Hocoma

Robotic-assisted locomotion training after Spinal Cord Injury

Since 2001 a number of studies testing feasibility as well as efficacy of Lokomat assisted treadmill training after Spinal Cord Injury (SCI) have been published in peer reviewed journals. Lokomat training was successfully applied to para- as well as tetraplegic patients with complete (Benito-Penalva et al., 2012; Colombo et al., 2001; Manella et al., 2010; Schwartz et al., 2011) as well as incomplete SCI (Alcobendas-Maestro et al., 2012; Benito-Penalva et al., 2012; Colombo et al., 2001; Field-Fote and Roach, 2011; Galen et al., 2011; Hornby et al., 2005; Houldin et al., 2011; Lam et al., 2011; Lam et al., 2008; Mirbagheri, 2005; Mirbagheri et al., 2011; Schwartz et al., 2011; Sherman et al., 2009; Winchester et al., 2005; Wirz et al., 2005). Neuronal centres in the spinal cord became activated in a similar way by Lokomat training as during manually assisted treadmill training (Colombo, 2001) which eventually resulted in significant improvements in subjects' gait velocity, endurance and performance of functional tasks (Alcobendas-Maestro et al., 2012; Galen et al., 2011; Hornby et al., 2005; Manella et al., 2010; Schwartz et al., 2011; Wirz et al., 2005), and reduced the requirements for assistive devices during walking (Alcobendas-Maestro et al., 2012). Lokomat training furthermore modified abnormal reflex function, improved impaired voluntary movement (Hornby et al., 2005; Mirbagheri, 2005; Mirbagheri et al., 2011; Wirz et al., 2005) and was followed by reduced ventilatory demand as well as locomotor-respiratory coupling during walking (Sherman et al., 2008). The training promoted supraspinal plasticity in the motor centers known to be involved in locomotion (Winchester et al., 2005). When compared to other training approaches advantages in favour of robotic assisted training were so far only observed for incomplete patients early (2 - 6 months) after injury (Alcobendas-Maestro et al., 2012; Benito-Penalva et al., 2012) but not in chronic patients (Field-Fote and Roach, 2011). Further studies with high patient numbers and well defined inclusion/exclusion criteria and training paradigms are required to investigate possible advantages of Lokomat assisted training in comparison to conventional training approaches. In the future, training with the Lokomat may not only facilitate prolonged training sessions and reduce the workload of therapists (Colombo et al., 2001), but will assist physical therapists by providing task-specific practice of stepping in people following spinal cord injury and other neurological pathologies (Houldin et al., 2011; Lam et al., 2011; Lam et al., 2008).

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Field-Fote, E., and Roach, M. (2011). Influence of a Locomotor Training Approach on Walking Speed and Distance in People With Chronic Spinal Cord Injury: A Randomized Clinical Trial. Physical Therapy 91, 1-13.

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Hornby, T.G., Zemon, D.H., and Campbell, D. (2005). Robotic-assisted, body-weight-supported treadmill training in individuals following motor incomplete spinal cord injury. Phys Ther 85, 52-66.

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Lam, T., Pauhl, K., Krassioukov, A., and Eng, J.J. (2011). Using robot-applied resistance to augment body-weight-supported treadmill training in an individual with incomplete spinal cord injury. Phys Ther 91, 143-151.

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Lokomat Robotic-Assisted Versus Overground Training Within 3 to 6 Months of Incomplete Spinal Cord Lesion: Randomized Controlled Trial

Alcobendas-Maestro M., Ana Esclarín-Ruz A., Casado-López R. M., Muñoz-González A., Pérez-Mateos G., González-Valdizán E., Martín J. L. R.

ABSTRACT

Objective: The aim of this study was to compare Lokomat assisted training with conventional overground training.

Design: Randomized, single-blind, parallel-group design.

Setting: Patientes were trained at the Hospital Nacional de Paraplejicos, Toledo, Spain.

Participants 80 SCI patients, 3 to 6 months after lesion onset, C2 – T12, ASIA C and D; Patients were able to stand with external support and without orthostatic reactions but were unable to walk.

Intervention: : All participants underwent standard physical treatment, based on daily sessions of joint mobilization below the level of the spinal injury, strengthening of supra-lesional musculature and remaining motor functions, muscle stretching and postural relaxation techniques to treat spasticity, trunk stabilization and rotation work as well as practice of self-care skills. Within this daily routine all patients received 40 sessions (5 times per day for 8 weeks) of mobility training. In the robotic group mobility training included 30 minutes of Lokomat assisted training (BWS was set to 60% and then decreased in accordance with individual load tolerance, but not less than 25%. Speed was selected where patients walked most comfortable). The control group received mobility training alone. Patients did not receive any formal training for walking other than during these sessions.

Main Outcome Measures: Primary outcome measurements included the 10-meter walking test and the Walking Index for Spinal Cord Injury (WISCI II) Scale. Patients were allowed to use the necessary orthosis and technical aids and were asked to walk in a straight line at a comfortable pace to cover the distance. Secondary outcome measures included the 6-minute walk test, the walking and stairs tasks of the FIM-L. Muscular strength of the lower limbs were measured with the ASIA scale, the Lower Extremity Motor Score (LEMS) subscale. Presence of spasticity measured with the Ashworth Scale (0-4) and existence of pain was measured with a Visual Analog Scale scored from 0 to 10.

Results: Significant ($P < .05$) differences in favor of walking training with the Lokomat were found for the WISCI II, walking distance, FIM-L as well as LEMS. No significant differences were found for walking speed.

Conclusions: Robotic-assisted training was equivalent to conventional walk training in patients with a variety of non progressive spinal cord pathologies for walking speed. The need for orthotics and assistive devices was reduced, perhaps because of greater leg strength in the robotic group.

Paper Reference: Alcobendas-Maestro M., Ana Esclarín-Ruz A., Casado-López R. M., Muñoz-González A., Pérez-Mateos G., González-Valdizán E., Martín J. L. R., Lokomat Robotic-Assisted Versus Overground Training Within 3 to 6 Months of Incomplete Spinal Cord Lesion: Randomized Controlled Trial, 2012, Neurorehabil Neural Repair.

Gait Training in Human Spinal Cord Injury Using Electromechanical Systems: Effect of Device Type and Patient Characteristics

Benito-Penalva J., Edwards D. J., Opisso E., Cortes M., Lopez-Blazquez R., Murillo N., Costa U., Tormos J.M., Vidal-Samsó J., Valls-Solé J., Medina J.

ABSTRACT

Objective: The aim of this study was to determine the clinical characteristics (motor impairment and time after injury) of SCI patients that respond better to gait training receiving the same frequency and duration of training on two different electromechanical devices (Lokomat and Gait Trainer). Also to compare the effects of robot-assisted to conventional therapy.

Design: Randomized, controlled trial.

Participants 103 motor incomplete (ASIA D and C) and complete (ASIA A and B with residual voluntary hip flexion and knee extension) SCI patients.

Intervention: Patients received locomotor training either on the Lokomat (39 patients) or the Gait Trainer (66 patients) for 5 d/week in 8 weeks as a complement to other standard daily therapies. BWS as well as speed were adjusted over training progression. Training started 2 (early) or 6 (late) months after injury.

Main Outcome Measures: Patients were assessed at baseline as well as after 4 and 8 weeks of training with the Lower Extremity Motor Score (LEMS), the Walking Index for Spinal Cord Injury II scale (WISCI II) as well as the 10MWT.

Results: Both devices were tolerated and no adverse effects were reported. All three outcome measurements showed statistically significant improvements after the use of both electromechanical devices without statistically significant differences between devices. Improvements for both devices were better when compared to the improvements in patients receiving the conventional standard of care (EM-SCI database). In terms of patient characteristics the greatest rate of improvement was shown for motor incomplete patients as well as patients early (< 6 months) after injury.

Conclusions: The use of electromechanical systems for intensive gait training in SCI led to improvements in lower-limb motor function as well as gait across a diverse range of patients. Improvements are most evident in motor incomplete patients, and patients who begin their training early after injury.

Paper Reference:

Benito-Penalva J., Edwards D. J., Opisso E., Cortes M., Lopez-Blazquez R., Murillo N., Costa U., Tormos J.M., Vidal-Samsó J., Valls-Solé J., Medina J., Gait Training in Human Spinal Cord Injury Using Electromechanical Systems: Effect of Device Type and Patient Characteristics, 2012, Phys Med Rehabil, 2012; 93:404-12.

Driven gait orthosis for improvement of locomotor training in paraplegic patients

Colombo G., Wirz M., Dietz V.

ABSTRACT

Objective: To compare the effects of manually assisted locomotor training in paraplegic patients with the automated training by a driven gait orthosis.
Design: Single case.
Setting: Patients were trained at ParaCare, University Hospital Balgrist in Zurich, Switzerland.
Participants: Two spinal cord injured patients. The first patient had an incomplete lesion at C3, the second a complete lesion at C5.
Intervention: Both patients received Lokomat assisted treadmill training as well as treadmill training with manual assistance.
Main Outcome Measures: The EMG activity of different leg muscles (rectus femoris, biceps femoris, gastrocnemius medials (GM) and tibialis anterior (TA) was compared during both training modes. Differences in GM and TA activity were quantified by calculating the variation ratio between EMG of patients as well as healthy subjects.
Results: No significant difference between the two training modes was found according to the leg muscle EMG activity.
Conclusions: Neuronal centres in the spinal cord become activated in a similar way by manually assisted and automated locomotor training. With the driven gait orthosis training sessions can be prolonged and workload of therapists can be reduced, and therefore, automated training represents an alternative to the conventional therapy.

Paper Reference:
Colombo G., M Wirz M., Dietz V., Driven gait orthosis for improvement of locomotor training in paraplegic patients, Spinal Cord, 2001, 39, 252 – 255.

Influence of a locomotor training approach on walking speed and distance in people with chronic spinal cord injury: a randomized clinical trial

Field-Fote E.C., Roach K.E.

ABSTRACT

Objective: The objective of this study was investigating the effect of 4 locomotor training approaches on walking speed and walking distance in people with chronic SCI.

Design: Single-blind, randomized clinical trial

Setting: The Miami Project to Cure Paralysis, Miami, Florida, USA**.**

Participants: 62 people with a chronic SCI (>1 year, ASIA C or D, injury at or above T10, ability to take at least 1 step).

Intervention: Patients were trained 5 days per week for 12 weeks) either (1) on a treadmill with manual assistance (TM), (2) treadmill with stimulation (TS), (3) overground training with stimulation (OG), or (4) treadmill training with Lokomat assistance (LR). Maximum load during walking was imposed (max 30 % BWS), treadmill speed was rather high and kept at a challenging level. Lokomat guidance force was kept at 100 % therefore patients were encouraged to walk actively.

Main Outcome Measures: Overground walking speed and distance were the primary outcome measures. Follow up in 10 patients 6 months after training cessation.

Results: For speed, no significant between-group differences were observed. Distance gains were greatest with overground training (OG). Effect sizes for speed and distance were largest with OG. Effect sizes for speed were the same for TM and TS. There was no effect for LR. The effect size for distance was greater with TS than with TM or LR, for which there was no effect. Ten participants who improved with training were retested at least 6 months after training; walking speed at this time was slower than that at the conclusion of training but remained faster than before training.

Conclusions: People with chronic motor incomplete SCI have the potential to increase their overground walking speed and walking distance in a specified time (functional walking capacity).

Overground locomotor training resulted in greater improvements in functional walking capacity than did treadmill-based training. This might be due to the fact that overground walk training provides the ability to train real-world task of walking, furthermore increased voluntary effort for step initiation and forward progression, and provides more opportunities for learning how to generate and control the forces required for walking overground.

Paper Reference:

Field-Fote E.C., Roach K.E., Influence of a locomotor training approach on walking speed and distance in people with chronic spinal cord injury: a randomized clinical trial, 2011, Physical Therapy 91(1): 1-13.

A portable gait assessment tool to record temporal gait parameters in SCI

Galen S.S., Clarke C.J., Allan D.B., Conway B.A.

ABSTRACT

Objective: The aim of this study was to investigate the validity of a portable gait assessment tool in objectively assessing the temporal gait parameters and changes in walking ability in incomplete spinal cord injured (SCI) subjects, who participated in Lokomat assisted gait training.

Design: Cohort study.

Setting: Bioengineering Unit, University of Strathclyde and Scottish Centre for Innovation in Spinal Cord Injury (SCISCI), Queen Elizabeth National Spinal Injuries Unit, Southern General Hospital, Glasgow, UK.

Participants 18 SCI patients, ASIA C/D, 5 subacute/chronic, 13 acute (< 6months after injury).

Intervention: Lokomat assisted treadmill training (60 min, 5x per week, 6 weeks). At the start of the Lokomat training subjects walked at a speed of 1–1.2 km/h and with a body weight support between 70 and 80 %. These parameters were progressed depending on the subject's tolerance. The speed of walking was increased to a maximum of 2 km/h and the body weight was reduced based on the subject's ability to maintain knee extension during midstance of the gait cycle.

Main Outcome Measures: Assessments were performed before during and after the intervention and included standard clinical evaluations for example the ASIA scoring system including the Lower Extremity Motor Score (LEMS) and the WISCI II scale. Temporal gait parameters were assessed by a simple and portable gait analysis tool that can specifically measure changes in temporal gait parameters and the quality of gait during over ground walking within a clinical environment. It consists of a pair of insoles instrumented with force sensing resistors that were strategically positioned over the sole of each foot.

Results: The gait assessment tool showed more sensitivity in recording changes in the quality of gait (walking speed, double support time, cadence, and stride length) compared with the ambulatory status measured by the WISCI II score. The comparisons in temporal gait parameters between pre and mid intervention measures were significant among subjects in the acute group with the exception of double support time. The subjects in the chronic group did not show significant changes in the WISCI II Score although they were able to tolerate a reduced BWS at the end of the Lokomat training.

Conclusions: Lokomat assisted training led to significant improvements in walking speed, cadence and stride length in acute (< 6 months post lesion) spinal cord injured patients. Statistically significant changes during the first 3 weeks of training indicate that an effective dose of robotic training can be administered within a relatively short time period in ISCI subjects during the acute phase. It may also indicate a trend that the majority of positive changes in gait become established within the first 3 weeks of Lokomat based treadmill training.

The subjects in the chronic group did not show significant changes in the WISCI II score although they were able to tolerate a reduced body weight support at the end of the Lokomat training. This may be due to that fact that all of the subjects in the chronic group were ambulant prior to the Lokomat training and may therefore be close to their maximum potential recovery.

Paper Reference:

Galen, S.S., Clarke C.J., Allan D.B., Conway B.A., A portable gait assessment tool to record temporal gait parameters in SCI, 2011, Med Eng Phys (2011), 33(5): 626-632.

Robotic-assisted, body-weight-supported treadmill training in individuals following motor incomplete spinal cord injury

Hornby T.G., Zemon D.H., Campbell D.

ABSTRACT

Objective: To describe the use of the Lokomat system in a clinical setting and the transition to therapist-assisted bodyweight supported treadmill training in an attempt to augment voluntary recovery of motor function.
Design: Single case design.
Setting: Patients were trained at the Department of Physical Therapy, University of Illinois, Chicago, USA.
Participants: Three patients (2 male, 1 female) with an American Spinal Injury Association (ASIA) Impairment Scale classification of C or D and neurological level of T10 or higher.
Intervention: In addition to concurrent physical therapy and occupational therapy sessions, all patients attended scheduled locomotor training sessions, consisting of either Lokomat or therapist-assisted bodyweight supported treadmill training. Lokomat-assisted treadmill training was scheduled 3 times per week. Speed of training was set between 2.0 and 2.5 km/h as determined by patient tolerance and comfort. The amount of body-weight support provided was minimized to allow maximum lower-extremity loading.
Main Outcome Measures: Changes in motor impairment, functional limitations, and locomotor disability were assessed weekly using standardized measures: FIM, WISCI II, gait speed, gait endurance, Timed "UP & GO" Test.
Results: Following this training, 2 patients recovered independent over-ground walking and another improved his gait speed and endurance. Changes in muscle strength or spastic motor behaviours were also observed.
Conclusions: The use of robotic devices may assist physical therapists by providing task-specific practice of stepping in people following neurological injury.

Paper Reference:
Hornby T.G., Zemon D.H., Campbell D., Robotic-assisted, body-weight-supported treadmill training in individuals following motor incomplete spinal cord injury, 2005, Phys Ther., 85(1):52-66.

Locomotor adaptations and aftereffects to resistance during walking in individuals with spinal cord injury.

Houldin A., Luttin K., Lam T.

ABSTRACT

Objective: To determine whether people with motor incomplete spinal cord injuries (SCI) modulate flexor muscle activity in response to different levels of resistance in a similar way as uninjured controls. Furthermore whether people with motor-incomplete SCI exhibit after-effects indicative of the capacity to develop anticipatory locomotor command and that the extend of these effects will be related to the degree of locomotor recovery.

Design: Cohort study

Setting: School of Human Kinetics, University of British Columbia, Vancouver, Canada.

Participants Patients with motor incomplete SCI (ASIA D, ambulatory, able to walk 10m over ground) and 17 healthy controls**.**

Intervention: All subjects walked in the Lokomat.. Body weight support was individually adjusted for SCI patients in order to ensure appropriate stance phase kinematics during walking, 0% in 8 healthy subjects (control 1) and 0, 20, 40 and 60% in 9 healthy subjects (control 2). Treadmill speed was adjusted to each patient's tolerance with all healthy and most SCI subjects able to walk 0.5 m/s. After 1 minute of undisturbed walking the Lokomat applied different levels of a velocity-dependent resistance to the weaker leg, normalized to each subject's maximum voluntary contraction of the hip flexors (MVC) measured previous to the trial. SCI subjects and control 1 underwent around 5-7 walking trials with different levels of resistance (1, 3, 5, 7, 19, 15, 20% MVC). Control 2 walked two trials (10 and 20% MVC) for each condition of BWS (0, 20, 40 and 60 %). Each trial consisted of 20 steps against resistance followed by 20 steps without resistance. Resistance was turned of at mid stance.

Main Outcome Measures: EMG was applied to record activity of the rectus femoris (RF), biceps femoris (BF), tibialis anterior (TA) and the medial gastrognemius (MG). Kinematics of the lower limb was recorded by Lokomat position sensors (hip ad knee angles) and twin axis electrogoniometer (ankle).

Results: Both groups responded to the resistance with an overall increase in RF activity during swing, however only the control group demonstrated a strong relationship between the amounts of added resistance and the changes in RF activity whereas the SCI group showed weak modulation of muscle activity to different levels of resistance. Following removal of the resistance, both groups showed after effects in peak hip flexion and the magnitude of these after effects was significantly higher in the SCI group compared to the controls. Interestingly these after effects manifested differently: controls responded to the removal of resistance with a higher step, whereas the SCI subjects exhibited increased step length. The size of the after effect was related to the amount of added resistance. In addition, the SCI group showed a negative relationship between the size of the after effect and the improvement of locomotor function.

Conclusions: Different levels of resistance against leg movements in subjects with motor incomplete SCI as well as healthy subjects during Lokomat assisted training lead to changes in muscle activity (increase in RF activity) and kinematic patterns. SCI patients in contrast to healthy subjects display a weak correlation between amount of resistance and RF response. After-effects can be found in both groups and are correlated to the amount of resistance applied, however SCI patients display longer stride length whereas healthy subjects show increased step height. The size of the aftereffects was negatively correlated to locomotor recovery in SCI patients.

Paper Reference:

Houldin A., Luttin K., Lam T., Locomotor adaptations and aftereffects to resistance during walking in individuals with spinal cord injury, 2011, J Neurophysiol 106(1): 247-258.

Using robot-applied resistance to augment body-weight-supported treadmill training in an individual with incomplete spinal cord injury

Lam T., Pauhl K., Krassioukov A., Eng J.

ABSTRACT

Objective: The aim of this study was to determine the feasibility and effect of using Lokomat applied forces to resist hip and knee flexion during the swing phase which might help to strengthen motor patterns during swing with positive effects on gait.

Design: Single case study

Setting: Blusson Spinal Cord Centre, Vancouver, USA.

Participants 43-year-old man with a T11 incomplete chronic SCI (ASIA D, 2 years after injury able to stand and walk indoors for brief periods during the day).

Intervention: underwent 36 Lokomat assisted training with the gait orthosis providing forces that resisted hip and knee flexion during the swing phase. The amount of resistance was based on maximum voluntary contraction (MVC) tested with L-Force. Body-weight support was initially 50% and speed 1.1km/h. Both parameters were gradually increased over training sessions.

Main Outcome Measures: Tolerance to the training program was monitored using the Borg CR10 scale and heart rate and blood pressure changes during each training session. Outcome measures included the 10-Meter Walk Test, Six-Minute Walk Test, modified Emory Functional Ambulation Profile [mEFAP], activities-specific Balance Confidence Scale as well as the Canadian Occupational Performance Measure. Kinematic parameters of gait, lower-extremity muscle strength (force-generating capacity), lower-limb girth, and tolerance to orthostatic stress were measured before and after the training program.

Results: The patient could tolerate the training. Overground walking speed, endurance, and performance on all subtasks of the mEFAP improved and were accompanied by increased lower-limb joint flexion and toe clearance during gait. The patient's ambulatory self-confidence and self-perceived performance in walking also improved.

Conclusions: This new training approach was feasible and potentially effective for improving skilled overground walking performance in ambulatory patients.

Paper Reference:

Lam T., Pauhl K., Krassioukov A., Eng J., Using robot-applied resistance to augment body-weight-supported treadmill training in an individual with incomplete spinal cord injury, Phys Ther 91(1): 143-151.

Swing Phase Resistance Enhances Flexor Muscle Activity During Treadmill Locomotion in Incomplete Spinal Cord Injury

Lam T., Wirz M., Lünenburger L., Dietz V.

ABSTRACT

Objective: To investigated whether leg loading during the swing phase of walking enhances flexor muscle activity in ambulatory patients with incomplete spinal cord injury (SCI).

Design: Single case study.

Setting: Patients were trained at the School of Human Kinetics, University of British Columbia, Vancouver, Canada and the Spinal Cord Injury Center, Balgrist University Hospital, Zurich, Switzerland.

Participants: 9 patients (5 male, 4 female) with incomplete SCI due to trauma, ischemia, or tumor participated in this study. All patients were classified according to the American Spinal Injury Association (ASIA) standards as ASIA D and were able to walk overground for at least 10 m with or without aids.

Intervention: Patients had surface electromyography (EMG) and joint kinematics recorded from the lower extremities during treadmill walking. Swing phase loading of the legs was achieved by weights (1-3 kg) attached to each lower extremity or by a velocity-dependent resistance applied by the Lokomat robotic gait orthosis.

Main Outcome Measures: For both, the weighted and robotic-generated resistance conditions, surface electrodes were used to record the electromyographic (EMG) activity of the rectus femoris (RF), biceps femoris (BF), tibialis anterior (TA), and medial gastrocnemius (MG) muscles, bilaterally. In 3 patients EMG recordings were collected from one side only. Sagittal-plane joint movements were recorded by twin-axis electrogoniometers taped over the knee joints.

Results: During walking with weights, a consistent increase in knee flexor activity and sometimes also hip or ankle flexor activity could be observed during the swing phase. In accordance to this swing phase flexor EMG activity tended to be greater during robot applied velocity-dependent resistance during walking. Enhanced knee flexion was observed in all patients after the weights or the robot generated resistance was removed.

Conclusions: In patients with incomplete SCI flexor muscle activity can be enhanced during the swing phase through additional proprioceptive input with brief after effects. Further studies will determine if this kind of training can improve the gait of ambulatory SCI patients.

Paper Reference:

Lam T., Wirz M., Lunenburger L., Dietz V., Swing phase resistance enhances flexor muscle activity during treadmill locomotion in incomplete spinal cord injury, 2008, Neurorehabilitation and neural repair, 22(5):438 - 446.

Therapeutic Effects of Robotic-Assisted Locomotor Training on Neuromuscular Properties

Mirbagheri M.M., Tsao C., Pelosin E., Rymer W.Z.

ABSTRACT

Objective: to characterize the effects of Lokomat training on the mechanical abnormalities of the ankle joint. Also to determine the effects of this physical training on repeated voluntary movements of the ankle from full plantarflexion to dorsiflexion at maximum speed quantified.

Design: Single case design.

Setting: Patients were trained at the Department of Physical Medicine and Rehabilitation, Northwestern University Medical School, Chicago, USA.

Participants: Five incomplete SCI subjects with different degrees of spasticity were examined.

Intervention: Lokomat training was performed 3 days per week during a 1-hr period including set-up time with up to 30 minutes of training during a single session. Treadmill speed was started as low as 1.0 kmph and increased up to 2.5 kmph as tolerated.

Main Outcome Measures: Joint position, velocity and torque were recorded by a potentiometer, tachometer & torque transducer, respectively. Electromyograms (EMGs) from tibialis anterior (TA) and gastrocnemius (GS) were recorded using bipolar surface electrodes.

Results: Reflex stiffness, abnormally increased in SCI, was significantly reduced following Lokomat training. Active range of motion, peak-velocity and peak-acceleration of voluntary movement also increased as a result of Lokomat training.

Conclusions: Lokomat training has a potential to modified abnormal reflex function and improve impaired voluntary movements.

Paper Reference:
Mirbagheri, M.M., C. Tsao, C., Pelosin E., Rymer W.Z., Therapeutic Effects of Robotic-Assisted Locomotor Training on Neuromuscular Properties, Proceedings of the 2005 IEEE, 9th International Conference on Rehabilitation Robotics, June 28 - July 1, 2005, Chicago, IL, USA.

Robotic-Assisted Locomotor Training Impact on Neuromuscular Properties and Muscle Strength in Spinal Cord Injury

Mirbagheri M.M., Patel C. Quiney K.

ABSTRACT

Objective: The aim of this study was to investigate the effect of Lokomat assisted training on neuromuscular properties and muscle strength of the spastic ankle in patients with incomplete spinal cord injury.
Design: Single case.
Participants: 12 patients with incomplete spinal cord injury and different degrees of spasticity.
Intervention: Patients received Lokomat assisted training (3 d/week, 4 weeks, 45 min). Training time, speed and body weight support were adjusted over time and patients were encouraged to train actively.
Main Outcome Measures: Patients were evaluated before as well as at 1, 2 and 4 weeks after training. An identification system was used to measure the effects of Lokomat assisted gait training on reflex stiffness and intrinsic muscular stiffness. Isometric maximum voluntary contraction (MVC) of ankle extensors and flexors was assessed by having the subject contract the ankle muscles maximally towards plantarflexion and dorsiflexion at the ankle neutral position; torque and EMGs were sampled for 5 s.
Results: Reflex stiffness as well as intrinsic (muscular) stiffness were significantly reduced after 4 weeks of Lokomat assisted training. MVC's were significantly increased following 4 weeks of Lokomat assisted training.
Conclusions: Lokomat training is effective in reducing spasticity and increasing muscle strength.

Paper Reference:

Mirbagheri M.M., Patel C., Quiney K., Robotic-Assisted Locomotor Training Impact on Neuromuscular Properties and Muscle Strength in Spinal Cord Injury, 2011, 33rd Annual International Conference of the IEEE EMBS.

Locomotor training using a robotic device in patients with subacute spinal cord injury

Schwartz I., Sajina A., Neeb M., Fisher I., Katz-Luerer M., Meiner Z.

ABSTRACT

Objective: To evaluate the clinical effect of combined treatment of Lokomat assisted gait training and conventional physical therapy as compared with conventional therapy alone in subacute SCI patients.

Design: Quasi experiment; single experimental group with matched historical control.

Setting: Department of physical Medicine and Rehabilitation, Hadassah University Hospital, Jerusalem, Israel; Department of Physical Therapy, School of Health Professions, Tel-Aviv University, Tel-Aviv, Israel.

Participants 28 SCI patients (6 ASIA A; 7 ASIA B; 13 ASIA C; 2 AISA D)

Intervention: Patients received Lokomat assisted gait training (approx. 75 days after injury) 2-3 times a week (approximately 30min) in combination with physical therapy (using the Bobath principles) 5 times a week (30 – 45 min). At the beginning of Lokomat training approximately 50% of each subjects bodyweight was supported and decreased in increments of 10% during following training sessions. Walking speed was kept at the maximum tolerated speed of each individual patient. For comparison a group of comparable patients according to age, severity, level and cause of injury treated in the same department in previous years, was defined. These patients had received regular physiotherapy five times a week for 30 – 45min.

Main Outcome Measures: Patients were assessed upon admission and discharge from the rehabilitation centre. Main outcome measurements were AIS, spinal cord independent measurement (SCIM), walking index for SCI II (WISCI II) and the functional ambulation scale (FAC).

Results: At the end of the rehabilitation both groups showed significant improvements in both the FAC and the WISCI score without differences between groups. Functional abilities according to the SCIM score were also improved in both groups with significant greater gains for the Lokomat assisted group compared with the controls. **Conclusions:** Lokomat assisted gait training may be an important additional treatment to improve the functional outcome of subacute SCI patients.

Paper Reference:

Schwartz I., Sajina A., Neeb M., Fisher I., Katz-Luerer M., Meiner Z., Locomotor training using a robotic device in patients with subacute spinal cord injury, 2011, Spinal Cord.

Locomotor-respiratory synchronization after body weight supported treadmill training in incomplete tetraplegia: a case report.

Sherman M.F., Lam T., Sheel A.W.

ABSTRACT

Objective: To report on the respiratory and kinematic changes associated with Lokomat assisted treadmill training in an individual with an incomplete cervical spinal cord injury (SCI).

Design: Single case.

Setting: The patient was trained at the School of Human Kinetics, University of British Columbia, Vancouver, Canada.

Participants: A 38-year-old man with an incomplete SCI at the C1/C2 level, graded on the American Spinal Injury Association Impairment Scale (ASIA) as ASIA D.

Intervention: Three Lokomat sessions (45 min) per week for 12 weeks.

Main Outcome Measures: Before and after training, respiration was measured at the mouth using a pneumotachograph while treadmill walking at 1.6 kmh.

Results: Completion of 12 weeks of Lokomat training resulted in a lowering of minute ventilation during treadmill exercise. A coupling of locomotion and respiration was observed during treadmill walking after the training program, whereas the relationship was initially absent.

Conclusions: Lokomat training can result in a reduced ventilatory demand and promote locomotor–respiratory coupling during walking in an individual with an incomplete cervical SCI.

Paper Reference:
Sherman M.F, Lam T, Sheel A.W., Locomotor-respiratory synchronization after body weight supported treadmill training in incomplete tetraplegia: a case report., 2009, Spinal Cord, 27 (12) 896 – 898.

Changes in Supraspinal Activation Patterns following Robotic Locomotor Therapy in Motor- Incomplete Spinal Cord Injury

Winchester P., McColl R., Querry R., Foreman N., Mosby J., Tansey K., Williamson J.

ABSTRACT

Objective: To evaluate the potential for supraspinal reorganization associated with 12 weeks of bodyweight supported Lokomat training using fMRI. Also to further determine if the potential changes in patterns of supraspinal activation were associated with functional gains produced by Lokomat training.

Design: Single case design.

Setting: Patients were trained at the Department of Physical Therapy, Dallas, TX, USA.

Participants: Four men with motor-incomplete SCI participated in this study. Time since onset ranged from 14 weeks to 48 months post-SCI injury.

Intervention: All subjects were trained with the Lokomat system 3 times per week for 12 weeks.

Main Outcome Measures: Training was preceded and followed by fMRI study of supraspinal activity during a movement task. Testing of locomotor disability included the Walking Index for Spinal Cord Injury (WISCI II) and over-ground gait speed.

Results: All subjects demonstrated some degree of change in the blood-oxygen-level-dependent (BOLD) signal following Lokomat training. All subjects demonstrated activation of the foot and toe area of the sensorimotor cortex following robotic locomotor training. The varying functional gains in ambulatory capacity made by these 4 patients were associated with different patterns of cortical and cerebellar activation and the magnitude of these changes.

Conclusions: Intensive task-specific rehabilitative training, such as robotic treadmill training, can promote supraspinal plasticity in the motor centers known to be involved in locomotion followed by functional changes.

Paper Reference:
Winchester P., McColl R., Querry R., Foreman N., Mosby J., Tansey K., Williamson J., Changes in supraspinal activation patterns following robotic locomotor therapy in motor-incomplete spinal cord injury, 2005, Neurorehabilitation and neural repair, 19(4):313-324.

Effectiveness of Automated Locomotor Training in Patients With Chronic Incomplete Spinal Cord Injury: A Multicenter Trial

Wirz M., Zemon D.H., Rupp R., Anke Scheel A., Colombo G., Dietz V., Hornby T.G.

ABSTRACT

Objective: To determine whether automated locomotor training with the Lokomat can increase functional mobility in people with chronic, motor incomplete spinal cord injury (SCI).

Design: Repeated assessment of the same patients or single case experimental A-B design.

Setting: Research units of rehabilitation hospitals in Chicago, Heidelberg, Germany, Basel and Zurich, Switzerland.

Participants: Twenty patients with a chronic (>2y postinjury), motor incomplete SCI, classified by the American Spinal Injury Association (ASIA) Impairment Scale with ASIA grades C (n=9) and D (n=11) injury. Most patients (n=16) were ambulatory before locomotor training.

Intervention: Locomotor training was provided using Lokomat-assisted, body-weight–supported treadmill training 3 to 5 times a week over 8 weeks. Single training sessions lasted up to 45 minutes of total walking time, with gait speed between 0.42 and 0.69m/s and body-weight unloading as low as possible (37% ± 17%).

Main Outcome Measures: Primary outcome measures included the 10-meter walk test, the 6-minute walk test, the Timed Up & Go test, and the Walking Index for Spinal Cord Injury II (WISCI II) tests. Secondary measures included lower-extremity motor scores and spastic motor behaviours to assess their potential contribution to changes in locomotor function. All subjects were tested before, during, and after training.

Results: Locomotor training using the Lokomat resulted in significant improvements in the subjects' gait velocity, endurance, and performance of functional tasks. There were no significant changes in the requirement of walking aids, orthosis, or external physical assistance. There was no correlation between improvements in walking speed or changes in muscle strength or spastic motor behaviours.

Conclusions: Intensive Lokomat assisted locomotor training on a treadmill results in improved overground walking.

Paper Reference:
Wirz M., Zemon D.H., Rupp R., Scheel A., Colombo G., Dietz V., Hornby T.G., Effectiveness of automated locomotor training in patients with chronic incomplete spinal cord injury: a multicenter trial, 2005, Archives of Physical Medicine and Rehabilitation, 86:672-80.