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Effectiveness Of Early Ambulation with Indigenously Prepared Harness Sling on Functional Independence in Incomplete Spinal Cord Injury

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ABSTRACT

Purpose of the study: Spinal cord injury (SCI) refers to damage to the spinal cord caused by either traumatic events, such as falls or road traffic accidents, or non-traumatic factors, including tumors, degenerative diseases, vascular disorders, infections, toxins, or congenital anomalies. The higher the injury on the spinal cord, the more extensive the disability, ranging from quadriplegia in cervical injuries to paraplegia in thoracic or lumbar injuries. These neurological deficits significantly impact daily functioning and often necessitate multidisciplinary rehabilitation. Thus, this study aimed to assess the effectiveness of early ambulation using an indigenous prepared harness to enhance ambulation among SCI patients.

Methodology: A total of 30 patients were included in the study. The inclusion criteria were patients with incomplete SCI, aged between 20-50 years, and paraplegic or quadriplegic patients. 30 participants were allotted by purposive sampling technique. Each allotted participant was given rehabilitation for 45 mins- 1 hr.

Analysis: The analysis was done using the SPSS software. The SCIM III and WISCIM II were the outcome measures used to assess the participant's pre and post-study.

Results: The result of the study indicated significant improvement in both the outcomes post the study with p value being 0.01 for SCIM III and a p-value being 0.002 for WISCIM II.

Conclusion: The study concluded that indigenously prepared harnesses used for incomplete SCI patients proved to be effective in enhancing early ambulation and locomotor training.

Keyword: *Incomplete SCI patients, Harness, Rehabilitation*

1. INTRODUCTION

Spinal cord injury (SCI) is a severe neurological condition associated with substantial socioeconomic consequences for affected individuals and the healthcare system[1]. It refers to damage to the spinal cord, spanning from the foramen magnum to the cauda equina, caused by compression, laceration, or bruising. This injury disrupts the functions of the spinal cord below the affected area, leading to significant impairments. SCI is also a major cause of disability in affected individuals[2]. In India, an estimated 1.5 million individuals are living with spinal cord injury (SCI), with approximately 20,000 new cases diagnosed annually. Of these, 60-70% comprise individuals from rural, economically disadvantaged backgrounds with limited or no formal education. The majority of cases occur in males aged 16-30 years, indicating a higher incidence within the young, active, and economically productive demographic[3]. The clinical presentation of spinal cord injury (SCI) is influenced by the severity and anatomical location of the lesion, often resulting in partial or complete sensory and/or motor deficits below the level of injury. Lesions in the lower thoracic region typically lead to paraplegia, whereas cervical-level injuries are commonly associated with quadriplegia. Approximately 50% of SCI cases involve the cervical region, with C5 being the most frequently affected level. Injuries to the thoracic and lumbar areas account for 35% and 11% of cases, respectively[4]. Globally, the primary etiologies of spinal cord injury (SCI) include motor vehicle accidents, gunshot wounds, stab injuries, falls, and sports-related trauma, with diving being the most frequently reported sport-related cause. The injury typically results from mechanisms such as flexion, compression, hyperextension, or flexion-rotation, collectively referred to as "primary damage. Secondary damage arises from the body's physiological response to the initial trauma, including hemorrhage, inflammation, and the release of various chemical mediators[5]. The American Spinal Injury Association (ASIA) classifies spinal cord injuries based on motor and sensory function assessments. The American Spinal Injury Association (ASIA) Impairment Scale (AIS) is a standardized classification system used to assess the severity of spinal cord injuries. ASIA-A (Complete injury) denotes the absence of sensory and motor function in the sacral segments S4-S5, indicating total loss of neurological function below the level of injury. ASIA-B (Sensory Incomplete) signifies preserved sensory function below the neurological level, including sacral segments S4-S5 (light touch, pinprick sensation, or deep anal pressure), but with no motor function maintained more than three levels below the motor level on either side of the body. ASIA-C (Motor Incomplete) indicates that motor function is preserved below the neurological level, but more than half of the key muscles below this level have a muscle strength grade of less than 3/5, signifying significant weakness. ASIA-D (Motor Incomplete) also involves preserved motor function below the neurological level; however, at least half of the key muscles demonstrate a strength grade of 3/5 or higher, allowing for functional movement against gravity. ASIA-E (Normal) is assigned when both sensory and motor functions are intact, as evaluated using the International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI). In patients with prior neurological deficits, an ASIA-E classification may be designated, but individuals without spinal cord injury do not receive an ASIA classification.

The ASIA impairment scale is used mainly to classify whether the injury is complete or incomplete. A complete injury is having no sensory and motor functions in the lowest sacral segments i.e. at S4 and S5. However, an incomplete injury is defined as having motor and/or sensory function below the level i.e. at S4 and S5 levels[6].

Motor incomplete spinal cord injury (SCI), characterized by the preserving voluntary motor function below the neurological level of injury, offers a considerable prognosis for the recovery of functional ambulation. Rehabilitation for such cases prioritizes restoring ambulatory capabilities as a key therapeutic goal. The extent of motor function spared significantly impacts outcomes, influencing the ability to engage in gait training, weight-bearing activities, and mobility-related tasks. Rehabilitation strategies often include strength training, task-specific interventions, and advanced modalities such as functional electrical stimulation, to enhance neuroplasticity and facilitate motor recovery[2]. Therefore, the main strategy in SCI rehabilitation constitutes therapies for improving motor function and enhancing early ambulation

2. MATERIALS AND METHODOLOGY

This observational study was approved by the Institutional Ethics Committee of KVV, Deemed to be University, Karad. All subjects included in the study were given a brief idea about the study and consent was taken before the study. A total of 30 patients with Incomplete spinal cord injury were recruited in the study. The inclusion criteria included participants aged between 20-50 years, those with paraplegia or tetraplegia due to level of injury at C5-T1 or at T1 to T12, and those who were willing to participate in the study. Conversely, individuals with other neurological conditions like stroke or other systemic diseases like infection, and patients with transient ischemic attacks were excluded from the study.

Sr No	Week	Protocol
1.	0-1	Chest PT Passive ROM Bed Mobility: Rolling Pelvic Bridging(initiation)
2.	2-3	Breathing Exercises Diaphragmatic Breathing Thoracic Expansion PROM Bed Mobility Prone on hands Weight shifts (with support in sitting)
3.	4-5	Passive ROM Bed Mobility Pelvic Bridging Prone on hands Weight shifts (with support in sitting) Prone on elbows Sit to stand (initiation)
4.	6-7	Passive ROM/ Active assisted exercise Bed Mobility Pelvic Bridging (hold 5 sec) Side lying-sitting Sit to stand (withhold) Standing (with support of harness)
5.	7-8	Active assisted exercise Sit to stand Standing (20-30 secs) Marching Step up Step down Gait (initiation)

3. RESULTS

30 individuals with a cervical or thoracic SCI participated in the study. The majority of SCI individuals were male (82%) with an age range of 20–50 years (average 31.8711 years). All individuals sustained an incomplete SCI in our study. The

average time post-injury was 1.8783 years.

Table 1: Characteristics of the individuals

Gender	Male 20 Female 10
Age group	20-50
Neurological Level	C5-T1, T11-T12
Diagnosis	Tetraplegia Paraplegia
Time since injury	1-2 years
Type of Injury	Incomplete Injury

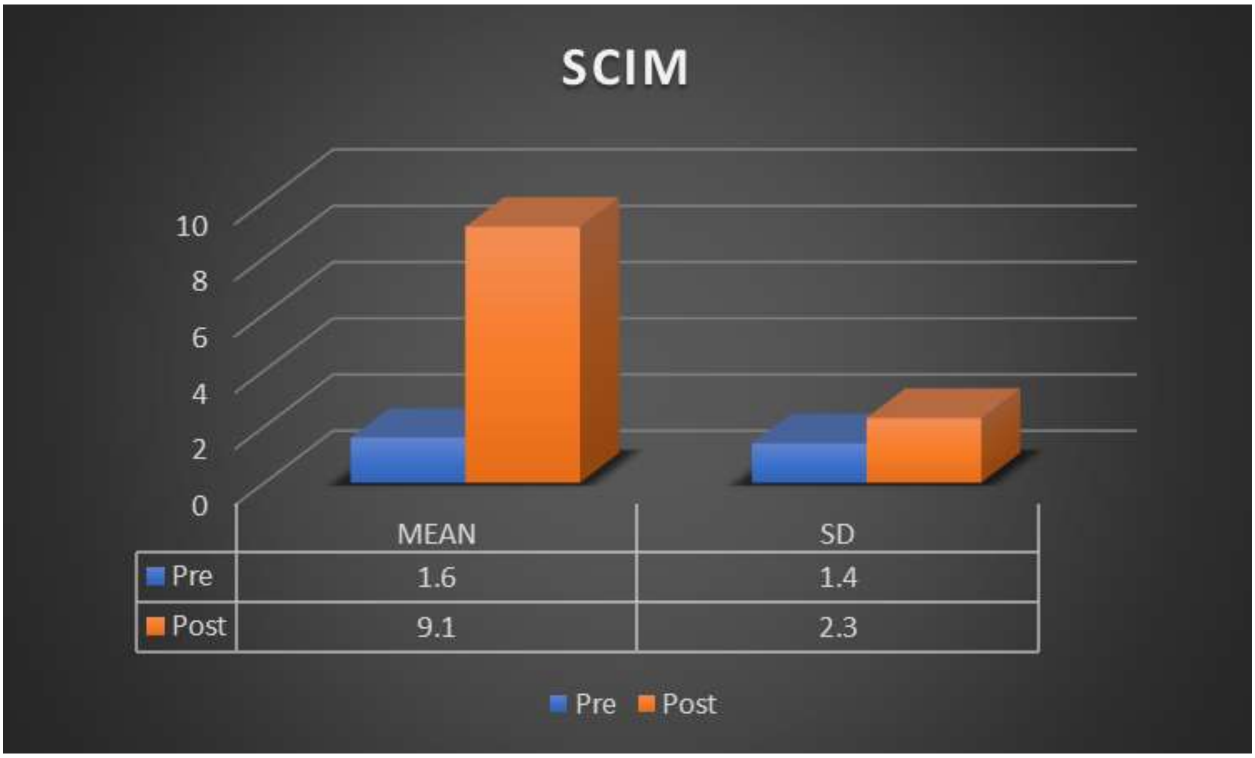

Figure 1: Spinal Cord Independence Measure [7]

The figure shows the pre and post values after giving the intervention to the participants. It signifies that the scores have improved after the protocol.

Outcome measure	Pre Mean	Pre SD	Post Mean	Post SD
Spinal Cord Independence Measure	1.6	1.4	9.1	2.3
Walking index for spinal cord injury	30.2	3.8	53.8	6.8

Figure 2: Walking index for spinal cord injury (WISCIM)[8]

The graph shows improved post values of the participants compared to the pre values which signifies improvement in gait post giving the intervention

4. DISCUSSION

Our study highlights the significance of using harness support in patients with incomplete spinal cord injuries, addressing issues such as pain, discomfort. Previous research has shown that occipito-cervical pain in SCI patients is comparable to pain levels seen in other conditions where hypotension is prominent, such as pure autonomic failure and multiple system atrophy. Additionally, pain characteristics—such as its association with an upright posture, arm exercise, and relief when lying flat suggest a causal link to hypotension [9-10]. In our study we focus on the independence of the participants pertaining to their gait component. Our values reveal that the 8 week intervention on the participants with the use of functional harness proves to be beneficial and aids in early recovery and regainment of the lost functions.

A study by Baydur (2001) demonstrates that individuals with traumatic tetraplegia respond differently than those without such injuries, showing an increase in forced vital capacity (FVC) and inspiratory capacity (IC) when in the supine position. One proposed mechanism suggests that the diaphragm increases its inspiratory excursion in the supine posture because its muscle fibers are longer at the end of expiration. This places them on a more advantageous part of their length-tension curve, increaseing IC[11-12].

Our findings offer new insights into low-frequency autonomic rhythms in humans. We observed that the magnitude but not the central frequency of low-frequency muscle sympathetic nerve activity and arterial pressure spectral powers increases directly with the tilt angle. In our study, respiratory fluctuations in muscle sympathetic nerve activity, as well as in systolic and diastolic pressures, increased proportionally with the tilt angle, while respiratory fluctuations in RR intervals decreased accordingly. These observations provide a clearer understanding of these physiological changes[13-15].

Significant locomotor recovery in mammals, including humans with spinal cord injury (SCI), can often be attributed to the reorganization of preserved neural pathways. Research suggests that even if only 10% of descending spinal tracts remain intact, some degree of locomotor function may be regained. Additionally, the neuronal networks below the level of the lesion can adapt to produce locomotor activity independently, even without input from the brain. Previous studies have shown that individuals with complete or incomplete spinal cord injury (SCI) who underwent locomotor training for several months were able to generate coordinated stepping movements and demonstrated increased leg extensor EMG activity. Among those with incomplete SCI who regularly engaged in locomotor activity, leg extensor EMG activity remained elevated even after three years. In contrast, individuals with complete SCI who remained wheelchair-bound experienced a significant decline in EMG activity. These findings suggest that training-induced plasticity in spinal neuronal centers can be maintained only with ongoing locomotor activity[16].

Dietz and colleagues proposed that neuronal circuits for "locomotor pattern generation" exist from the thoracic to cervical levels, with the strength of the pattern depending on the lesion level. This was based on EMG analyses of the gastrocnemius and tibialis anterior muscles during body-weight-supported treadmill training (BWST) in 13 clinically complete and 5 clinically incomplete SCI subjects. Additionally, after several weeks of step and stand training, some clinically complete SCI subjects could bear weight while standing, with one subject able to stand unassisted, bearing 90% of body weight, for 45 seconds. Chronic, clinically incomplete subjects increased their weight-bearing capacity and eventually stood independently for several minutes[17].

Early initiation of locomotor training in patients with incomplete spinal cord injury (SCI) is highly recommended to maximize the training duration and prepare the body for optimal recovery once some supraspinal control is regained. This approach significantly enhances the potential to achieve a high level of locomotor function[18].

Smooth and normal locomotion relies heavily on cortical and peripheral sensory input; however, the initiation and timing of stepping are primarily governed by a self-oscillating interneuronal network within the lumbar spinal cord. Even an isolated lumbar spinal segment can generate rhythmic outputs that flex and extend joints in a cyclical pattern. The lumbar stepping motor neuron circuits are particularly influenced by serotonergic and noradrenergic descending pathways originating from brainstem nuclei. These pathways adjust the sensitivity of sensory and motor neurons, modulate the oscillatory activity of spinal neurons, and fine-tune specific components of the locomotor pattern[19].

The subjects' responses to training suggest that spontaneous recovery alone may not account for the observed improvements in locomotor status. Additionally, all participants in the study were young to middle-aged adults. Neuroplasticity and spontaneous recovery likely vary with the age at the time of injury, making age an influential factor in recovery outcomes.

5. CONCLUSION

Individuals with incomplete spinal cord injury (SCI) who participated in several months of locomotor training were able to generate coordinated stepping movements. This indicates that training-induced plasticity in the neuronal centers of the isolated spinal cord can only be sustained with ongoing locomotor activity. These findings highlight that such rehabilitative approaches have contributed to notable improvements in overall outcomes, including reductions in mortality and enhancements in life expectancy

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