



THE EFFECTIVENESS OF LOCOMOTORS TRAINING ON GAIT & LOWER LIMB STRENGTH WITH BODY WEIGHT IN SPINAL CORDED INCOMPLETE INJURY PATIENTS- A CASE REPORT

EFIKASNOST LOKOMOTORNOG TRENINGA NA HOD I SNAGU DONJIH EKSTREMITETA KOD PACIJENATA S NEPOTPUNOM POVREDOM KIČMENE MOŽDINE – PRIKAZ SLUČAJA

Muslim Khan^{1*}, Iqra Muslim², Ifra Muslim², Yahya Muslim²

¹Iqra National University, Peshawar, Pakistan

²King Hospital, Swat, Pakistan

Case Study

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ABSTRACT

Incomplete spinal cord injury patients (SCI) highly prioritize walking restoration irrespective of the level, severity, age, gender & the time after lesion. Walking restoration in patients with incomplete SCI has been extensively studied. For functional & mobility restoration, physical rehabilitation is currently the main intervention worldwide. Strategies adopted worldwide for the physical rehabilitation of SCI patients includes robotic assisted gait training, functional electrical stimulation (FES), Epidural stimulation, spinal surface stimulation, treadmill training with & without body weight support. This case report is an attempt to find out the effectiveness of the of locomotors training on gait & lower limb strength with body weight in spinal cord incomplete injury patients.

A patient with incomplete SCI age 43years, ASIA score-C was treated with body weight support for 9 months (January, 2019-october, 2019) in the physiotherapy department of the King hospital, Swat. The outcome measures used were ASIA scale, Manual muscle testing (MMT) for lower extremity, Spinal cord injury functional ambulation inventory (SCI-FAI) and walking Index for SCI-11 (WI-. SCI-11).

The study results showed positive improvement in lower extremity strength & gait parameters (spatial & temporal parameters) on SCI –FAI, however, Score on WI-. SCI-11 & assistive device scale was not improved.

This case report results can be concluded that locomotors training is highly effective in incomplete SCI patients in improving their functional mobility & restoration.

Key words: Incomplete SCI, central cord pattern, locomotors training, treadmill training with body weight support.

* Correspondence author: Muslim Khan, Iqra National University, Peshawar, Pakistan
E-mail: drmuslim17@gmail.com

SAŽETAK

Pacijentima s nepotpunom povredom kičmene moždine (SCI) vraćanje sposobnosti hodanja predstavlja visoki prioritet, bez obzira na nivo, težinu povrede, starosnu dob, spol ili vrijeme proteklo od nastanka lezije. Obnavljanje funkcije hoda kod osoba s nepotpunom povredom kičmene moždine detaljno je proučavano. Kada je riječ o funkcionalnom oporavku i mobilnosti, fizička rehabilitacija trenutno predstavlja glavnu intervenciju širom svijeta. Strategije koje se globalno primjenjuju u fizičkoj rehabilitaciji pacijenata sa SCI uključuju: robotski potpomognut trening hoda, funkcionalnu električnu stimulaciju (FES), epiduralnu stimulaciju, površinsku stimulaciju kičme i hodanje na traci sa ili bez podrške vlastite tjelesne težine. Ovaj prikaz slučaja predstavlja pokušaj da se ispita efikasnost lokomotornog treninga na hod i snagu donjih ekstremiteta uz podršku tjelesne težine kod pacijenata s nepotpunom povredom kičmene moždine. Pacijent star 43 godine s nepotpunom SCI povredom, ASIA ocjena C, tretiran je uz podršku tjelesne težine tokom perioda od devet mjeseci (januar 2019 – oktobar 2019) u Odjeljenju za fizikalnu terapiju bolnice King, Swat. Korišteni su sljedeći instrumenti za procjenu ASIA skala, Manualno testiranje mišićne snage (MMT) donjih ekstremiteta, Inventar funkcionalne ambulacije za povredu kičmene moždine (SCI-FAI) i Indeks hodanja za SCI-11 (WI-SCI-11). Rezultati studije pokazali su značajno pozitivno poboljšanje u snazi donjih ekstremiteta i parametrima hoda (prostorni i vremenski parametri) prema SCI-FAI, dok poboljšanje na WI-SCI-11 i skali za pomoćna ortopedska sredstva nije bilo statistički značajno. Na osnovu ovog prikaza slučaja može se zaključiti da je lokomotorni trening izuzetno efikasan kod pacijenata s nepotpunom povredom kičmene moždine u poboljšanju njihove funkcionalne mobilnosti i oporavka.

Ključne riječi: Nepotpuna povreda kičmene moždine, obrazac centralnog oštećenja moždine, lokomotorni trening, trening hodanja na traci s podrškom tjelesne težine.

INTRODUCTION

Independent locomotion is essential for physical and psychological health. Although it is not a survival skill, the inability to move independently leads to an unfulfilled life in individuals with spinal cord injuries (SCI) (Pulverenti et al., 2022; Murray et al., 2022). Thus, functional and mobility restoration is prioritized in SCI through patient-specific goals. Incomplete spinal cord injury patients highly prioritize walking restoration, regardless of lesion level, severity, age, gender, or time since injury (Hofer et al., 2022). Walking restoration in patients with incomplete SCI has been extensively studied. Physical rehabilitation is currently the main global intervention for functional and mobility recovery (Gollie et al., 2020).

Rehabilitation strategies include (a) robotic-assisted gait training, (b) functional electrical stimulation (FES), (c) epidural stimulation, (d) spinal surface stimulation, and (e) treadmill training with and without body weight support (Garnier-Villarreal et al., 2022). Among these, body weight support treadmill training (BWSTT) has been widely used and recognized as effective for improving function and mobility in individuals with incomplete SCI (Evans et al., 2022). BWSTT has also been proposed as a cost-effective strategy that supports patients'

reintegration into society and family while enhancing their residual potential for mobility (Evans et al., 2022; Hawkins et al., 2022).

BWSTT facilitates near-normal gait patterns in SCI patients by partially unloading body weight. It involves supporting a portion of the patient's body weight while assisting with walking to provide temporal and kinematic cues on a motorized treadmill. It is a form of gait training grounded in practicing physiological gait patterns, where induced attentional cues enhance focus on kinematic and temporal aspects of gait (Evans et al., 2022; Lin et al., 2022). As reported by researchers, a prerequisite for achieving functional potential in incomplete SCI patients is the presence of basic stereotyped synergy that enables forward propulsion—a mechanism believed to be driven by the central pattern generator (CPG) in the spinal cord. BWSTT can train the CPG to improve gait and mobility (Samejima et al., 2022; Boerger et al., 2022; Kim et al., 2022). Training the CPG via BWSTT is considered cost-effective, feasible, and clinically effective (Calabrò et al., 2022).

This case report aimed to determine the effectiveness of locomotor training on gait and lower limb strength with body weight support in patients with incomplete spinal cord injury.

MATERIAL AND METHODS

Sample of Participant

The study involved a 43-year-old male patient with incomplete spinal cord injury (SCI), classified as ASIA Impairment Scale (AIS) grade C, with no cognitive deficits. The patient underwent rehabilitation at the Physiotherapy Department of King Hospital, Swat, for an initial rehabilitation phase of 9 months.

Method of Conducting Research

The participant was informed about the study's objectives and procedures, and written consent was obtained. Ethical approval was secured from the hospital's administration and relevant committees before commencing the study. The patient underwent regular neurological and physical therapy assessments.

Intervention

The patient received Body Weight-Supported Treadmill Training (BWSTT) for 45 minutes/day, 4 times/week, over 9 months (totaling 140–144 sessions). The weight relief was adjusted based on gait performance, starting at 50% and progressively modified as gait parameters improved. Precautions were taken to ensure proper weight distribution, avoiding excessive knee flexion or heel-off during gait loading. In addition to BWSTT, the patient underwent conventional physical therapy to enhance strength and endurance.

Measuring Instruments

The following standardized tools were used for assessment:

1. ASIA Impairment Scale – Evaluated motor and sensory function.
2. Manual Muscle Testing (MMT) – Assessed lower extremity strength.
3. SCI-FAI – Measured functional ambulation.

4. WISCI-11 – Quantified walking ability.
5. Modified Ashworth Scale (MAS) – Evaluated spasticity.

Data Processing Methods

Baseline and follow-up scores were recorded and compared to evaluate functional improvements. Adjustments in BWSTT parameters (weight support) were made based on real-time gait analysis and clinical feedback. This structured approach ensured systematic monitoring of the patient's progress throughout the rehabilitation period.

RESULTS AND DISCUSSION

The study results showed significant positive improvement in lower extremity strength & gait parameters (spatial & temporal parameters) on SCI –FAI, however, Score on WI-. SCI-11 & assistive device scale was not significantly improved. The outcome measures of the study were; a) WISCI-11 for the assessment of the ambulatory function in the incomplete SCI b) ASIA scale for the assessment of lower extremities c) SCI-AI d) MAS e) MMT. Pre-test score (baseline) & post-test score at the end of the study were taken, recorded & analyzed. WISCI-11 is an ordinal scale ranging from 0 to 20 and is used to assess gait limitations, gait patterns (such as swing-through or swing-to), and the need for assistive devices in patients with incomplete SCI. The SCI-FAI is an observational gait assessment tool comprising three categories: (1) gait parameters, (2) temporal parameters, and (3) the use of assistive devices. The ASIA scale assesses the strength of five key muscles in the lower extremities using MMT. Higher scores on all three measures indicate improved performance and function (Boerger et al., 2022; Calabrò et al., 2022; Maggio et al., 2022; Kim et al., 2022; Samejima et al., 2022; Lin et al., 2022). The changes observed on the study's outcome measure are given below in Table 1.

Table-1: Observational data on the study's outcome for the patient with incomplete SCI

Time period	ASIA score		WISCI-11 score	SCI-FAI		
	R-LEMS	L-LEMS		Assistive devices	Gait parameters	Temporal gait parameters
January, 2021 Pre-test baseline score)	7/25	6/25	14/20	11/14	10/20	4
October, 2021 (Post-test score)	12/25	11/25	15/20	11/14	16/20	5

Table-2. SCI-FAI score based on 2 minute walk test (2MWT)

Time period	2MWT-SCI-FAI score
January, 2021 Pre-test baseline score)	55 feet
October, 2021 (Post-test score)	190 feet

Incomplete SCI patients highly prioritize walking restoration regardless of lesion level, severity, age, gender, or time since injury (Hofer et al., 2022). This need has been extensively studied. For functional and mobility restoration, physical rehabilitation remains the primary intervention worldwide. Strategies applied globally for SCI rehabilitation include: (a) robotic-assisted gait training, (b) functional electrical stimulation (FES), (c) epidural stimulation, (d) spinal surface stimulation, and (e) treadmill training with or without body weight support (Garnier-Villarreal et al., 2022; Evans et al., 2022; Hawkins et al., 2022).

This case report aimed to determine the effectiveness of locomotor training on gait and lower limb strength using body weight support in patients with incomplete spinal cord injury. The observed improvements in SCI-FAI scores and muscle strength reinforce the potential benefits of body weight-supported locomotor training, while limited progress on the WISCI-11 and assistive device scale highlights ongoing challenges.

The theoretical framework is grounded in studies on central pattern generators (CPGs) in individuals with incomplete SCI. These studies suggest that repeated stepping and continuous gait movement may stimulate CPG circuits at the spinal level (Calabrò et al., 2022; Maggio et al., 2022; Kim et al., 2022). The CPG is believed to be responsible for producing rhythmic gait patterns through activation via repetitive proprioceptive and kinesthetic stimuli generated by lower limb movements during BWSTT. This activation of the CPG may promote neural plasticity by modulating the interaction between peripheral reflex activity and the CPG itself. Increased training using BWSTT strengthens this interaction, leading to improved outcomes (Samejima et al., 2022; Boerger et al., 2022; Kim et al., 2022).

The case report results can be concluded that locomotors training is highly effective in incomplete SCI patients in improving their functional mobility & restoration & therefore, this study suggests that BWSTT need to be used in the gait physical rehabilitation of the incomplete SCI patients for improvement of their gait parameters.

CONCLUSION

The study results showed significant positive improvement in lower extremity strength & gait parameters (spatial & temporal parameters) on SCI –FAI, however, Score on WI-. SCI-11 & assistive device scale was not significantly improved. This case report results can be concluded that locomotors training is highly effective in incomplete SCI patients in improving their functional mobility & restoration.

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REFERENCES

1. Boerger, T. F., McGinn, L., Wang, M. C., Schmit, B. D., & Hyngstrom, A. S. (2022). Degenerative cervical myelopathy delays responses to lateral balance perturbations regardless of predictability. *Journal of Neurophysiology*, 127(3), 673–688. <https://doi.org/10.1152/JN.00159.2021>
2. Calabrò, R. S., Billeri, L., Ciappina, F., et al. (2022). Toward improving functional recovery in spinal cord injury using robotics: A pilot study focusing on ankle rehabilitation. *Expert Review of Medical Devices*, 19(1), 83–95. <https://doi.org/10.1080/17434440.2021.1894125>
3. Evans, N. H., Suri, C., & Field-Fote, E. C. (2022). Walking and balance outcomes are improved following brief intensive locomotor skill training but are not augmented by transcranial direct current stimulation in persons with chronic spinal cord injury. *Frontiers in Human Neuroscience*, 16, 849297. <https://doi.org/10.3389/fnhum.2022.849297>
4. Garnier-Villarreal, M., Pinto, D., Mummidisetty, C. K., et al. (2022). Predicting duration of outpatient physical therapy episodes for individuals with spinal cord injury based on locomotor training strategy. *Archives of Physical Medicine and Rehabilitation*, 103(4), 665–675. <https://doi.org/10.1016/j.apmr.2021.07.815>
5. Gollie, J. M., Guccione, A. A., Keyser, R. E., Chin, L. M. K., Panza, G. S., & Herrick, J. E. (2020). Walking endurance, muscle oxygen extraction, and perceived fatigability after overground locomotor training in incomplete spinal cord injury: A pilot study. *Journal of Spinal Cord Medicine*. <https://doi.org/10.1080/10790268.2020.1798137>
6. Hawkins, K. A., DeMark, L. A., Vistamehr, A., et al. (2022). Feasibility of transcutaneous spinal direct current stimulation combined with locomotor training after spinal cord injury. *Spinal Cord*. <https://doi.org/10.1038/s41393-022-00801-1>
7. Hofer, A. S., Scheuber, M. I., Sartori, A. M., et al. (2022). Stimulation of the cuneiform nucleus enables training and boosts recovery after spinal cord injury. *Brain*. <https://doi.org/10.1093/brain/awac184>
8. Kim, J. N., Shin, M. Y., Chong, W. S., Yu, C. H., & Kim, K. (2022). Development of rail-based dynamic rehabilitation training system considering user's movement. *Journal of Mechanics in Medicine and Biology*, 22(3). <https://doi.org/10.1142/S0219519422400036>
9. Kristoffersson, A. (2022). A systematic review of wearable sensors for monitoring physical activity. *Sensors (MDPI)*. <https://www.mdpi.com/1445870>
10. Lin, J. T., Hsu, C. J., Dee, W., Chen, D., Rymer, W. Z., & Wu, M. (2022). Anodal transcutaneous DC stimulation enhances learning of dynamic balance control during walking in humans with spinal cord injury. *Experimental Brain Research*, 240(7–8), 1943–1955. <https://doi.org/10.1007/s00221-022-06388-6>
11. Maggio, M., Naro, A., De Luca, R., et al. (2022). Body representation in patients with severe spinal cord injury: A pilot study. *MDPI*. <https://www.mdpi.com/1583022>

12. Murray, D., Keyser, R. E., Chin, L. M. K., Bulea, T. C., Wutzke, C. J., & Guccione, A. A. (2022). EMG median frequency shifts without change in muscle oxygenation following novel locomotor training in individuals with incomplete spinal cord injury. *Disability and Rehabilitation*, 44(1), 52–58. <https://doi.org/10.1080/09638288.2020.1755729>
13. Ortiz, M., Nathan, K., & Hahm, J. A. (2022). Brain-machine interfaces for neurorobotics. *Springer Handbook of Neurorobotics*. https://link.springer.com/content/pdf/10.1007/978-981-15-2848-4_52-1.pdf
14. Padula, N. (2022). Community-based activity-based therapy for spinal cord injuries rehabilitation. *Elsevier*.
<https://www.sciencedirect.com/science/article/pii/B9780128224984000415>
15. Pulverenti, T. S., Zaaya, M., & Knikou, M. (2022). Brain and spinal cord paired stimulation coupled with locomotor training affects polysynaptic flexion reflex circuits in human spinal cord injury. *Experimental Brain Research*, 240(6), 1687–1699. <https://doi.org/10.1007/s00221-022-06375-x>
16. Samejima, S., Caskey, C. D., Inanici, F., et al. (2022). Multisite transcutaneous spinal stimulation for walking and autonomic recovery in motor-incomplete tetraplegia: A single-subject design. *Physical Therapy*, 102(1). <https://doi.org/10.1093/ptj/pzab228>
17. Uhlich, S., Falisse, A., Kidziński, Ł., Muccini, J., & Kording, K. (2022). OpenCap: 3D human movement dynamics from smartphone videos. *bioRxiv*. <https://www.biorxiv.org/content/10.1101/2022.07.07.499061.abstract>