Lokomat® Clinical Report

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UT Southwestern uses Lokomat system to search for clues on how to enhance SCI training

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Patricia Winchester, PT, PhD
Director, Spinal Cord Injury Laboratory
The Univ. of Texas Southwestern Medical School

The primary research aim of the Spinal Cord Injury Laboratory at UT Southwestern Medical Center is to better understand neural mechanisms responsible for human locomotion and its recovery after neurologic injury.

Patricia Winchester PT, PhD and Keith Tansey MD, PhD, along with Ross Querry, PT, PhD, and Karen McCain, DPT, share an interest in brain and spinal cord neuroplasticity. Their 2005 functional MRI (fMRI) study showing regional brain activity changes in Lokomat-trained patients may explain why locomotor therapy enables patients with a wide range of injuries and diseases to regain walking skills.*

*Recently, **Lokomat Clinical Report** visited Dr. Winchester and her team, and one of their ongoing patients, Jeremy Medders. The objectives of this visit were to better understand how this nationally recognized center is advancing the profession's understanding of how to better treat patients with spinal cord injuries and how that understanding translates into improved mobility for those they treat.*

*Subsequent to this interview, Dr. Tansey accepted the position of Director, SCI Research at the Shepherd Center in Atlanta. Drs. Winchester and Tansey plan to continue their collaboration using the Lokomat systems at both institutions.

What is the research focus in the SCI Lab?

Dr. Keith Tansey: A good part of our research focuses on trying to understand the balance between sensory information that's *useful* to getting the neural circuitry working correctly and identifying sensory information *distracting* that circuitry from doing its normal function.

In the spinal cord injury lab, our goal was to better understand the changes in neural circuitry with training. To that end, we look at the Lokomat not only as a training tool but as a measurement tool. If we understand where and how training impacts these circuits, we might be able to reinforce these changes with therapy or drugs, to get a better therapeutic effect.

For instance, right now many patients with motor-complete spinal cord injuries don't get trained because there is no evidence

UT Southwestern patient Jeremy Medders chats with his wife Jennifer as he trains on the Lokomat system. Jeremy was injured in January 2007 when he fell from a ladder.

"...the Lokomat is not only a great training tool, it's a great study tool for understanding what's going on in locomotor centers of the brain..."

The UT Southwestern team — Drs. Querry, Winchester and Tansey — watch the Lokomat system's feedback display as Jeremy completes his 18th week of therapy at the clinic.

that they will regain the ability to walk over ground. But one of the things we've discovered is that these motor-complete patients have the same reflexes as normal patients when they're lying or standing, but when they start walking, those reflexes drop off. Something about walking may be inhibiting the central pattern generators in the spinal cord. It may be because their spinal cords are so unexcitable during the time they're being trained. So if we can find a way to increase that excitability with drugs or stimulation, perhaps that group of patients can gain benefit from training with the Lokomat.

Karen McCain, DPT

Are you using any drugs or any protocols at Southwestern in an attempt to increase that neuronal excitability?

Dr. Tansey: Not yet. We have patients continue on the medication that they come to us with, on the assumption that they have been optimized to best control their spasticity and functional status.

Occasionally, before we start a trial we'll say to the patient, that it might be beneficial if they had a little bit more medication to reduce the possibility that their spasticity might stop the Lokomat, or perhaps that their dose might be reduced, to see if they might be stronger. Once they start the trial, they stay on that medication regimen until the end.

Ideally, the first step would be to perform a group of measures with the patient off drugs. Then bring them back a week later on drugs with the idea of identifying patient populations who could be trained with and without drugs. With the Lokomat, we might be able to see if there's a difference between the two groups as far as need for body weight support, speed, etc. We might be able to detect performance differences for a patient on the drugs versus the day that he's not on them.

Thus, the Lokomat is not only a great training tool, it's a great study tool for understanding what's going on in gait-controlling parts of the brain under different circumstances.

How does a patient like Jeremy get admitted into your research program and how are they evaluated and treated?

Dr. Winchester: Patients from all over the Dallas/Fort Worth area, as well as North Texas are referred by their healthcare providers or can even self refer. To be included in our studies the patients must have a motor incomplete spinal cord injury and be between the ages of 18 and 60. They have to have range of motion sufficient to stand upright in the Lokomat – they can't have contractures in their knees or hips that exclude them from being able to be set up appropriately in the Lokomat. They cannot be at risk for pathologic fractures due to osteoporosis or weigh more than 250 lbs.

Once they sign a consent form agreeing to participate in our study, we establish a detailed baseline. They have an fMRI scan, SPECT scans, an

University of Texas Southwestern Spinal Cord Injury Program

The Spinal Cord Injury Laboratory is part of a comprehensive spinal cord injury support program at The University of Texas Southwestern Medical Center. That program encompasses clinical care, clinical research, and a translational research focus that enables discoveries made in animal models to be tested in human subjects and then used to advance the standard of care for spinal cord injury patients.

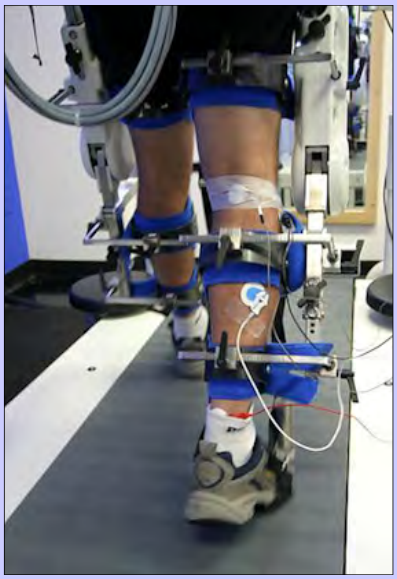
Annually, University of Texas Southwestern provides care to approximately 350 patients with SCI or other spinal cord disease, seeing on average 20 patients a day. These figures include about 80 new traumatic SCI patients admitted in the immediate acute period and about 120 patients undergoing rehabilitation for their condition. Care is provided in the ICU, in two inpatient rehabilitation units, and two outpatient SCI Clinics by two multidisciplinary, interdepartmental teams, the Spinal Surgery Service with physicians from neurosurgery, orthopedics and trauma, and the SCI Medicine Service with physicians from neurology and physical medicine and rehabilitation.

Clinical Research

The SCI Program at UT Southwestern carries out clinical research in two settings, the hospital and clinic and in the human SCI laboratory. Projects in the hospital and clinic range from studies investigating the optimal management of ventilators for high cervical SCI patients to studies where non-pathogenic bacteria are introduced into the bladders of SCI patients with frequent infections to prevent the return of disease-causing bacteria.

In the human laboratory, the focus of research is on activity-dependent neural plasticity and functional recovery following SCI. Recently, the technique of Body Weight Supported Treadmill Training (BWSTT) has been shown to improve neurological recovery in SCI, especially in motor incomplete subjects. The lab uses both therapists and a robotic device, the Lokomat system, to carry out BWSTT. UT Southwestern is one of only a few centers in North America that can offer training in the Lokomat.

Research in the human SCI laboratory has focused on identifying the locations within the nervous system where neural plasticity occurs in response to BWSTT and the magnitude of those changes. The UT Southwestern team found that patients who recovered over ground walking after gait training were able to show greater activity in a specific part of the brain during a foot movement task while getting a functional MRI of their brains. The amount of blood flow to the cerebellum, a center for motor learning and coordination, was increased in proportion to the speed of recovered walking in motor incomplete SCI patients.



The UT Southwestern lab routinely performs EMG studies on newly recruited study participants, to determine the most effective speed and unweighing settings that result in the most effective training parameters for each patient.

Currently, the lab is investigating whether there is also plasticity in the spinal cord following training. Rather than using imaging, this study involves the electro-physiological stimulation and measurement of a lower leg reflex. In this investigation, the Lokomat is not only a training device but also a testing device as it can trigger the reflexes to be studied at specific points in the gait cycle. Our preliminary studies have characterized how different severity of SCI and time since injury affect the excitability of the spinal neural circuits involved in this reflex.

To evaluate the potential for supraspinal reorganization in response to body weight supported treadmill therapy, the brains of four men with motor-incomplete spinal cord injuries were scanned while performing an ankle-movement maneuver, using functional magnetic resonance imaging (fMRI) before and after Lokomat therapy, three times weekly for 12 weeks. Testing of locomotor disability included the Walking Index for Spinal Cord Injury (WISCI II) and over ground gait speed.

Post-therapy fMRI studies showed that all subjects demonstrated some degree of change in the blood-oxygen-level-dependent (BOLD) signal following therapy, with greater activation in sensorimotor cortical regions (S1, S2) and cerebellar regions. The UT Southwestern researchers concluded that intensive task-specific rehabilitative training, such as robotic BWSTT, can promote supraspinal plasticity in the motor centers known to be involved in locomotion. Furthermore, improvement in over-ground locomotion is accompanied by an increased activation of the cerebellum.

To confirm these findings, the UT Southwestern research team is currently repeating this study, using SPECT (single -photon emission computed tomography) with a radiopharmaceutical that can be injected while the patient is at peak exercise on the Lokomat. A SPECT scan performed within an hour after Lokomat therapy can be compared to a similar SPECT study performed while the patient is at rest. Investigators believe that this study will prove a more rigorous technique for evaluating supraspinal plasticity effects of locomotor therapy, and could prove a guide to better therapy.

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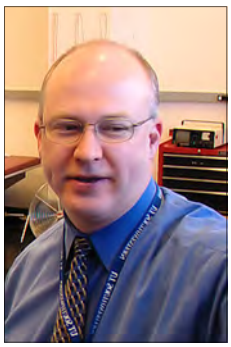


Ross Querry, PT, PhD

EMG study, H-reflex studies and then their spasticity and strength are assessed using software from the Lokomat (L-Stiff and L-Force).

Jeremy is an example of an excellent patient. He's a 26-year-old married man who suffered a fall from a ladder on January 12, 2007 while helping a neighbor cut off some tree limbs after a storm. The impact of his fall crushed his thoracic vertebrae at T8-T9.

Where was Jeremy initially treated?

Dr. Winchester: Jeremy was initially transported to the Presbyterian Hospital of Greenville, TX, where he lives and then transferred to Parkland Hospital in Dallas. After a week at Parkland, he was transferred to the spinal cord rehabilitation facility at Zale Lipshy University Hospital for inpatient rehabilitation. He was referred to the SCI laboratory by his orthopedic surgeon. He proved to be an ideal candidate for both robotic gait therapy and our new brain neuroplasticity imaging study (SPECT).

Tell us about Jeremy's treatment in the SCI Lab.

Dr. Winchester: Jeremy first presented with significant spasticity in both legs that precluded him from walking. On his first session, we even had difficulty getting him set up in the Lokomat with a good gait pattern due to his spasticity. For the next 18 weeks, he came to our lab Mondays, Wednesdays and Fridays for treatment. Within just a few treatments, we noted a remarkable decrease in his spasticity. Every week we were able to progress his program by decreasing body weight support and increasing the treadmill speed. As Jeremy improved, we began walking over ground with a walker and used electrical stimulation to facilitate stepping.

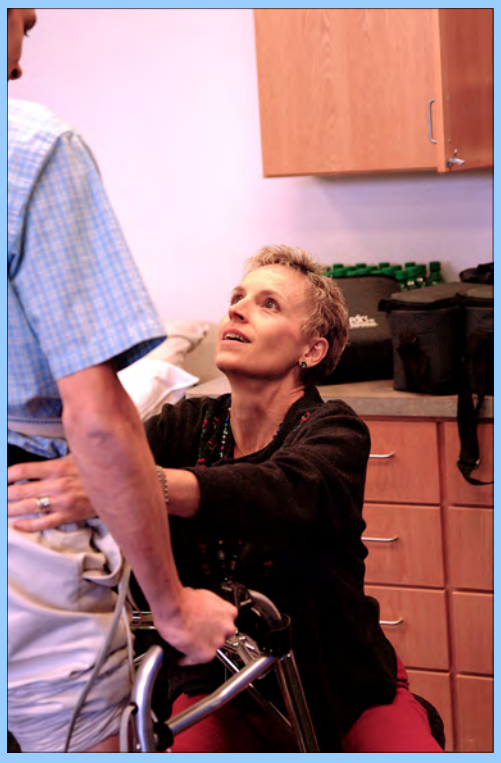
Why are EMG studies a part of your evaluation protocol?

Dr. Querry: We use EMG as part of our admission evaluation to determine each patient's ideal set up in the Lokomat to produce the optimum gait kinematics (treadmill speed and amount of body weight support). With Jeremy, we found that if he walked slower with less body weight support, his spasticity was reduced and his gait pattern was improved.

With EMG, we're actually able to see the muscle activation patterns in the key muscles of the legs while the patient is walking in the Lokomat. Thus, EMG helps us fine-tune the best Lokomat settings for a specific patient.

How would you assess Jeremy's progress since he started therapy in your laboratory?

Dr. Winchester: After 8 weeks of Lokomat training, he could come to standing with a walker and minimal assist of one therapist. As he improved



we began stepping. Initially, he required electrical stimulation to facilitate stepping but by the 12th week he began to take steps on his own. He is now able to walk with a rolling walker and minimal assist of one therapist. I believe he will achieve the ability to walk independently.

What are your criteria for moving a patient to over ground walking?

Dr. Winchester: The transition to over ground walking is based upon their ability to maintain stance stability without excessive upper-extremity weight-bearing. Thus when a person can stand with minimal weight through their arms we begin over ground stepping. The focus then shifts to facilitating stepping; we use a variety of therapeutic techniques, including electrical stimulation.

Do you ever use electrical stimulation in conjunction with the Lokomat system?

Dr. Winchester: We have used functional electrical stimulation synchronized to the Lokomat system, a feature that was specially developed for our research. Electrodes are placed to elicit a flexor withdrawal reflex or dorsiflexion during the swing phase of gait. We have three patients who, at the end of their three months of training with the Lokomat, could stand but were still having trouble taking a step. We initiated synchronized stimulation during Lokomat training to assist in facilitating stepping and at the end, all three demonstrated an improvement in their ability to walk.

What homework does Jeremy do?

Dr. Winchester: Jeremy practices standing up at home. He now knows how important it is to stand with the correct posture without relying on his arms. He uses AFOs to correctly position his ankles. We encourage Jeremy to practice standing on a daily basis but to quit when he gets fatigued. Jeremy also understands how important it is to stretch the spastic muscles in his legs every day.

Dr. Tansey: Patti's giving some really important counsel here – the important therapeutic objective is not strength or endurance, it's technique, it's motor skill. We tell patients here, "Stop worrying about how strong you are" and "Stop worrying about how much endurance you have. Think about walking like it was learning play a piece on the piano. Speed and endurance don't count for much there, either – it's really about correct technique."

If you walk a very short distance for a very short time and you're not very strong, but you do it well, you will train all the neural circuitry with the appropriate sensory input.

If you learn motor behavior wrong, you have to unlearn it before you can learn it right, and that's why patients who are walking poorly but won't give it up, are harder to train than the ones who can't walk at all to begin with. Nothing is accomplished

"We have used functional electrical stimulation synchronized to the Lokomat. Electrodes are placed to elicit a flexor withdrawal reflex or dorsiflexion during the swing phase of gait."

Far from an austere research setting, UT Southwestern Spinal Cord Injury Laboratory is a very human, hands-on environment, where all members of the laboratory and patients work collaboratively to achieve their rehabilitation and research goals.

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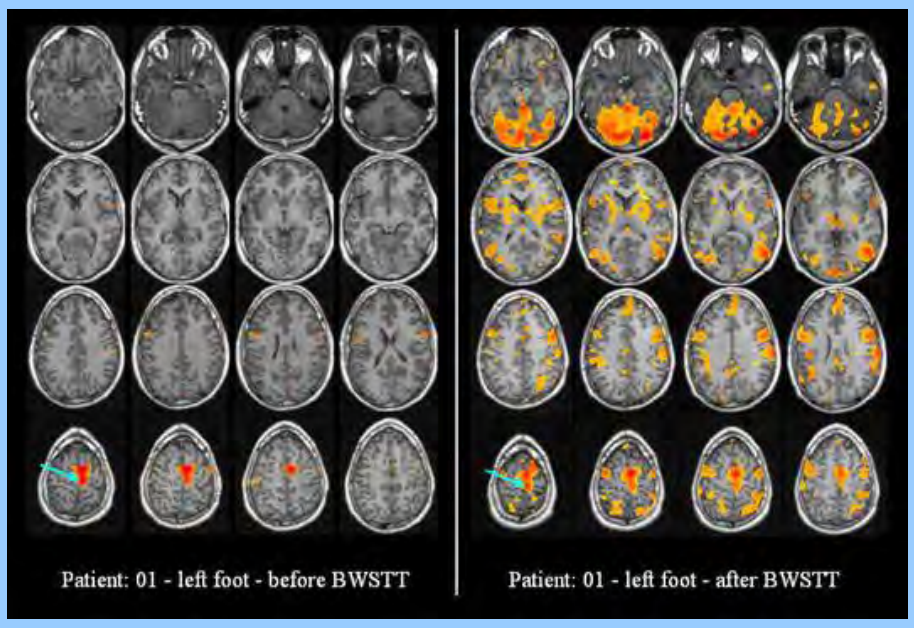

Functional MRI during a foot moving task of a SCI patient before (left) and after (right) gait training in the Lokomat system. The orange areas in the top right figure show the increased blood flow (and neural activity) in the cerebellum.

fMRI Studies Indicate Lokomat System Therapy Promotes Supraspinal Plasticity in Motor Centers Known to be Involved in Locomotion

To evaluate the potential for supraspinal reorganization in response to body-weight supported treadmill therapy, the brains of four men with motor-incomplete spinal cord injuries were scanned while performing an ankle-movement maneuver, using functional magnetic resonance imaging (fMRI) before and after Lokomat therapy, three times weekly for 12 weeks. Testing of locomotor disability included the Walking Index for Spinal Cord Injury (WISCI II) and over-ground gait speed.

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with poor form, poor technique, or poor quality of movement.

Everything at home as well in the lab should be done according to the correct pattern of movement. Endurance and strength can come later. It's like a baseball pitcher's curve ball, which has more to do with how well he controls the ball than how strong his arm is, or how hard he can throw. Similarly, gait therapy is all about correctly doing the right movements, over and over and over and over again.

For the first time since his accident in January 2007, Jeremy experiences a standing hug from his wife Jennifer as he begins periodic overground walking exercise, in addition to Lokomat system training.

"Everything at home as well in the lab should be done according to the correct pattern of movement. Endurance and strength can come later."

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