

PARACYCLE®

Motion Training with Functional Electrical Stimulation Made in IRAN

Prevent Secondary health conditions as a result of having

- Spinal Cord Injury
- Parkinson
- Multiple Sclerosis (MS),
- Cerebral palsy (CP),
- Head injury



Spinal cord injury (SCI) is a serious medical condition that causes functional, psychological and socioeconomic disorder. Individuals with SCI develop and experience a number of secondary health conditions as a result of having a SCI.

The most common secondary conditions are:

- Respiratory complications
- Cardiovascular complications
 - Orthostatic hypotension
 - Autonomic dysreflexia
- Urinary and Bowel complications
 - Bladder dysfunction
 - Neurogenic Bowel
 - Urinary tract infection
- Spasticity
- muscle atrophy
- Pain
- Pressure ulcers
- OSTEOPOROSIS AND BONE FRACTURES
- Depression

ParaCycle[®]

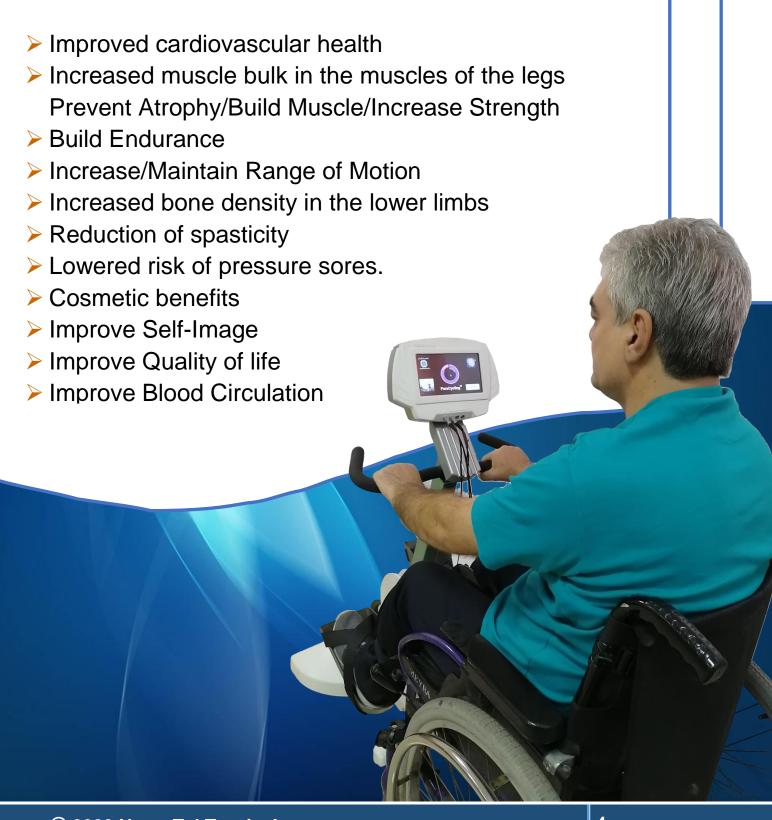
The ParaCycle is a new motor neuroprosthesis system that enables peoples with spinal cord injury, traumatic brain injury, Multiple Sclerosis (MS), cerebral palsy (CP), and stroke patients to have leg-cycling motion using functional electrical stimulation.

In the ParaCycle system, sequences of current pulses excite the intact lower motor neurons, which in turn contract paralyzed muscles. Activation of the lower motor neurons is achieved using electrodes placed on or near the innervating nerve fibers. By changing the parameters of the stimulation signal, the level of contraction can be altered to perform a specific task. To provide leg-cycling motion of the paralyzed limbs, an appropriate electrical stimulation pattern should be delivered to a set of muscles. In the ParaCycle system, an efficient control strategy generates appropriate stimulation signals which are delivered to the paralyzed muscle via surface electrodes.

The ParaCycle provides on-line monitoring of functional operation of the system and electrode lead connection, and appropriate visual and audible alarm indicate the fault condition.



CLINICAL BENEFITS USING PARACYCLE



PUBLICATIONS

- 1. E. Jafari and A. Erfanian, A Distributed Automatic Control Framework for Simultaneous Control of Torque and Cadence in Functional Electrical Stimulation Cycling, ," IEEE Trans. Neural Systems and Rehabilitation Eng., vol. 30, pp. 1908 1919, May 2022. DOI: 10.1109/TNSRE.2022.3188735.
- 2. A. Farhoud and A. Erfanian, "Fully automatic control of paraplegic FES pedaling using higher-order sliding mode and fuzzy logic control," *IEEE Trans. Neural Systems and Rehabilitation Eng.*, vol. 22, no. /3, pp 533-542, July 2022.
- 3. E. Rouhani and A. Erfanian, A Finite-Time Adaptive Fuzzy Terminal Sliding Mode Control for Uncertain Nonlinear Systems, *International Journal of Control, Automation, and Systems*, 2018.
- 4. V. Nekoukar and A. Erfanian, Dynamic Optimization of Walker-Assisted FES-Activated Paraplegic Walking: Simulation and Experimental Studies, *Medical Engineering & Physics*, vol. 35, pp. 1659-1668, 2013.
- 5. V. Nekoukar and A. Erfanian, "A Decentralized Modular Control Framework for Robust Control of FES-Activated Walker-Assisted Paraplegic Walking Using Terminal Sliding Mode and Fuzzy Logic Control," *IEEE Trans.* Biomed. Eng., vol. 59, no. 10, Oct. 2012, pp. 2818-27.
- 6. V. Nekoukar and A. Erfanian, An adaptive fuzzy sliding-mode controller design for walking control with functional electrical stimulation: A computer simulation study, *International Journal of Control, Automation, and Systems*, vol. 9, no. 6, 2011, pp. 2818-27.
- 7. H.-R. Kobravi and A. Erfanian, "A decentralized adaptive fuzzy robust strategy for control of upright standing posture in paraplegia using functional electrical stimulation, *Medical Engineering & Physics*, vol. 34, no. 1, Jan. 2012, pp. 2818-27.
- 8. V. Nekoukar and A. Erfanian, Adaptive fuzzy terminal sliding mode control for a class of MIMO uncertain nonlinear systems, *Fuzzy Sets and Systems*, vol. 179, no. 1, Sept. 16, 2011, pp. 2818-27.
- 9. H.-R. Kobravi and A. Erfanian, "A decentralized adaptive robust method for chaos control," *Chaos, American Institute of Physics,* vol. 19, 2009, pp. 033111-1, 033111-7
- 10. H.-R. Kobravi and A. Erfanian, "A decentralized adaptive robust control based on sliding mode and nonlinear compensator for control of ankle movement using functional electrical stimulation of agonist-antagonist muscles," *J. Neural Eng.* vol. 6, 2009, pp. 2818-27.
- 11. A. Ajoudani and A. Erfanian, "A neuro-sliding mode control with adaptive modeling of uncertainty for control of movement in paralyzed limbs using functional electrical stimulation," *IEEE Trans. Biomed. Eng.* vol. 56, no. 7, pp. 1771-1780, July 2009.
- 12. K. Misaghian and A. Erfanian, "Adaptive Neuro-Sliding Mode Control of FES-Cycling," 13th Annual Conference of the International FES Society, Freiburg, Germany, September 21-25, 2008.
- 13. A. Farhoud and A. Erfanian, "Higher-Order Sliding Mode Control of Leg Power in Paraplegic FES-Cycling," 32th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBS), Buenos Aires, Argentina, August 31-Sept. 4, 2010.
- 14. V. Nekoukar and A. Erfanian, "Adaptive Terminal Sliding Mode Control of Ankle Movement Using Functional Electrical Stimulation of Agonist-Antagonist Muscles," 32th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBS), Buenos Aires, Argentina, August 31-Sept. 4, 2010.
- 15. V. Nekoukar and A. Erfanian, "Optimal walking trajectories estimation using wavelet neural network for FES-assisted arm-supported paraplegic walking," 10th Vienna International Workshop on FES and 15th IFESS Conference, Vienna, Austria, Sept. 8-12, 2010.
- 16. A. Seyedi and A. Erfanian, "Reducing the upper body effort during FES-assisted arm-supported standing up in paraplegic patients," 10th Vienna International Workshop on FES and 15th IFESS Conference, Vienna, Austria, Sept. 8-12, 2010.

- 17. V. Nekoukar and A. Erfanian, Robust Closed-Loop Control of Walker-Assisted FES-Activated Paraplegic Walking Using Terminal Sliding Mode and Fuzzy Logic Control, 17th Annual International FES Society Conference, September 9-12, 2012, Banff, Albert, Canada.
- 18. A. Roshani and A. Erfanian, Influences of multielectrode stimulation and stimulation parameters on selective activation of motor pools in intraspinal microstimulation, 17th Annual International FES Society Conference, September 9-12, 2012, Banff, Albert, Canada.
- 19. H. Karimi Roozbahani and A. Erfanian, Dynamic Modeling of FES-Activated Walker Assisted Paraplegic Standing, 1th Basic and Clinical Neuroscience Congress, Nov. 7-9, 2012, Tehran, Iran.
- 20. A. Khorasani and A. Erfanian, Adaptive Neuro-Fuzzy Sliding Mode Control of Multi-Joint Movement Using Intramuscular Functional Electrical Stimulation, 1th Basic and Clinical Neuroscience Congress, Nov. 7-9, 2012, Tehran, Iran.
- 21. A. Roshani and A. Erfanian, Recruitment Properties of Intraspinal Microstimulation Using Pulse Amplitude Modulation and Pulse Width Modulation, 1th Basic and Clinical Neuroscience Congress, Nov. 7-9, 2012, Tehran, Iran.
- 22. A. Shabzendedar and A. Erfanian, Generating Motor Primitives Using Epidural Electrical Stimulation of the Spinal Cord, 1th Basic and Clinical Neuroscience Congress, Nov. 7-9, 2012, Tehran, Iran.
- 23. A. Roshani and A. Erfanian, "Fuzzy Logic Control of Ankle Movement Using Multi-electrode Intraspinal Microstimulation," 35th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBS), Osaka, Japan, July 3-7, 2013.
- 24. H. Karimi and A. Erfanian, "Adaptive Terminal Sliding Mode Control of Walker-Supported Standing in Paraplegia," 18th Annual International FES Society Conference, June 6-8, 2013, Donostia-San Sebastián, Gipzukoa, Spain.
- 25. A. Khorasani and A. Erfanian, "Higher-Order Sliding Mode Control of Multi-Joint Movement in Spinal Rats Using Intramuscular Functional Electrical Stimulation," 18th Annual International FES Society Conference, June 6-8, 2013, Donostia-San Sebastián, Gipzukoa, Spain.
- 26. A. Roshani and A. Erfanian, "A Fuzzy Logic Controller with Rule-Based Co-Activation Supervisor for Control of Ankle Movement Using Multielectrode Intraspinal Microstimulation," 18th Annual International FES Society Conference, June 6-8, 2013, Donostia-San Sebastián, Gipzukoa, Spain.
- 27. A. Shabzendedar and A. Erfanian, "Fuzzy Logic Control of Motor Primitives in Spinal Rat Using Epidural Electrical Stimulation of the Spinal Cord," 18th Annual International FES Society Conference, June 6-8, 2013, Donostia-San Sebastián, Gipzukoa, Spain.
- 28. A. Roshani and A. Erfanian, "A SMC-Based control framework for control of ankle movement using multielectrode intraspinal microstimulation," 19th Annual International FES Society Conference, Sept. 17-19, 2014, Kuala Lumpur, Malaysia.
- 29. E. Rouhani and A. Erfanian, "Adaptive fuzzy terminal-based neuro-sliding mode control of ankle-joint movement using intraspinal microstimulation," 19th Annual International FES Society Conference, Sept. 17-19, 2014, Kuala Lumpur, Malaysia.
- 30. S. H. Sadat-Hosseini and A. Erfanian, "Sliding Mode Control of Intramuscular Functional Electrical Stimulation Using Fuzzy Neural Network with Terminal Sliding Mode Learning," 7th International IEEE EMBS Conference on Neural Engineering, April 22-24, 2015, Montpellier, France.
- 31. E. Rouhani, and A. Erfanian, "Control of Intraspinal Microstimulation Using an Adaptive Terminal-Based Neuro-Sliding Mode Control," 7th International IEEE EMBS Conference on Neural Engineering, April 22-24, 2015, Montpellier, France.







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