



PROGETTO

Supervisore:

Albano Luigi

Titolo/*Title*: **Evaluation of spinal cord stimulation assisted by motor rehabilitation training for restoring motor function after spinal cord injury**

Curriculum: **Neuroscienze e Neurologia Sperimentale**

Link alla pagina personale del sito web di Ateneo o del polo ospedaliero di riferimento:

<https://www.hsr.it/dottori/luigi-albano>

Descrizione del progetto (max 3.000 caratteri spazi inclusi)

Background/gap of knowledge

Traumatic spinal cord injury (SCI) is one of the main causes of disabilities in people < 50 years of age. SCIs have devastating physical, social and vocational consequences for patients and their families, and a loss of independence mainly related to motor impairment and persistently increased lifelong mortality rates are the hallmarks of SCI. Therefore, the development of effective treatments becomes crucially important[1].

Rationale and hypothesis

Epidural spinal cord stimulation (SCS) has been a clinically approved technology for the treatment of neuropathic pain since the 1970s[2]. This therapy requires the implantation of a multielectrode array in the epidural space, between the spinal cord and the vertebral bone, to deliver continuous electrical pulses to the spinal cord. Just a few years after the first implants, a patient with partial paralysis due to multiple sclerosis receiving SCS to treat chronic pain regained volitional control of her lower extremities, facilitation of sitting, standing, and ambulation during stimulation[3]. Therefore, SCS was applied in SCI animal models and thereafter in a very limited number of individuals with incomplete/complete SCI [4-7]. Results were remarkable: after intense physical training associated with SCS, 6/8 participants were able to stand and walk on a treadmill or overground with a minimal level of support (walker, crutches, etc.).



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However, a clear understanding of how SCS works to restore motor functions in human is still lacking, since hypothesis have been drawn from clinical experience which, currently is limited. Moreover, long-term results in humans are currently lacking. This may explain why neuromodulation is not more widely applied to treat SCI.

We hypothesize that:

- 1) the combination of SCS and locomotor training will induce an immediate but also a long-term motor improvement in subjects with functionally complete/incomplete spinal cord injury;
- 2) Artificial intelligence algorithm based on clinical, neurophysiological and MRI features will provide high prognostication abilities in the treatment personalization.

Objectives and specific aims

- 1) To assess the short and long-term effect of SCS associated to motor rehabilitation on restoring motor function in SCI patients.
- 2) To investigate brain and spine plasticity and network reorganization to understand how SCS and training can be related to motor improvement.
- 3) To build an artificial intelligence model, based on clinical, neurophysiological, multiparametric brain/spine MRI and stimulation measures for the identification of the optimal treatment protocol.

Expected outcomes

After the combination of SCS and rehabilitation, SCI patients would improve motor impairment and would be able to stand and/or step independently after 6 months. This treatment might act on the multidimensional aspects of locomotion, like spasticity, pain, quality of life and sensation.

Competenze che deve acquisire lo studente (Max 600 caratteri spazi inclusi):

During the project the student will acquire the following skills:

- Understanding spinal cord stimulation devices, parameters and definition of protocols to obtain motor improvement.
- Interpretation and analysis of neurophysiological (electromyography/electroencefalography), kinematic and MRI (structural, diffusion tensor MRI, functional MRI) data in SCI patients.
- Understanding neurophysiological, kinematic and MRI modifications overtime and their correlations with clinical changes.
- Defining machine learning models to predict the most effective stimulation parameters for individual patients.
- Drafting of research reports and articles.



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Bibliografia (max. 15)

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2. Jackson, A. and J.B. Zimmermann, *Neural interfaces for the brain and spinal cord--restoring motor function*. Nat Rev Neurol, 2012. **8**(12): p. 690-9.
3. Cook, A.W. and S.P. Weinstein, *Chronic dorsal column stimulation in multiple sclerosis. Preliminary report*. N Y State J Med, 1973. **73**(24): p. 2868-72.
4. Seáñez, I. and M. Capogrosso, *Motor improvements enabled by spinal cord stimulation combined with physical training after spinal cord injury: review of experimental evidence in animals and humans*. Bioelectron Med, 2021. **7**(1): p. 16.
5. Gill, M.L., et al., *Neuromodulation of lumbosacral spinal networks enables independent stepping after complete paraplegia*. Nat Med, 2018. **24**(11): p. 1677-1682.
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