

# Recent Trends and its Effect in Incomplete Spinal Cord Injury Loco-Motor Rehabilitation – A Review

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## Abstract

**Objective:** The purpose of this study is to find out the current trends and its effects in locomotor rehabilitation of individuals with incomplete spinal cord.

**Methods:** Articles were searched through PubMed and Google scholar (year 2016-2020) written in English literature was performed regarding recent advances in the rehabilitation technologies of incomplete SCI patients.

**Results:** Results of this research were according to the based on the clinical findings: Exoskeleton-assisted Gait Training (EGT), Virtual Reality (VR), Robot-Assisted Locomotor Training (RALT), Home based Virtual Reality, Dynamic weight shifting into treadmill, are currently being used.

**Conclusion:** As per the study, there has been advancement in rehabilitation technologies and a significant improvement was noticed in incomplete spinal cord injury patients. More clinical trials and further study is needed for better improvement.

**Keywords:** SCI • Incomplete SCI • Rehabilitation • Gait training • Locomotor • Recent technologies • Walking • Robotics • Impairment

## Introduction

A spinal cord injury is the damage to the spinal cord lesion which results in loss of sensory or motor function. SCI is a devastating condition results in poor quality of life [1]. Approx. 17,730 individual's experiences SCI each year [2] in a gender ratio of 3:4 in male is to female. As per the WHO, the frequency of SCI is expanding in developing countries including India [3]. In India, the average annual incidence of SCI is 15,000 with a prevalence of 0.15 million [4]. Generally, more than 50% of patients having motor incomplete injury [5], it depends on the level and extent of the lesion. In this article, we are discussing about the locomotor rehabilitation in incomplete spinal cord injury patient. Motor dysfunction leads to disturbances in gait pattern and weakened muscular strength [6]. Incomplete SCI with locomotor dysfunction experiences limited or no movement and completely rely on assistive device as well as physically dependent on others. The inability to stand and walk not only limit community involvement, but the patient may expose to other secondary health complications [7]. Many rehabilitation techniques have been come across to conquer these physical demands. Through this study, we discuss the emerging trend in the rehabilitation of individuals with incomplete spinal cord lesion, focusing mainly on locomotor function. Many rehabilitation techniques have been explored to enhance the quality of life of patient and help in reducing primary as well as secondary complications. We are focusing only on the lower extremity devices. Orthosis and wheelchair are primary sources but they require a significant amount of energy expenditure. Thus, the patient may feel some sort of difficulty in accessing and mobility [8]. Other than this, there are various locomotor training devices which are used to recover walking function and improve gait pattern.

Researches in SCI rehabilitation has expanded that initiate or augmenting movements, like external motorized or robotics devices. These devices are utilized with two objectives: to improve recovery through repetitive functional

movement and to act as a mobility device beyond orthosis and wheelchairs [8]. Various gait training methods has been proposed in recent years- Conventional Over-ground Walking Therapy (OGT), Body Weight Supported Treadmill Training (BSWTT), Virtual Reality (VR), Functional Electrical Stimulus (FES), Robot-Assisted Gait Training (RAGT) or Lokomat, Powered Exoskeletons [9-12] or Robotic Exoskeleton (RT-exo), and many more. Locomotor training using partial BWS, TM, manual assistance by therapist are important therapeutic intervention to retrain walking in people with incomplete SCI patients. Manual assisted technique requires 2-3 patients to provide body weight support and prevent the subject from falling during gait training program. BWS and TM system are designed to combine with Robotic device, so that it can reduce additional cost required in manual assistance of physical therapist. A meta-analysis study investigates that robotic training in iSCI patients found greater improvement in walking independently [13]. BWS without TM can be used in over-ground surfaces. Advancement and utilization of powered exoskeleton is moderately new, the current evidence supporting their use and purported benefits. Powered exoskeleton devices have raised as potential upright mobility devices [14]. The benefit of this device is to enhance walking speed and improve strength and tending to other conditions like spasticity, pain, and quality of life [15]. The use of Virtual reality (VR) therapy is also a new rehabilitation approach among individuals with spinal cord injury [16]. Robot-Assisted Gait Training (RAGT) helps improve muscle tone and lower motor function like walking in people with spinal cord injury and decrease secondary complications like pain and spasticity [17]. However, recent advances in clinical research using various interventions designed to improve locomotor ability in a variety of patient population.

## Literature Search

### Inclusion criteria

- Incomplete SCI [18]
- Recent articles
- ASIA scale C, D [18]
- Age: more than 16 year, both male and female [19]
- Acute, sub-acute and chronic conditions [19]
- Traumatic and non-Traumatic injury [19]

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## Exclusion criteria

- Complete SCI [18]

## Data sources

Articles were searched through PubMed, Google scholar. Only studies published in the English language were preferred, based on current evidence from 2016-2020. Using appropriate inclusion and exclusion criteria, 20 articles were reviewed in which, only 10 articles fulfill the criteria. All studies mainly focus on advancement in locomotor rehabilitation technologies of incomplete spinal cord injury.

## Results and Discussion

To our knowledge, this is the first review study investigating the current trends and its effect in locomotor rehabilitation in individuals with iSCI. The main goal of the rehabilitation technique is to achieve independent mobility and to restore walking function in patients with iSCI [20]. Various gait training devices have been proposed in recent years [21].

### Exoskeleton-assisted Gait Training (EGT)

It is a rigid outer mechanical framework with some degree of movement in it and able to perform complex task. This device is designed to reduce work load on physical therapist and to prevent injuries. Exoskeleton device is used in combination with assistive devices. Several exoskeleton technologies are becoming developed and commercialized for the purpose of walking, jumping and running. Lower limb robotic assistive devices or exoskeletons have been developed to help people with lower limb weakness [22] and it can be used as a gait training device [23]. For achieving an upright posture, the exoskeleton-assisted device is wrapped with thigh and shank, this human-machine contact device is planned according to the participant's safety and resilience level. Individuals with incomplete spinal cord injury have the capacity to improve from being maximally dependent on the device toward the start of the examination to being weaned off the device and becoming independent at the end of the examination. The author Shuo-Hsiu Chang, et al., investigated the achievability of offering EGT on gait training in patients with incomplete SCI. A significant improvement in stride and step length of a patient was observed through this study. Hence, EGT can be applied in patients with iSCI to encourage walk recuperation. But, this study needs large sample size and expected to be more accurate [24]. Long-term data is necessary for understanding the efficacy of exoskeleton.

### Virtual Reality (VR)

Computer-generated technology (VR) has been introduced in the field of SCI rehabilitation with various advantages of using it as a therapeutic tool [25]. Also, Virtual Reality Therapy used as a treatment and assessment tool. This device is safe and ecologically valid for the measurement of cognitive and motor function. Most of the VR therapy mainly focuses on the improvement of virtual environment and to provide patient a good and feasible environment. VR training is a repetitive practice, performance-based tasks, and feedback [26]. Virtual Reality or VR therapy is effective in providing stability and mobility, it deals with psychological factors and enhance the quality of life and give positive visual feedback through interaction with virtual environment. The effect of virtual reality on balance ability in individuals with iSCI was reviewed in Anas R. Alashram, et al. study [27]. There are various advantages of VR training in SCI rehabilitation such as patient deals with real-life and fun-based tasks. Secondly, it can be performed at home with a safe environment. But insufficient data, small sample size, poor methodology did not prove the efficacy of VR on SCI patients.

### Robot-Assisted Locomotor Training (RALT)

Various locomotor strategies have been utilized in endeavors to recuperate walking function, in which RALT is one of them [28,29]. The advances in robotic technologies have helped in the development of gait rehabilitation in the field of spinal cord injury. There are various robotic rehabilitation techniques which help in stimulation of muscle activity and decrease number of therapist require

for assessing and holding the patient during gait training. A meta-analysis study from 2017 concluded that RALT had a similar effect as compared to body-weight supported locomotor training in re-establishing goals<sup>13</sup>. Additionally, in the study by Anu Pillara, et al. Robot-Assisted Locomotor Training did not improve walking function in patient with chronic incomplete Spinal Cord Injury. This randomized clinical trial suggests that there is slight or no significant improvement in walking. Thus, the primary goal of rehabilitation was not achieved. RALT may have a modest effect or may be beneficial for training purposes [30].

### Home-based Virtual Reality: Augmented training

This therapeutic training is similar to Virtual Reality, but it adds more advanced component in a mobile framework, and is a home-based task. They provide interactive, sensory stimuli and biofeedback session using portrayals of lower limb of the patients This Augment therapy has been effective in the rehabilitation of the individual with iSCI [31]. Author Michael Villiger, et al. hypothesized that unsupervised home-based VR augmented neuro-rehabilitation training was useful for incomplete spinal cord injury patients. The training was done with the help of a mobile framework (You Kicker system). Virtual portrayals of the legs and feet were controlled by movement sensors. The augmented training was set up by a specialist at the patient's home over a period of 4 weeks with 16-20 sessions. After 4 weeks of treatment sessions, the therapist found a positive response and improvement in the lower limb. The patient was likely to be more attractive, and get familiar with the device. This type of framework may give extra advantages as far as decreased subject transportation cost and exertion and for evaluating the subject's activity outside the center [32].

### Dynamic weight shifting into treadmill training

Weight shifting toward the standing leg preceding the progression, is an important component of the gait training. In many cases, individuals with incomplete SCI exhibit lacking weight moving toward the standing leg due to the muscle weakness of hip abductors/adductors [33] and these muscles help in maintaining lateral balance during gait training [34]. Two motorized cable were attached to the pelvis and other two were tied to the legs enhancing weight shifting during swing and stance phase. A randomized control pilot study concluded that dynamic weight shifting during treadmill training by applying pelvis assistance force seems to be more effective than other conventional treadmill training in terms of endurance [35]. Author Jui-Te Lin, et al. says that applying pelvis assistance force enhance weight shifting as well as improvement in gait step length while walking on the treadmill [36]. Several technologies have been researched and are currently being investigated in which Exoskeleton assisted locomotor training, robotic training, virtual reality therapy are currently being used on patients. These are implemented on patients with effective response in improvement in gait training, as well as by applying pelvis assistance force to improve strength and fast recovery. Although, exoskeletons represent a promising technology and may reduce secondary health complications related to physical disabilities. These technologies encourages patient to achieve their goal and enhance self-independency in the disabled patient suffering from spinal cord injury. Further long-term researches and more clinical trials are needed to add more data in it.

## Conclusion

We investigated the advancement in various locomotor rehabilitation techniques and its effect in incomplete SCI patients. The effect of various therapeutic techniques which we discuss has significant improvement in locomotor function and enhances the quality of life of the patient. These technologies are continually being advanced, and long-term follow up data are needed to understand the efficacy of these devices. The fate of these latest technologies is brilliant for iSCI patients and will keep on being researched. However, progressively clinical preliminaries and research will continue to establish their viability.

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