relative to walking (i.e., speed, interlimb and intralimb coordination, and kinematics) provided during training would likely enhance the neural output generating walking. **[7]**

Functional electrical stimulation (FES) of the lower limb is one potential technique that has been used to promote gait restoration for people with motor-complete SCI**.** In contrast, an 'orthotic effect' may be used to describe the immediate improvement in walking speed observed while using the device compared to unassisted walking. **[5]**

Electrical Stimulation over the common peroneal nerve has been shown to stimulate a flexor withdrawal response in the ipsilateral limb. Enhancing flexion of the hip, knee and ankle during the swing phase of gait through facilitating the flexor withdrawal response with FES as shown in the FIG.1, in people with SCI has been documented by Granat et al (1993). **[8]**

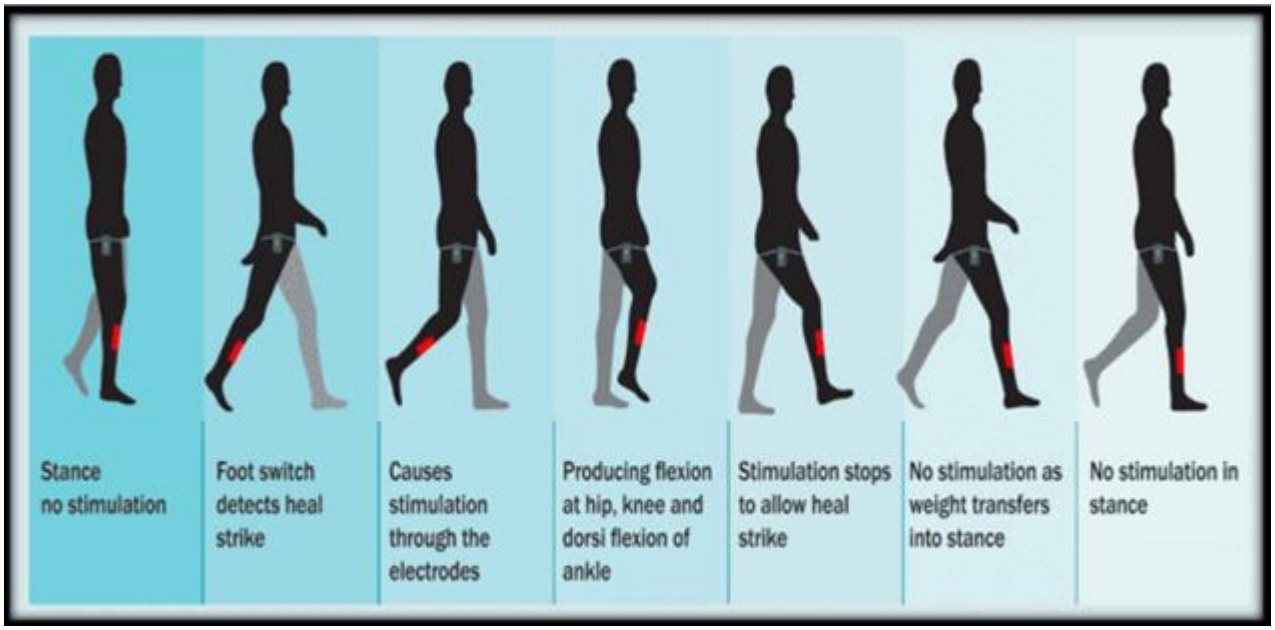


Figure 1: FES GAIT [8]

Two reviews by Nightingale et al (2007) and Ragnarsson (2008) conclude that there is evidence to support the use of FES to improve function and quality of life in people with SCI. **[8]**

So, this study is done in order to show the effectiveness of FES assisted intensive locomotor training in patients with Pott's Paraplegia.

2. Literature Review

The aim of this review is to share our clinical experience and summarise the publications about spinal infection rehabilitation. There are very few studies about the rehabilitation of spinal infections. Therefore, there is a need for a comprehensive rehabilitation programme with an emphasis on Gait training in order to promote early independent walking.

3. Objective of the Study

To show the effectiveness of FES assisted Intensive Gait training in patient with Pott's paraplegia.

4. Case Presentation

This report details the case of a patient with incomplete spinal cord lesion, in a 15-year-old child having major complain of dependent walking. The case progressed to the point that post - surgery, he had bilateral lower limb weakness, leading to difficulty in initiating lower limbs making him wheelchair bound. Medications with Physical therapy sessions were ongoing.

Diagnosis and History

Diagnosis: Pott's Spine with paraplegia
Level: D6 Spine
Date: May 15th, 2021.

Present Illness: A 15 year old ♂ was having history of sudden onset of weakness in bilateral lower limb, initiation of pain after 5 days, so consulted neurologist who suggested for investigating reports which showed tuberculosis of spine with symptoms as motor dysfunction in bilateral lower limbs (left>right). So, doctor advised for surgical treatment after which Post- Surgical Rehabilitation was started, till date.

Surgical History: D6 laminectomy (May 19th, 2021)

Drug History: Antituberculosis drugs

Rehabilitation history: Patient took conventional therapy for 6 days per week for 3.5 hours for 9 months in home environment which included all the passive movements and the weight bearing exercises and 30 min of walking, leading to initiation of right lower limb muscles within the period of 9 months.

Objective Assessment
Patient is having predominant pattern of weakness in left>Right lower limb with increased extensor tone in Antigravity muscles during standing and walking along with Elbow walker and braces as walking aids.

Examination

Motor Function:
TONE: INCREASED
SPASTICITY: PRESENT (ANTIGRAVITY MUSCLES)
REFLEXES: EXAGGERATED
MMT: WEAKNESS (left>Right lower limb)

GAIT Analysis

Type of GAIT: Supported Walking using assistive devices

Use of Assistive Devices: Elbow Walker, AKBK Braces, Safety Belt

Phases of GAIT:
Heel strike – Reduced BIL (LEFT>RIGHT) due to increased tone in his calf.
Initiation of Left hip and knee flexion during swing phase - Reduced BIL (LEFT>RIGHT)
Compensatory strategies- side flexes on the right during left swing phase, circumducts his left hip during swing phase.

5. Clinical Procedure

The patient with motor-complete spinal cord injury and drop foot (neurological level of injury D6) formed a referred sample for treatment. Written informed Consent was taken from the patient. After Surgical Procedure and conventional home based rehabilitation, he received intense locomotor training in our program. The locomotor training included Repetitive walking for total 2 hours with the application of FES (Fig. 2) over left lower limb using foot-up splint (Fig. 3) bilaterally and assistive devices. Pre and Post therapy, outcome measures were taken.

Figure 2: FES

Figure 3: Foot Up Splint

Goal For Recovery
Progression from Elbow walker to Single Quadripod stick walking.

6. Method

Patient received Assisted over-ground Walking, with the use of FES supported over left lower limb along with the foot-up splints bilaterally and assistive devices. Intensive Locomotor training was done through continuous walking in the sequential order as 1 hour of Gait training followed by conventional therapy for 2 hours after which repetition of walk was done for 1 hour in a single session. Treatment parameters were indicated as below:

Treatment Session:
Intensity: Locomotor Training: 2 hours
Conventional Training: 2 hours
Total treatment period: 4 hours/ session
Total number of sessions: Single session /day
Frequency: 6 days/week
Duration: 12 weeks

Set-Up
Functional Electrical Stimulation: The FES clinician decided whether treatment was indicated for one or both limbs. The assessment was based on the severity of the presentation of both lower limbs. The criteria used to make this assessment primarily focused on safety through examining the amount of dorsiflexion, heel strike and foot clearance of the Right lower limb. On the basis of assessment FES was applied over the Left Lower Limb.

Stimulation Muscles:
(a) Stimulation to the dorsiflexors for a single dropped foot application
(b) Hamstring stimulation to assist with knee flexion during the swing phase of gait to counteract effect of extensor tone of the muscles.

Electrode Placement
Positive electrode over the Tibialis Anterior muscle
Negative electrode over the lateral aspect of Popliteal Fossa

Stimulation Parameters:
The devices stimulated at 40Hz using asymmetrical biphasic waveform, with current intensity up to 50 mA and pulse width up to 180 microseconds. There were other parameters which were set-up to smoothen the gait pattern such as timings, heel-raise, heel-strike, Swing phase timings.

Foot Up Splint: Bilaterally splint was applied as an adjunct to support dropped foot for the ground clearance during walking to smoothen gait pattern.

Treatment Progression Using FES:
- During initial 2.5 weeks, FES assisted Locomotor training was done using elbow walker. (FIG.4)
- FES assisted locomotor training was done using standard walker for 4 weeks. (FIG.5)
- FES assisted locomotor training was done using Bilateral stick for 5.5 weeks. (FIG.6)

Figure 4: FES Walking Using Elbow Walker

Figure 5: FES Walking Using Standard Walker

Figure 6: FES Walking Using Bilateral Quadripod Stick

Outcome Measures: 1) Walking Index for Spinal Cord Injury – II (WISCI II) 2) 10-meter walk test (10MWT)

7. Results

1) Walking Index for Spinal Cord Injury – II (WISCI II)

Table 1: Pre and Post Test Scores of WISCI II

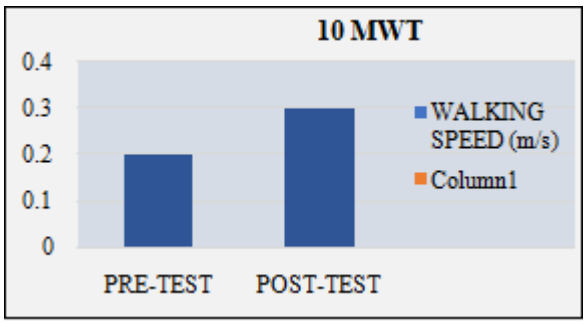
Pre - Treatment Scores					
Descriptors	Devices	Braces	Assistance	Patient Reported Comfort Level	
	Parallel Bars 10+ Meters	Short Braces-Uses 2	MIN/MOD Assist *2 People	Slightly Comfortable	
WISCI Level	Level	Devices	Braces	Assistance	Distance
	1	Parallel Bars	Braces	2 Persons	Less Than 10 Meters
Post - Treatment Scores					
Descriptors	Devices	Braces	Assistance	Patient Reported Comfort Level	
	CANES- QUAD USES 1	No Braces	No Assistance	Slightly Comfortable	
	Level	Devices	Braces	Assistance	Distance
WISCI Level	19	One Crane / Crutch	No Braces	No Assistance	10 Meters

Table. 1 shows transition of WISCI II scores from level 1 to level 19, which indicates increase in the level of independence from parallel bar supported walking to single quadripod cane walking.

10MWT	Pre-Test	Post-Test
Time Taken to Cover Distance	26 s	22 s
Walking Speed	m/s	0.3 m/s

2) 10-meter walk test (10MWT):

Table 2: Pre and Post Test Measures for 10MWT
Table 2, shows change in the gait speed post intervention



Graph 1: Pre and Post Test Walking Speed
Graph 1, Shows change in the walking speed of the patient post intervention

8. Discussion

The results of the study found improvement in the level of independence along with the change in the gait speed.

According to the Walking Index for Spinal cord Injury II, it showed an increase in the level of WISCI II from level 1 to level 19 which indicated the improvement in the level of independence after intensive FES assisted Gait training. The similar study was done by Kelly Robinson et al on effectiveness of Functional Electrical Stimulation to elicit flexor withdrawal response for gait which concluded that Fes assisted walking improves the quality of gait pattern, reduce the effort of walking and improves safety of walking in people with SCI who have reduced ability to produce adequate hip and knee flexion. It can be used to rehabilitate gait or even as an orthosis to maintain current abilities. **[8]** There was shift as, transition from elbow walker along with the supportive braces to standard walker, to bilateral quadripod sticks, to single stick walking.

Another study was done by JC Shin et al in 2014 on effectiveness of robotic assisted gait training in patients with incomplete spinal cord injury patients which showed similar improvements in the WISCI levels. **[9]**

According to 10MWT, it showed change in the gait speed from 26 seconds to 22 seconds. So, it showed an improved walking speed of the patient post intervention with the change in the level of assistance. A study was done by Ajax Yang et al in 2015 on Assessment of In-Hospital Walking Velocity and Level of Assistance in a Powered Exoskeleton in Persons with Spinal Cord Injury. The results of the study showed that less the assistance a participant needed, the faster he or she achieved Exoskeleton Assisted Walking velocity measured using 10MWT.**[10]**

Hence, it was clear that purely concentrating on intensive Gait training have a significant effect in upright stability, reduced effort during walking leading towards an independent locomotion. We therefore hopefully would continue to work on his stability and goal of reducing the effort required to walk on uneven surfaces independently.

9. Conclusion

The study concluded that FES assisted intensive gait training lead to transition of patients with complete motor SCI from Elbow walker to Stick walking.

Supportive devices may augment functional ambulation particularly in people with incomplete SCI.

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