Case Study

Effect of Locomotor Training on Motor Recovery and Walking Ability in Patients with Incomplete Spinal Cord Injury: A Case Series

J. Phys. Ther. Sci.
26: 951–953, 2014

Shahnawaz Anwer, MPT[1, 2)*], Ameed Equebal, MBBS, MD[3)], Tushar J Palekar, MPT[2)], M Nezamuddin, MPT[3)], Osama Neyaz, MBBS[3)], Ahmad Alghadir, MS, PhD, PT[1)]

[1)] *Department of Rehabilitation Sciences, College of Applied Medical Sciences, King Saud University: Riyadh, KSA*
[2)] *Padmashree Dr. D. Y. Patil College of Physiotherapy, Dr. D. Y. Patil Vidyapeeth India*
[3)] *National Institute for the Orthopedically Handicapped (NIOH), India*

Abstract. [Purpose] The aim of this study was to describe the effect of locomotor training on a treadmill for three individuals who have an incomplete spinal cord injury (SCI). [Subjects and Methods] Three indivduals (2 males, 1 female) with incomplete paraplegia participated in this prospective case series. All subjects participated in locomotor training for a maximum of 20 minutes on a motorized treadmill without elevation at a comfortable walking speed three days a week for four weeks as an adjunct to a conventional physiotherapy program. The lower extremity strength and walking capabilities were used as the outcome measures of this study. Lower extremity strength was measured by lower extremity motor score (LEMS). Walking capability was assessed using the Walking Index for Spinal Cord Injury (WISCI II). [Results] An increase in lower extremity motor score and walking capabilities at the end of training program was found. [Conclusion] Gait training on a treadmill can enhance motor recovery and walking capabilities in subjects with incomplete SCI. Further research is needed to generalize these findings and to identify which patients might benefit from locomotor training.

Key words: Locomotor training, Spinal cord injury, Paraplegia

(This article was submitted Dec. 10, 2013, and was accepted Jan. 8, 2014)

INTRODUCTION

Several reports indicate that patients with incomplete spinal cord injury (SCI) can recover locomotor function after locomotor training[1, 2)]. The reason for this improvement in locomotor activity was thought to be mainly due to an adaptation of spinal neuronal networks to physiological proprioceptive inputs[3)]. Strengthening of cortical input might also play an important role in functional recovery of locomotion[4)]. A few studies have reported beneficial effects of locomotor training on a treadmill with partial body weight support in patients with incomplete paraplegia[5, 6)]. These effects can also be seen in patients with complete injuries of the spinal cord[7)].

Several investigators have reported significant improvement of lower limb muscle strength following locomotor training. However, some investigators have also investigated the effect of locomotor training on recovery of lower limb muscle strength as a secondary outcome[8–10)]. A conventional training program primarily provides compensatory strategies for achieving mobility and strengthening above the level of the lesion[11, 12)]. Previously, various methods to enhance locomotor recovery have been explored in humans using locomotor training that optimizes sensory information associated with locomotion[2, 7, 13)]. The purpose of this case series was to describe locomotor training incorporating gait training on a treadmill enhance motor recovery and walking capabilities in patients with incomplete SCI.

SUBJECTS AND METHODS

Subjects

Three patients (2 males, 1 female) with incomplete paraplegia received gait training on a treadmill as an adjunct to their conventional physiotherapy programs. Subject 1 was a 40 year-old male who was 14 months post injury and had a T6 injury classified as ASIA D based on the American Spinal Injury Association (ASIA) Impairment Scale and neurological classification standards. Subject 2 was a 48 year-old male who was 10 months post injury and had a T8 injury classified as ASIA C based on the ASIA Impairment Scale and neurological classification standards. Subject 3 was a 38 year-old female who was12 months post injury. She had a T10 incomplete spinal cord injury classified as ASIA D. The subjects were able to walk on level ground with the help of a standard walker or two crutches. Those subjects found medically unstable and symptomatic for bladder in-

*Corresponding author. Shahnawaz Anwer (E-mail: anwer_shahnawazphysio@rediffmail.com)

Table 1. Comparison of lower extremity motor score (LEMS) and walking capabilities

Variables	Subject 1		Subject 2		Subject 3	
	Baseline	Week 4	Baseline	Week 4	Baseline	Week 4
LEMS	19	32	17	30	17	28
WISCI	8	19	12	19	11	18

fection, decubitus ulcers, cardiopulmonary disease, or other significant medical complications prohibiting testing and/or training were excluded. The subjects signed an informed consent form approved by the institutional ethics committee. This study was conducted at the National Institute for the Orthopedically Handicapped (NIOH), Kolkata, India.

Methods

All three subjects underwent a gait training program for a maximum of 20 minutes on a motorized treadmill without elevation at a comfortable walking speed three days a week for four weeks as an adjunct to their standard physiotherapy programs. The speed was gradually increased from 0.5 m/sec to 3 m/sec as per the patient's ability while the subjects held onto for support. The therapist provided the subjects with verbal cues for taking equal step lengths and for sustaining an upright posture to maintain balance.

The subjects' standard physiotherapy program included stretching exercises for tight musculature. Each stretch was performed for three repetitions with a 30-second hold, followed by a minimum of 30 minutes of a standing program in an Oswestry frame. Subjects then participated in mat activities like standing on their knees, walking on their knees, push-ups, bridging, and abdominal curls for 30 minutes. Subjects also underwent in a strengthening program for upper extremities and balance training.

Strengthening exercises of upper extremity muscles such as the shoulder abductors, adductors, rotators, biceps brachii, and triceps brachii were completed for 3 sets of 10 repetitions each following the Delorme regimen of progressive resistive exercise (PRE)[14]. The rest periods between repetitions and sets were 30 seconds and 60 seconds respectively, and there was a 5-minute rest period between exercises. Increases of 10% resistance were made gradually every week[14]. Balance training consisted of task-oriented training on a physio ball. While sitting on the physio ball, each subject reached forward, to the left, and to the right while trying to touch the therapist's hand. Only when the subject could actually touch the therapist's hand were they marked as "task completed". For forward reach, both hands of the subjects were extended. For the left and right side reach, reaching from one side to the other was counted as one repetition. Each task was performed in sets of 5, with each set consisting of 10 repetitions and a one-minute rest between each set.

The lower extremity strength and walking capabilities were used as the outcome measures of this study. Lower extremity strength was measured by lower extremity motor score (LEMS). The LEMS represents the sum of the scores on the manual muscle strength test for five key lower extremity muscles as defined in the International Standards for Neurological Classification of Spinal Cord Injury[15]. The specific muscle groups tested correspond roughly to segmental innervation levels L2–S1 and included hip flexors, knee extensors, ankle dorsiflexors, great toe extensors, and ankle plantar flexors; ordinal scores ranging from 0 to 5 were used for scoring. The total scores from all lower-extremity muscles tested bilaterally were summed to provide the Lower-Extremity Motor Score (LEMS). The total score ranges between 0 and 50. The correlation of ASIA motor scores with conventional manual muscle testing in all major muscle groups of the lower extremity was previously found to be high[16]. However, Noreau and Vachon[17] reported decreased sensitivity of manual muscle testing in people with SCI at grades greater than 3. Similarly, Jonsson et al.[18] found inconsistent inter-rater reliability of motor scores generated during ASIA assessment (Kappa statistics 0.48 −0.89 for LEMS).

Walking capability was assessed using the Walking Index for Spinal Cord Injury (WISCI II). The WISCI II categorizes a person's walking capability based on the need for physical assistance and assistive devices and/or braces[19]. It is a 20-item scale with a score ranging from 0 (meaning the patient is unable to walk) to 20 (meaning the patient can walk with no assistive device, no braces, and no assistance for at least 10 meters)[20].

RESULTS

All three subjects improved their lower extremity motor scores and walking capabilities over the four-week training period. Table 1 details the outcomes of training for each subject.

DISCUSSION

This study evaluated the effect of treadmill training on the motor recovery and walking capabilities in three patients with incomplete SCI. Previous studies have shown locomotor recovery after locomotor training in patients with incomplete SCI[1, 2, 9]. The results of this study also suggest that treadmill training without weight support is feasible and beneficial for patients with incomplete paraplegia.

In present study, all three patients improved their levels of lower extremity muscle strength and walking capabilities over the four-week training period. In patients with incomplete SCI, treadmill training may strengthen cortical input, which in turn may contribute to these improvements[4]. Hornby et al.[21] reported that after treadmill training, subjects with incomplete SCI showed improved lower extremity muscle strength and walking capability.

Recently, Gorassini et al.[22] reported that after treadmill training, subjects with incomplete SCI showed an increase in muscle activity on EMG with functional recovery of walking skills. Similarly, Anwer et al.[23] reported improved gait parameters and functional independence after 4 weeks of treadmill training in patients with incomplete spinal cord injury. Conversely, Wirz et al.[8] found that only 2/20 patients with ASIA C or D grade SCI demonstrated improvements in walking ability, as determined by WISCI II scores.

In previous studies, training intensity was reported to be 15 minutes[3, 24], 20 minutes[25], or 30 minutes[26] at a frequency of 3 days a week[8] or 5 days a week[26]. Similarly, we chose a training protocol consisting of 20 minutes at a frequency of 3 days a week for 4 weeks. However, the patients in the present study recieved treadmill training without body weight support.

In this report, we presented the results of three individual case studies. Without a control group, factors other than the locomotor training may have contributed to the outcomes and affected the recovery of muscle strength and locomotion. Investigating the influence of injury chronicity, level, and severity and of age at the time of injury on the outcomes of locomotor training is certainly warranted via controlled, experimental studies. The present study suggests that gait training on a treadmill can be used to enhance motor recovery and walking capabilities in subjects with incomplete SCI. Further research is needed to generalize these findings and to identify which patients might benefit from locomotor training.

ACKNOWLEDGEMENT

The authors extend their appreciation to the Deanship of Scientific Research at King Saud University for funding this work through research group project No. RGP-VPP-209.

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