

## Gait Rehabilitation for Patients with Incomplete Spinal Cord Injury (iSCI): Conventional and Treadmill Training

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### บทคัดย่อ

การเดินเป็นเป้าหมายที่สำคัญอย่างหนึ่งของผู้ป่วยบาดเจ็บไขสันหลังแบบไม่สมบูรณ์ การรักษาทางกายภาพบำบัดเพื่อพัฒนาความสามารถด้านการเดินสามารถแบ่งออกได้เป็น 2 ชนิดใหญ่ๆ คือ การรักษาแบบดั้งเดิมและการฝึกเดินบนลู่วิ่งกล การพัฒนาความสามารถด้านการเดินแบบดั้งเดิมสำหรับผู้ป่วยกลุ่มนี้ยังไม่มีแบบแผนที่แน่ชัดและมักประยุกต์วิธีการรักษาที่ใช้สำหรับผู้ป่วยในกลุ่มอื่นๆ ที่มีปัญหาใกล้เคียงกัน โดยมักเป็นการพัฒนาองค์ประกอบที่จำเป็นในการเดินหรือการฝึกเดินบนพื้นราบ อย่างไรก็ตาม การจะฝึกเดินได้ ผู้ป่วยจำเป็นต้องมีความแข็งแรงของกล้ามเนื้อและความสมดุลของร่างกายที่ดีพอสำหรับการควบคุมการเคลื่อนไหวในแต่ละระยะของการเดินได้ การฝึกเดินบนลู่วิ่งกลเป็นการรักษาทางเลือกที่ช่วยให้ผู้ป่วยได้ฝึกองค์ประกอบทั้งหมดของการเดินพร้อมกันทันทีหลังจากที่อาการทางการแพทย์ของผู้ป่วยคงที่แล้ว โดยการช่วยเหลือของนักกายภาพบำบัดและอุปกรณ์พยุงน้ำหนักตัว วิธีการที่ใช้สำหรับฝึกผู้ป่วยเดินบนลู่วิ่งกลยังมีความแตกต่างและหลากหลาย บทความนี้รายงานข้อมูลเกี่ยวกับการพัฒนาความสามารถด้านการเดินด้วยวิธีการดังกล่าวซึ่งอาจเป็นประโยชน์สำหรับนักกายภาพบำบัดในการเลือกวิธีการรักษาสำหรับผู้ป่วยของตนเอง

**คำสำคัญ:** ภาวะไขสันหลังบาดเจ็บแบบไม่สมบูรณ์, การเดิน, การฟื้นฟูความสามารถ, การฝึกเดินบนลู่วิ่งกล, กายภาพบำบัด

### Introduction

Most patients with incomplete spinal cord injuries (iSCI) need both medical and rehabilitation treatments. In an initial or emergency period, patients mainly undergo medical treatments which include techniques to relieve spinal cord compression and stabilise the spinal column to limit further injury. A prompt medication therapy is usually administered within 8 hours of the injury.

Medication for patients with SCI normally involves corticosteroids such as methylprednisolone and tirilazad to reduce inflammatory responses, limit lesion expansion, prevent secondary lesion cascade and facilitate a marked improvement of functional recovery<sup>(1-3)</sup>. Patients are typically involved in rehabilitation during the later stage after injury when their spinal columns have good stability<sup>(4)</sup>. After an emergency period, these patients want to

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## Gait Rehabilitation for Patients with Incomplete Spinal Cord Injury (iSCI): Conventional and Treadmill Training

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### Abstract

Walking is an important goal that patients with incomplete spinal cord injury (iSCI) want to achieve. Physiotherapy approaches to improve this ability can be divided into 2 main types: conventional and treadmill training. Conventional walking training for patients with iSCI is not unique and likely to employ the techniques used for patients with similar conditions from other pathologies. The methods are based mainly on either individual components necessary for walking or the whole task of walking. However, training on the whole task of walking requires patients to have enough strength and balance to perform both the stance and swing phases of the gait. Treadmill training is an alternative form of whole task walking training that can be started immediately when the patient has stable medical conditions with assistance from therapists and a harness. There are vast variations of the setting methods for treadmill therapy. This article reports information of these training methods which may benefit physiotherapists to choose the treatment for their patients.

**Key words:** Incomplete spinal cord injury (iSCI), Gait, Rehabilitation, Treadmill training, Physiotherapy

be able to walk again. This article details gait rehabilitation for patients with iSCI, with the emphasis on conventional and treadmill walking training.

### Conventional Rehabilitation for Patients with Incomplete Spinal Cord Injury

Normally, conventional physiotherapy programmes for patients with iSCI are not unique

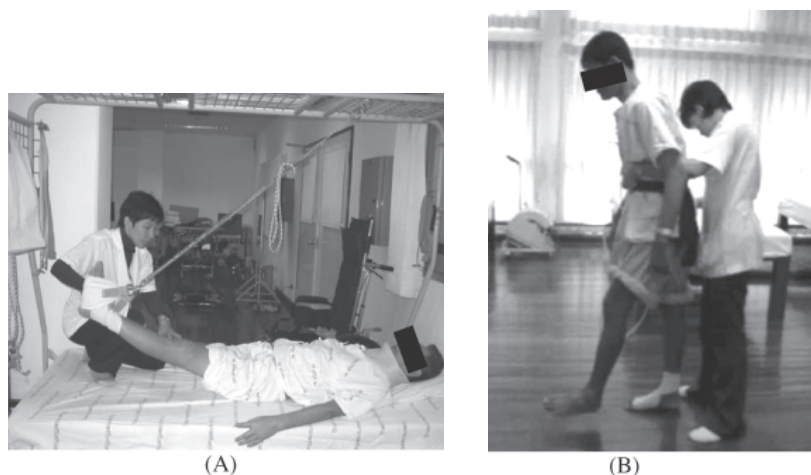
and are likely to employ the strategies used for patients who experience similar problems from other conditions such as stroke<sup>(4)</sup>. The treatments mainly involve physical rehabilitation such as muscle stretching and strengthening, functional training of activities in daily living (ADL), balance and walking, and perhaps using an assistive device<sup>(5, 6)</sup>. For walking, traditional methods of physiotherapy can be divided roughly into 2 types

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which are training on individual components and training on the whole task of walking<sup>(7)</sup>. Training on individual components usually begins with an analysis of missing or abnormal components by using movement analysis. The remediation is provided mainly through methods of therapeutic exercise to the affected muscles and joints in static postures (lying or sitting)<sup>(8)</sup> (**Figure 1A**). These

training techniques are based on the belief that every muscle is activated in the same pattern regardless of the phases or the tasks to be performed<sup>(7)</sup>. Training also includes mobility and balance in different positions such as lying, sitting and standing which are suggested to be basic elements needed for walking ability.



**Figure 1** Conventional training on (A) an individual muscle (hip extensor muscle) and (B) a whole task of overground walking training

Training on the whole task of walking involves methods of pre-gait training and walking itself (Figure 1B). The programmes of pre-gait training aim to improve walking capability through methods of weight shifting in a variety of stance postures, and practicing the essential components of walking such as individual muscle strength<sup>(9)</sup>. Then the process of walking training would proceed beyond supported standing training only when the patient has sufficient strength and balance to maintain the legs in extension during the weight bearing phase, and to flex at the hips and knees to make a step<sup>(10)</sup>.

In some patients who cannot maintain the knees in extension, the treatments may combine with application of assistive device(s) to brace the knee(s) in extension. In addition, for those patients with arm strength good enough to support the body-weight, an appropriate walking device such as parallel bars, a walker frame or crutches may be introduced to facilitate the whole task of walking training<sup>(11, 12)</sup>. The process of conventional walking training is likely to take place in an empty room aiming to gain confidence of the patient during practice walking<sup>(9, 13, 14)</sup>. The methods require

patients to walk at their self-selected speed with one (or rarely two) therapists to provide manual support by using a safety belt around the waist and verbal feedback<sup>(15, 16)</sup>. Training at a self-selected (slow walking) speed may not provide the usual locomotor-related inputs<sup>(13)</sup>. The process of walking training also needs to wait until the lower limbs are strong enough to maintain an upright-extended posture. This may delay the process of a whole task walking training; thus makes the movement system less plasticity. In addition, since walking is a complex task that requires numerous subsystems working cooperatively, training on individual components may not improve gait performance. Wirz et al.<sup>(17)</sup> report that an increment of muscle strength is not always associated with an improvement of walking capability. As a result, interventions to enhance walking capability nowadays have been shifted to training on a whole task specifically by using body-weight support treadmill training (BWSTT).

## Treadmill Walking Training

Treadmill training is an alternative method of walking training that allows patients to practice the whole task of walking directly after stable medical conditions. The task gives an opportunity to practice essential components for walking-weight bearing, stepping and balancing-simultaneously<sup>(18, 19)</sup>. The method requires assistance from a harness and 2-3 physiotherapists (**Figure 2**). A harness supports part of the patient's body-weight therefore removing some of biomechanical and equilibrium constraints caused by full weight-bearing<sup>(20)</sup>. A harness also allows the patient to practice walking within a safety environment; thus helping the patient to increase his/her confidence during movement<sup>(8)</sup>. Manual help from therapists assists and ensures movements of the limbs and trunk. Thus assistance from a harness and therapists makes the process of early task-specific walking training become possible<sup>(18)</sup>.



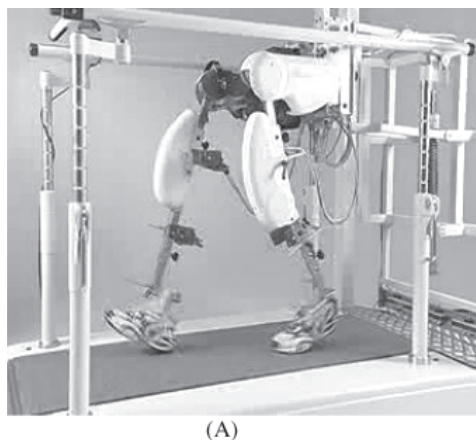
**Figure 2** Treadmill walking training with 3 therapists

There are some debates as to the best setting of treadmill training. In terms of treadmill speed, some studies set the speed according to the patient ability<sup>(8, 21, 22)</sup> whereas other studies begin with the slowest speed of the treadmill (start from 0.01 m/s)<sup>(23-25)</sup>. However, some studies indicate that training at a slow walking speed does not presumably provide the usual locomotor-related inputs. Rather, these studies suggest that an appropriate treadmill training speed should be set at the average overground walking speed of normal population<sup>(12, 13)</sup>. Bassille and Bock<sup>(7)</sup> suggest that an appropriate walking speed is important for activating and strengthening the targeted muscles. It can be used as an effective control parameter enabling patients to learn to utilise or counteract the motion-dependent forces helping the reorganisation of an optimal walking pattern<sup>(26)</sup>.

The time and frequency of training is also debated. The training time is typically set at 20 to 30 minutes per day. Some studies required patients to walk continuously until fatigued, rest and continue until the cumulative time reached that of the targeted time, whereas other studies divided the training time into multiple sessions of equal time<sup>(10, 13, 22, 23)</sup>. Frequency of the treatment varies between 3 and 5 times per week and lasts from 3 weeks to 5 months, making the number of sessions range between 15 and 85 sessions<sup>(13, 21, 23, 24)</sup>. At the beginning of the treatment programme, a harness supports 30% to 68% of the patient's body-weight<sup>(21, 25)</sup>. The method normally requires two or three therapists to provide manual guidance and ensure movements of the trunk and limbs<sup>(12, 13, 27)</sup>.

Behrman and Harkema<sup>(13)</sup> have proposed a method of setting that claims to provide the sensory cues necessary to facilitate stepping for both animals and humans. The researchers suggest that the training speed should be set within the range of overground walking speed in normal population (0.75-1.25 m/s), and the method should allow a maximum sustainable load on the stance limb. Therapists should encourage a patient to perform or maintain an upright, extended posture of the head, the trunk and the limbs. During the swing phase, the patient must shift the body-weight from the swing limb onto the stance limb, simultaneously with extend the hip of the loading limb. The patient should avoid weight bearing on the arms, move the arms reciprocally and have symmetrical interlimb patterns. Lastly, the training method should avoid or minimise any sensory distraction or conflict with the information necessary for walking<sup>(13)</sup>. Harkema<sup>(28)</sup> suggests that these setting components provide important information to trigger the initiation of stepping patterns.

However, treadmill training normally causes hand and back injuries to therapists as a result of repetitive lifting of patients' limbs<sup>(12)</sup>. Recently, lokomat (reciprocal gait orthosis, RGO, **Figure 3**) has been introduced in order to reduce these problems<sup>(17)</sup>. Nonetheless, lokomat is a costly machine and lack of evidence to confirm its effectiveness. Thus there is a need of further exploration on the effectiveness of gait rehabilitation for patients with iSCI.



**Figure 3** Locomat (reciprocal gait orthosis, RGO) (A) without patient (B) with patient

## Conclusion

The methods of conventional walking training for patients with iSCI are widely different which normally employ strategies used for patients with similar conditions from other disorders. The treatments are based mainly on either the individual components necessary for walking or walking itself. Treadmill training is an alternative form of whole task walking training that can be started immediately when the patient has stable medical conditions with assistance from therapists and a harness. However, there are many forms of setting, advantages and disadvantages of treadmill training that physiotherapists need to consider in order to select the best appropriate treatment for their patients.

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