HyperMED

Incorporating
Melbourne Hyperbaric • Spinal Rehabilitation Group
The Hyperbaric Foundation of Australia • Oxy-Sports Health

HyperMED LOKOMAT™ NEURO RECOVERY

Spinal Cord Injury, Stroke, Traumatic Brain Injury, Cerebral Palsy, Multiple Sclerosis, Parkinsons and other Neuro-Degenerative Disorders ...

HyperMED installs the first Australian Lokomat – Robotic Assisted Walking
'At a cost of in excess of AUD $600,000 the vision has been a long time coming!' says Dr Hooper.

Lokomat has been developed by a Switzerland company Hocoma International. Lokomat and other emerging neuro-rehabilitation robotics are 'state of the art' sophisticated devices that positively impact the lives of individuals suffering chronic progressive neurodegenerative disorders.

Lokomat is the 'next generation' in neurological rehabilitation and features in most of the world's leading rehabilitation and university facilities. The USA has 14-hospital based Lokomats with the FDA now providing insurance funding for robotic assisted neuro-rehabilitation programs.

The Chicago Rehabilitation Hospital has 2-Lokomats and recently featured a C5/6 quadriplegic 13-year old girl who suffered massive spinal cord injury after diving into a swimming pool and hitting her head. The only movement within the 3-month period after her injury was occasional flickering of her big toe. After considerable lobby and financial support she was transferred to Chicago Rehab for an intensive rehabilitation program using Lokomat over a 2-year period. This story was featured on the NBC program across the USA; she walked out of the hospital!

HyperMED Australia incorporates the trading identities of the Spinal Rehabilitation Group (established 1986) and Melbourne Hyperbaric being the first facility in Australia using the merits and applications of Hyperbaric Oxygenation in the treatment and management of complex brain and spinal cord injury and related neuro-degenerative disorders.

The inclusion of both the adult and child Lokomat into our HyperMED Hyperbaric Oxygenation protocol is a world first!

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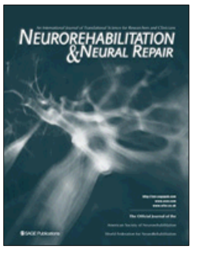
Robotic powered gait rehabilitation improved in excess of 80% of wheelchair bound patients suffering incomplete spinal cord injury; participants of the program gained significant functional returns including functional walking ability after robotic training. Spinal Cord Inj Rehabil 2005: 11(2): 34-49;

Lokomat Driven Gait Orthosis helps retrain brain and improves walking for partially paralyzed people

Dr. Patricia Winchester, chairwoman of physical therapy at UT Southwestern Allied Health Sciences School, works with a patient using the Lokomat robotic treadmill.

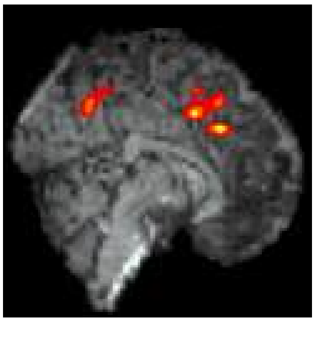
DALLAS - Nov. 29, 2005 - People who have suffered partial paralysis from spinal-cord injury show increased activity in the part of the brain responsible for muscle movement and motor learning after an aggressive 12 weeks of training on a Lokomat robotic treadmill, researchers at UT Southwestern Medical Center have found.



The recent study published in the journal *Neurorehabilitation and Neural Repair,* is the first to demonstrate that locomotor training can promote activation in the parts of the brain involved in walking in spinal-cord injury patients.

Additionally, the findings suggest that a diagnostic technique called functional magnetic resonance imaging (fMRI), used by the researchers to measure the activation of these brain areas, "may be useful in predicting which individuals will benefit from a particular intervention" after spinal-cord injury, Dr. Winchester said.

Researchers have demonstrated that locomotor training can promote activation in the parts of the brain involved in walking in spinal cord injury patients.



David Cunniff, one of the study patients, described his improvements as ‘quite dramatic.’ He said within about a month of intensive training on the Lokomat robotic treadmill, he stood up out of his wheelchair for the first time. ‘I had no idea I'd be able to do that,’ he said. Prior to the training, he could only stand with assistance and could not walk. Today he uses only a cane to move about. ‘I don't think I could have ever gotten to the place I am without the Lokomat robotic device.’ Mr. Cunniff said.

The study followed four spinal-cord injury patients with varying degrees of paralysis. All underwent intensive rehabilitation therapy using a computerized treadmill called the Lokomat Driven Gait Orthosis. The device supports the weight of the patient in a harness, while robotic devices control their limb movements on a treadmill. During training, the patient watches his or her progress on a real-time computer monitor. By providing sensory information to the spinal cord and brain, the device signals the body to step again.

The study participants were assessed before and after completion of the treadmill training with fMRI. Pictures of blood flow in the brain during body movement were compared to fMRI images taken when the patients were at rest. After training, those patients who showed the most progress in completing a simple task - flexing their ankles - showed increased activity in the portion of their brains called the cerebellum while undergoing fMRI. However, only those patients who showed a "substantial" change in the cerebellum during the task improved their ability to walk.

Of the four patients, Mr. Cunniff and another man who could walk with a cane after the training had the greatest changes in activation of the cerebellum. Prior to training, the second man required a walker, a brace and physical assistance to walk. Of the other two patients, one was able to walk with a walker and some physical assistance after the 12-week intensive Lokomat training. Before the training, he had been unable to walk or stand. The fourth patient could not walk before or after training, but nonetheless showed some increased brain activation - but not in the cerebellum - after using the Lokomat.

‘The study suggests that the specific part of the brain – the cerebellum; plays an important role in recovery of walking and function’

The researchers have now enrolled more than 25 study patients. The next step in the research is to use single positron emission computerized tomography (SPECT) to look at the patient's blood flow in the brain during the performance of a task. SPECT involves the administration of a radioactive dye that migrates to the patient's brain and produces a three-dimensional image of hot spots of brain activity.

Other UT Southwestern researchers involved in the study were Dr. Roderick McColl, associate professor of radiology; Dr. Ross Querry, assistant professor of physical therapy; Nathan Foreman and James Mosby, faculty associates in physical therapy; Dr. Keith Tansey, assistant professor of neurology and physical medicine and rehabilitation and director of the

Southwestern Spinal Cord Injury Program; and Dr. Jon Williamson, professor of physical therapy. The study was supported by the Western Rehabilitation Research Network and the Mobility Foundation Center.

Robot Helps Gunshot Victim Walk Again

HealthWatch Special Report: Rehabilitation Robot Allows Great Strides [January 11, 2006]

CHICAGO -- Spinal cord injuries are among the toughest conditions doctors encounter. So far, science has little to offer paralyzed patients. NBC5's Nesita Kwan reported that new technology in Chicago is offering some hope.

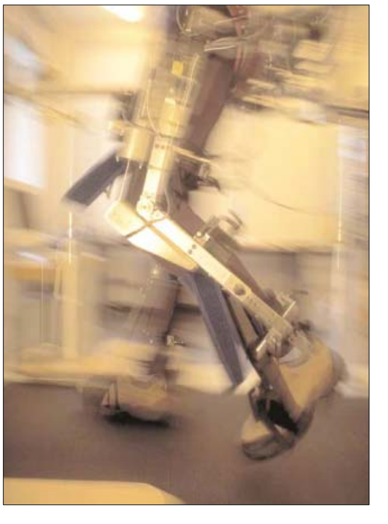
Not all spinal cord injuries are permanent. Doctors have found that patients with slight feeling can regain more movement than ever thought possible. Kwan reports that with the help of "an amazing machine," one Chicago woman is taking big strides.

‘I was out at a nightclub and I believe someone got into an altercation, came back and started shooting. I remember falling,’ Gernard Fulton said of the night of Oct. 1, 2004. Fulton, a healthy, active mother of two, was left with a bullet in her spine. ‘I didn't know that I was paralyzed,’ she told NBC5. But, she woke to a new life.

‘I couldn't walk. I couldn't feed myself. I couldn't do anything for myself,’ Fulton said. Fulton turned out to be one of a small minority of paralyzed patients with some feeling below their injury. ‘That means at least some of the nerves are working in the spinal cord all the way down, and you have a little bit of function left which can be potentially built on!,’ said Dr. Todd Kuiken Rehabilitation Institute of Chicago.

It's called an incomplete injury and doctors at the Rehabilitation Institute are studying whether the robotic machine they're using can help those patients heal. Fulton was introduced to the Lokomat machine. ‘She really started showing improvement around the sixth week of the study,’ Fulton's therapist said. ‘I was happy when I could wiggle a toe or finger,’ the patient said.

Doctors think it may reawaken the connection between the brain and the leg.



After months of training, Fulton has made great strides. Doctors still don't know why it works for some patients. ‘You've got your brain up here,’ Dr Kuiken said, ‘your body down here and the thing that connects it, the spinal chord. So, if the spinal chord is connected, it's like the main phone wire being damaged. So, we have to re-establish that brain-body connection any way we can.’

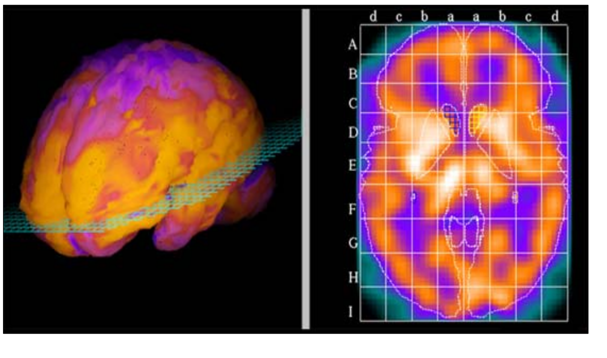
Ten months after stepping into the Lokomat, Fulton did the impossible: she went home. She wasn't able to return to her own apartment, three floors up, and had been living at her sister's more accessible home. Fulton walks with a cane and hasn't regained movement in her left arm, but it's what she can do that she is most thankful for. ‘It's a blessing. It's great. I mean, I'm happy about it,’ she said. ‘Ecstatic, actually, that I'm where I am.’

Baby steps may be part of the cure.

‘You have someone who has been in a chair, not able to walk,’ Dr Kuiken said. ‘Then to be in this device and have your legs moving in a more natural way, it's very exciting and gives everybody hope. Without the Lokomat a patient would need three to four therapists holding the patient up to help mimic walking and that can only be done for about 10 minutes. The Lokomat machine allows a longer workout to build up the legs faster. It may help not only people with spinal chord injuries, but those with other conditions as well, such as stroke and other degenerative neurological disorders.’

What conditions benefit from HyperMED Lokomat NeuroRecovery?

- Spinal Cord Injury
- Stroke
- Traumatic Brain Injury
- Cerebral Palsy
- Multiple Sclerosis
- Parkinson’s disease
- Motor Neuron Disease
- Post operative joint replacement

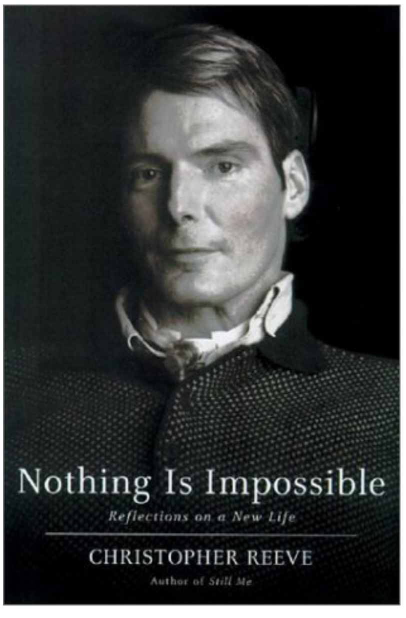


The Aging Population – you're living longer but living with disability!

Neurodegeneration will 'boom' as the population continues to age. Drug companies continue to compete on a highly lucrative market fueled by the fact that we as the public do not want to get old or get sick let alone suffer a chronic neurodegenerative illness. However, there are no magical bullets, pills, lotions or potions!

Quality of life and life expectancy are the prime focus of all practitioners devoted to the field of neurorehabilitation. However, the spirally cost to maintain a failing public health care system that is 'crisis care' orientated notwithstanding the fact that the vast majority of patients with complex neuro-disability continue to get worse; has meant that medicine must look towards innovation.

Nothing is Impossible



"What I do is based on powers we all have inside us; the ability to endure; the ability to love, to carry on, to make the best of what we have – and you don't have to be a 'Superman' to do it." Christopher Reeve.

The Christopher Reeves Foundation is wholly committed to finding cures and treatments for spinal cord injuries as well as improving the quality of life for people living with disabilities. The Foundation features Gait Assisted Walking programs including Lokomat; for more information regarding Grants and Research projects visit www.christopherreeve.org

Spinal cord injury and stroke related injury are typically sudden and unexpected. Neurodegenerative disorders are more progressive with all groups resulting in significant and progressive loss of neurological function and increasing disability.

Neurological disorders are devastating and costly in human and social terms. Medical improvements have greatly increased survival rates however individuals are living longer but with disability with little hope of improvement – until NOW!

The HyperMED Hyperbaric Oxygenation Lokomat approach is unique

The combination of Hyperbaric Oxygenation, whole body vibration and other immune stimulatory treatment has already provided amazing results with vast numbers of patients attending our Melbourne facility. In excess of 75% of attending patients are from interstate and many from overseas.

We believe the addition of Lokomat has the potential to provide further benefits. Patient welfare and quality of life can be further improved. Lokomat success overseas can be mirrored, and in fact be significantly enhanced by combining hyperbaric treatment and other proprietary measures.

HyperMED Lokomat at 15 Collins St Melbourne is currently the ONLY location in Australia to provide Lokomat Robotic Assisted Walking. We envisage that with appropriate Medicare funding HyperMED Lokomat will emerge on a state by state basis. The USA FDA and the EU has approved Lokomat for a multitude of conditions and we are confident that Medicare and Ancillary funding will follow.

Functional Gait Assisted Walking

During the past 15-years, treadmill training has become an established rehabilitation method for individuals with locomotor dysfunction such as spinal cord injured and stroke patients. Typically patients are suspended over a treadmill and their legs are individually guided by two assisting physiotherapists sitting next to the treadmill. The periodic excitation of the cutaneous, muscular, and joint receptors provides a periodic *'afferent input to the neural circuits located in the spinal cord and in the brain'.*

Intensive treadmill training reactivates and retrains damaged neural circuits.

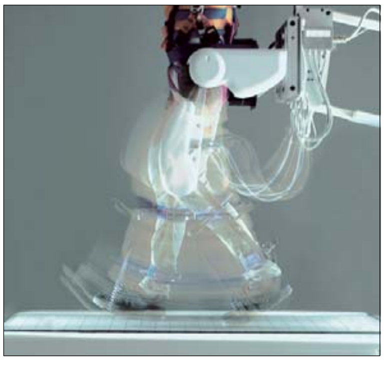
However, assisting the patient's leg movement manually is a very strenuous task for the physical therapists. Therefore, the duration and the number of training sessions are limited and many therapists complain of developing back related problems which potentially creates workers compensation issues! Gait Assisted Walking programs are virtually non-existent in Australia with inadequate funding models to overcome the 'therapist burn rate'.

In addition manual treadmill training can also result in irregular and poor physiological gait patterns. To remedy and over come patient and therapist disadvantages the rehabilitation robot Lokomat was developed by Hocoma International and the Balgrist University Hospital, Zurich.

'If you do not use it you lose it – if you have lost it then get it back!'

Other products are currently under research and development including Robotic Assisted Upper Extremity Guide; we are hopeful of introducing this and other neuro-rehabilitative products in the future!

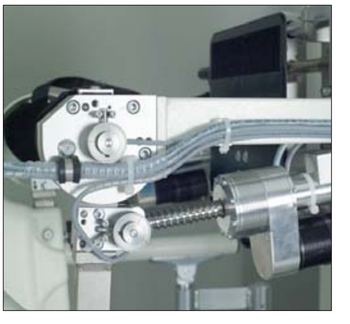
What are the advantages of the Lokomat Robotic Assisted Walking?



Lokomat is the 'Rolls Royce' of Robotic Gait Assisted Walking. Lokomat is designed to assist individuals whose ability to walk has been impaired as a result of stroke, spinal cord injury, brain injury, degenerative neurological and or orthopedic disability.

Lokomat is ideally incorporated 'early' into the rehabilitation program where functional neuroplasticity is greatest. However chronic injury also benefits and when coupled with aggressive Hyperbaric Oxygenation and physical therapy – improved functional outcomes are clinically evident.

The Lokomat automates correct functional treadmill training. Therefore, longer and more training sessions can be executed. The goal is a faster and better restoration of locomotion.



How does the Lokomat work?

The Lokomat provides 'gait training' by moving the legs in a normal physiological pattern that helps the spinal cord and brain to relearn the walking process; this is referred to as 'neuroplasticity and functional restoration'.

A harness supports the patient's body weight over a sensory assisted treadmill. The patient's legs and hips are strapped into the Lokomat robotic exoskeleton, which simulates a 'fluid walking motion'.

A computer records precise movement measurements and plots them on a graph, which is displayed in real time on a nearby monitor and allows patients and therapists to track and record individual progress.

Lokomat robotic functional training is driving CNS (central nervous system) reorganization and regeneration (neuroplasticity) in both the damaged spinal cord and injured brain. Functional MRI and brain SPECT scans confirm increased metabolic activity in damaged areas indicating neurovascular salvage and functional repair.

What impacts Neurological Recovery and the ultimate success of Lokomat?

At the recent World Federation in Neuro-Rehabilitation held in Zurich, October 2004; over 500 delegates attended with undoubtedly the elite of international speakers and featured exhibitors; numerous papers and research endeavors were presented high-lighting the potentials for recovery.

Gone are the days of simply living and coping with disability!

The objective and goal of Functional Restoration is to RESTORE FUNCTION. In order to achieve an improvement each patient must be individually assessed including current MRI (right) with treatment focused invariably on the following:

- correcting hypoxic sites
- delivery of growth factors and stem cell therapies to promote salvage and axonal sprouting
- activation of idling and non-functional neurons whilst promoting neovascularization (new capillary formation) – Hyperbaric Oxygenation
- functional gait retraining - Lokomat

What is Hyperbaric Oxygenation?

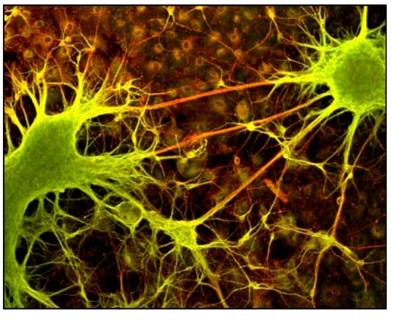
Hyperbaric Medicine (also known as Hyperbaric Oxygen Therapy or HBOT) is a method of safely delivering high doses of 100% Oxygen to the body while inside a pressurized chamber. Most treatments to enhance immune responses, athletic performances and treatment of chronic degenerative neurological conditions are safely performed between 1.75-2.0 ATA.

Hyperbaric works by increasing the saturative effect of dissolved oxygen into the blood and surrounding tissue structures that have been deprived of vital oxygen (hypoxic tissue). The pressure inside the chamber causes the Oxygen breathed to be dissolved at greater levels in the blood. Recent studies have reported that HBOT results in about a 15-20 fold increase in oxygen saturation. This is about a 2,000% increase of dissolved oxygen into the brain and spinal cord structures!

Approximately 20-30% of the body's consumption of Oxygen occurs within 3-5% of the body mass - the brain and spinal cord. These structures are extremely sensitive to Oxygen deficiency, and can have the most dramatic results with the use of HBOT. This increased tissue Oxygenation significantly accelerates the rate of healing, stabilization and repair.

- HBOT is non-invasive. It is not a surgical procedure
- HBOT is safe
- HBOT works extremely well with other forms of assertive physical therapies and or requisite medications. It enhances the effectiveness of both traditional and complimentary therapies

Why the use of Hyperbaric Oxygenation for Brain and Spinal Recovery?



Hyperbaric Oxygenation acts as a catalyst promoting neurovascular salvage and repair. The rule of thumb is that most brain and spinal cord patients require an absolute base line of between 40-60 hours with most cases commencing and receiving around 100-150 hours. Complex conditions may require several hundred hours to penetrate the deeper neurovascular structure with blocks of sessions coordinated every 4-6 months after the initial saturation (40-60 hours).

Generally an initial HBOT introduction is around the 40-60 hours mark for brain inured children with most parents making some comment of positive changes which indicates that the child is making progress and Hyperbaric Oxygenation is in the right direction.

Adult patients suffering brain and spinal injury typically require an absolute base line of around 100-hours to penetrate the deeper structures and commence recovery. Complex disorders may require literally several hundred hours combined with assertive physical therapy – hard work is required by all! We anticipate that Lokomat inclusion will speed the process of neuroplasticity. Unfortunately there is NO hard and fast rule and we cannot give unconditional guarantees!

What is the difference between traditional Hyperbaric and Neurological Hyperbaric Oxygenation?

Answer: Lower pressure and longer time!

Medicare covers a limited number of traditional conditions; typically delayed wound healing, acute necrotizing infections, gangrene, limb and life threatening disorders. Medicare funding for approved conditions is limited to hospitals with patients receiving HBOT in large multi-place chambers.

Medicare HBOT approval requires the patient to undergo HBOT at pressures greater than 2.8 ATA and beyond which is typically required for highly infective disorders.

These higher pressures are NOT considered to be appropriate for chronic neurological disorders and in fact can provide potential risk to the neurovascular patient.

Why an 'initial base line' of between 40-60 hours?

Hyperbaric Oxygenation (HBOT) mobilizes and elevates the patients own circulating CD34+ progenitor Stem Cells

[Abstract published *American Journal Physiology - Heart and Circulatory Physiology* (Nov 2005)] reports a single 2-hour exposure to HBOT at @ 2 ATA doubles circulating CD34+ progenitor stem cells and at approximately 40-hours of HBOT; circulating CD34+ cells increases eight fold (800%)!

'Hyperbaric Oxygenation provides a fertile platform for mobilizing the patients own stem cell capacity whilst preparing the body for further stem cell implantation techniques'. Dr Mal Hooper

The HyperMED Brain and Spinal injury experience

Hyperbaric Oxygenation was incorporated into our rehabilitation programs in 1996 with in excess of 60,000 separate chamber sessions performed without incident. Patients attending typically suffer complex degenerative neurovascular disorders including failed back surgery, chronic pain syndromes, spinal cord injury, stroke, cerebral palsy and numerous progressive neurological and immune related disorders.

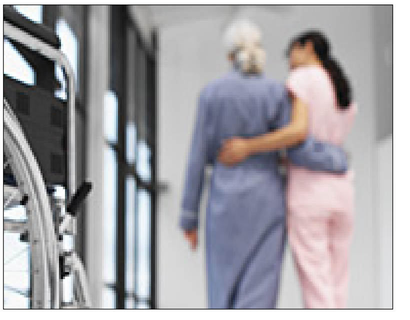
Hyperbaric Oxygenation is not a 'cure' but may significantly impact the disease process and quality of life of the individual. HBOT is not a stand alone proposition but recommended as part of an integrated clinical approach that monitors the course of the condition with appropriate clinical investigations and is tailored to the treatment requirements of that individual. The greatest potential for Hyperbaric Oxygenation is early in the disease process and not as a last resort!

We continue to treat vast numbers of patients with brain and spinal cord injury which leads to significant disability. However, many patients improve spontaneously, at least to some extent after the acute traumatic period; the principal mechanisms associated with the capacity to repair and self-regenerate are referred to as brain and spinal cord 'plasticity'. Plasticity refers to the capability of the brain and spinal cord to undergo rehabilitative change – salvage of the damaged area and ultimately functional restoration.

The influence of neuro-plasticity is an obvious priority in the acute stage of injury. However, evidence demonstrates that patients with chronic disability; even years after injury can be greatly improved by using methods and techniques focused on the underlying factors that influence the plasticity process. This gives great hope for children and adult patients with complex degenerative neurological disorders.

Neuro-plasticity is dependent on a number of key factors including the extent of glial (scar) formation which occurs as a result of injury; integrity of supporting blood supply and tissue oxygenation; and ultimately the ability of surviving nerve cells in partial lesions to take over additional functions – axon sprouting.

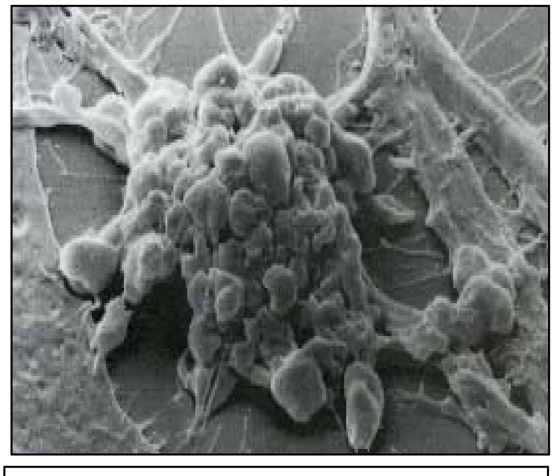
Apoptosis refers to 'programmed cellular degeneration'.



Apoptosis has been identified in all neurodegenerative disorders including brain and spinal cord injury. Apoptosis fosters the cycle of continued dysfunction, degeneration and ultimate neuronal death. In fact many brain and spinal cord patients continue to get worse and this is evidenced by additional MRIs of the region 3-5 years post the initial injury; in many cases there is further expansion of the original primary lesion and a cascade of secondary degenerative effects - apoptosis.

What triggers apoptosis - programmed cellular degeneration?
Answer: Hypoxia

What is Hypoxia? Answer: Oxygen Starvation



Programmed cellular degeneration triggered by Hypoxia [Apoptosis]. Clumping and clustering of damaged nerve cells surrounded by healthy neuronal tracts.

Oxygen deprivation (hypoxia) due to lack of adequate blood flow (ischemia) triggers apoptosis. Apoptosis modifies the expression of plasticity (the ability of the body to repair). Apoptotic bodies and altered DNA fragmentations are observed in the avascular ischemic region with increased inhibitory biochemical factors (proteins) released into the damaged parts of the brain and spinal cord causing further deterioration.

Hyperbaric Oxygenation (HBOT) directly increases the saturative effects of tissue oxygenation slowing and reversing hypoxic induced apoptosis - restoring blood supply to the compromised region by the development of new capillary networks (neovascularization) enabling the body to alter the course and impact of the disease process.

HBOT mobilizes the body's circulating stem cells. *American Journal Physiology - Heart and Circulatory Physiology* (Nov 05)] reports a single 2-hour exposure to HBOT at 2 ATA doubles circulating CD34+ progenitor stem cells (primordial cells targeted to salvage and restore damaged structures); and at approx. 40-hours of HBOT; circulating CD34+ cells increases eight fold (800%)!

- Hypoxia results in chronic swelling (edema) of damaged nerves leading to poor metabolic activity often described - dormant and non-functional responses
- Hypoxia causes inadequate capillary development as evidenced by SPECT and Functional BOLD MRI
- Hypoxia creates a 'weakened site'. Healing responses slow with inadequate and inferior material laid in the damaged region
- Hypoxia leads to development delay in children with normal milestones not achieved
- Hypoxia results in inadequate myelination of nerve coverings - spasticity and regions of low and hi tone
- Hypoxia causes inappropriate neural connections and abnormal biochemical responses resulting in modified or inappropriate mental function
- Hypoxia results in regions of poor energy which fosters opportunistic infections that thrive in low oxygen environments – chronic bacterial and viral infections
- Hypoxia triggers Apoptosis and drives the cycle of continuing neurovascular degeneration with a greater incidence of further injury and insult

HyperMED Hyperbaric Oxygenation Benefits

- Mobilizes the patients own circulating stem cells providing a fertile neurovascular platform for further stem cell related therapies and implantation
- Elevates the amount of dissolved Oxygen into compromised and damaged tissue structures. Accelerates recovery and promotes stabilization of individuals suffering complex and progressive neurodegenerative illness and disease
- Enhances immune capabilities - increasing white blood cell (WBC) and Natural Killer Cell (NK) function; accelerating wound healing and infection control. This has a 'killing' effect which dramatically raises the potential to fight chronic infection and overcome delayed healing
- Accelerates new tissue formation (fibroblast and collagen synthesis) essential for repair – ligaments, disc, muscle and bone structures
- Increases blood flow into retarded tissue by fostering new blood vessel capillary growth into the damaged and compromised areas. This is called neovascularization
- Activates damaged and non-functional neurons (nerve cells). This is extremely important in chronic injury including spinal cord, brain injury and neurologically impaired patients. Chronic swelling and inflammation deprives vital Oxygen, which results in nerve cells becoming abnormally low in metabolic function. In fact, in many spinal cord and brain injured patients', nerve cells are not completely severed but remain intact. However, the nerve cells are 'non-functional' because of the massive swelling that ultimately results in progressive scar formation because of Oxygen deprivation. Studies have demonstrated by raising the amount of Oxygen efficiency into the damaged area scar formation is reduced, blood flow is improved and dormant, non-functional and damaged nerve cells can be reactivated. Obviously, the best outcome is to start with aggressive HBOT in the early stages of injury
- Reinstates normal lymphatic drainage creating a 'clearance' effect reducing chronic swelling which causes painful inflammation
- Many prescribed drugs, antibiotics and immune stimulating vitamins and amino acids require Oxygen and are in fact greatly enhanced with benefits of Hyperbaric tissue Oxygenation
- HBOT changes cellular metabolism by altering Oxygen deprivation towards Oxygen efficiency at a cellular level; changing the cellular substrate from an anaerobic metabolism (energy poor) into an aerobic metabolism (energy rich). This has a net clearance effect enabling the body at a cellular level to detoxify and reverse the radical accumulation of toxins that ultimately mutate into abnormal cells (including cancer cells)
- Significantly reduces the ability of chronic infections including bacterial, viral and cancer cells to replicate and proliferate. Chronic infections do not survive in a high Oxygenated environment

Historical studies - Teaching the Spinal Cord to walk

Functional Gait retraining was reported by neurophysiologist Anton Wernig at the University of Bonn located near Karlsruhe, Germany (*Science Magazine* vol. 279, pp16, 1998). Spinal cord injured patients entering the Wernig rehabilitation program were rigorously evaluated, with suitable candidates undergoing an intensive program designed to encourage a 'walking response'.

Wernig's program revolves around the idea that the *injured spinal cord can be reprogrammed with a limited ability to walk*. Initial experiments conducted on cats demonstrated that cats with severed and injured spinal cords could be trained to support their weight and walk. This concept has considerable interest because evidence now indicates that the adult mammalian spinal cord can perform activities on its own, largely independently of the brain, including the functions necessary to walk. Neural circuits governing locomotion in the spinal cord can 'learn' by altering connections, in a way that may assist walking (Wernig 1995).

Today, doctors generally leave spinal cord injured patients alone, except for therapy to strengthen muscles or maintain some degree of flexibility. J. Thomas Mortimer, biomedical engineer at Case Western Reserve University in Cleveland states that Gait Assisted Walking is clearly stating to the injured patient that this 'may not be your lot'. Mortimer concedes that 'training may not restore normal walking', but states

'being able to walk a few paces and climb a few stairs could vastly improve such a person's life, enabling him to enter a friend's home, movie theatre, or a narrow bathroom that would otherwise be out of limits to him or her'.

The first suspicion that the spinal cord had independent function emerged in 1910. Charles Sherrington, a neurophysiologist at Oxford University in the United Kingdom, *found that cats whose spinal cords had been completely cut could perform limited stepping motions*. However, it was another ten years before the spinal cord was conclusively identified as the engine of locomotion to the spinal cord.

In 1967, Anders Lundberg and colleagues at the University of Goteborg Sweden, isolated the spinal cord in adult cats by cutting its link to the brain and also paralyzing all the muscles to deprive the cord of movement related sensory cues. The researchers then activated the animal's spinal neurons with an injection of L-dopa, a precursor for one of the cord's main neurotransmitters, noradrenaline. They recorded that the neurons that flex the legs and those that extend the legs fired in alternating patterns.

Lundberg concluded that the spinal cord holds a *'rhythm generator'* for locomotion that beats like a heart and is *independent of both sensory cues and the brain*. During the 1970s, Grillner and Peter Zangger further demonstrated that the cord not only produces a rhythm generator but also a more detailed electrical pattern in which different neural signals are sent to different leg muscles. Grillner showed that cats with severed spinal cords walked well if they were given certain drugs immediately after their cord had been cut. The older the animal, the more difficult it was to walk after injury.

Edgerton and Rossignol of the University of California Los Angeles (UCLA) showed that cats with severed cords, *'spinal cats'*, were able to relearn the locomotion pattern of a normal cat. Rossignol and Barbeau (1987) demonstrated dramatic improvements in the walking abilities of three spinal cats after 2-3 sessions a week, during which they were *retrained to walk with their hind limbs on a treadmill*. At first, the animals had to be held up by their tails, but eventually became able to support their own hindquarters while they walked. They also learned to place their paws sole first on the treadmill and to take longer and more natural steps. In addition, the cats' leg muscles also began to exhibit more normal patterns of electrical activity.

Edgerton (1990) compared the walking abilities of three groups of spinal cats: untrained animals, those trained to step and another group trained to stand only. The team showed that the step-trained cats could, after 5-months walk more naturally and rapidly than the untrained cats. By contrast, the cats that had only practiced standing could hardly step at all. Edgerton concludes,

'... Not only can the injured spinal cord learn, but also what it learns depends on the exact sensory input it receives. If you teach a cat to step, it learns to step, if you teach it to stand, it learns to stand, but cannot step'.

Barbeau (1989) performed a pilot study involving 10 patients, using a harness that could support up to 40% of their body weight. After 6 weeks of training, the researchers observed significant improvements - both on the treadmill and on the ground. Wernig (1990) and Bonn also had results with *12 patients showing that treadmill training had positive effects*.

Volker Dietz (1995) at the University Hospital Balgist in Zurich induced stepping in 10 paraplegics whose spinal cords were completely disconnected from their brains by placing them on moving treadmills with each patient supported in a harness. They reported that the *patterns of leg-muscle activity in these patients were similar to those in healthy subjects during treadmill walking.*

Wernig (1995) published in the *European Journal of Neuroscience* a comparison study comparing results with partially paralyzed patients trained on a *treadmill program for three to twenty weeks, compared with matched controls treated with conventional exercise programs*. Of the 36 patients with recent spinal cord injury who were wheelchair bound at the start of the study, 33 learned to walk independently, at least with the aid of walkers or canes, after treadmill training. By comparison, only 12 of the 24 wheel chair bound controls became independent walkers with conventional therapy. Further, 25 of another 33 patients with older injuries who had been wheelchair bound learned to walk independently with Wernig's program, compared to just 14 of the controls.

Keir Pearson (1995 and 1997), neurobiologist at the University of Alberta in Canada and colleagues Whelan and Hiebert demonstrated that the *influence of sensory nerves in the spinal locomotion system could adapt to compensate for injury*. Pearson and his team made a significant discovery whilst studying sensations from a walking cat. In 1994, they cut sensory nerves in the cat's calf muscle observing outcomes. Significant trials observed that the neuronal circuitry changes to compensate for an injury deficit.

Wernig Clinic: Spinal Cord Walking Program - Case Study

Sauer (a 27 year-old paraplegic) took his first step in 6 years since being confined to a wheelchair after a motorcycle accident, which left him almost completely paralyzed from the ribs down in 1989. Sauer received an *intensive-walking program at the Wernig's clinic and now walks with a wheeled walker around his apartment*. With help, Sauer can climb a few stairs. *'The human body is not built for sitting', Sauer declares. 'Sometimes it should walk'.*

Video Case Studies are also available:
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DENMARK	- Hammel Neuro Center, Hammel
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PORTUGAL	- Minitério da Saúde, Tocha
SPAIN	- Fundació Privada Institut de Rehabilitació Guttmann; Badalona, Barcelona
SWITZERLAND	- Balgrist University Hospital Spinal Cord Injury Center - Rehabilitation Center, Clinic Valens - Schweizer Paraplegiker Zentrum Nottwil - Rehabilitationszentrum für Kinder und Jugendliche, Affoltern
TURKEY	- Darüssafaka Physical Therapy and Rehabilitation Hospital, Kozyatagi, Istanbul
USA	- National Rehabilitation Center, Washington DC - Rehabilitation Institute of Chicago - University of Miami, Florida, School of Medicine - UCLA Neurology, Los Angeles - VA Palo Alto Health Care System, Palo Alto - Miami VA Medical Center, Miami - James Lawrence Kernan Hospital, Baltimore - Louis Stokes Veterans Affairs Medical Center, Cleveland - VA Healthcare Systems West Haven, Connecticut - UT Southwestern Medical Center, Dallas - Malcom Randall VA Medical Center, Gainesville - Washington DC VA Medical Center - Next Steps SCI Rehabilitation, Willow Springs, Illinois
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