POLITECNICO DI MILANO

PhD in BIOINGEGNERIA / BIOENGINEERING - 41st cycle

THEMATIC Research Field: SPINO-PERIPHERAL NEUROMODULATION FOR POST-STROKE REHABILITATION: DEVELOPING NON-INVASIVE PROTOCOLS COMBINING TRANSCUTANEOUS SPINAL AND NEUROMUSCULAR ELECTRICAL STIMULATION

Monthly net income of PhDscholarship (max 36 months)
1400.0 In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	Stroke is one of the leading causes of long-term disability worldwide, leaving millions of survivors with persistent motor impairments. Despite intensive rehabilitation programs, recovery oftenremains incomplete, highlighting the urgent need for innovative strategies to enhance motor relearning. Neuromodulation has recently emerged as a promising therapeutic avenue, as it directlyinteracts with neural circuits to promote plasticity and restore function. Among these approaches, Spinal Cord Stimulation has shown particular potential, with epidural Spinal Cord Stimulation (eSCS) demonstrating the ability to facilitate voluntary movements and reduce spasticity in individuals with spinal cord injury (SCI). However, the invasiveness of eSCS limits its scalability and applicability. Transcutaneous Spinal Cord Stimulation (tSCS) represents a non-invasive alternative, capable ofactivating spinal networks and potentiating residual descending drive. When combined with functional training, tSCS has already shown beneficial effects in SCI patients, but its use in post- stroke rehabilitation remains largely unexplored.This doctoral project proposes to design and validate the first spino-peripheral neuromodulation protocol for post-stroke patients, combining tSCS with NeuroMuscular Electrical Stimulation(NMES). While NMES is widely used in stroke rehabilitation, its therapeutic potential is maximized only when combined with voluntary effort and functional movement. The

	simultaneous application of tSCS and NMES could engage both spinal and corticospinal circuits, creating synergistic effects that enhance neuroplasticity and motor recovery.
Methods and techniques that will be developed and used to carry out the research	The project is structured into three main objectives. First, computational modelling will be developed to simulate stimulation-induced electric fields, optimizing electrode placement andstimulation parameters to target spinal networks involved in gait and lower limb function. Second, pilot human studies in healthy volunteers and stroke patients will evaluate the safety, usability, andtolerability of combined stimulation protocols. Third, preliminary efficacy trials will test synchronized stimulation during functional tasks such as exoskeleton-assisted walking and cycling,with the goal of generating proof-of-concept data for improved clinical outcomes.The research environment offers ideal conditions for success. The NearLab at Politecnico di Milano provides advanced infrastructure and scientific background. The scholarship is funded and co-lead by Villa Beretta Rehabilitation Research Innovation Institute, they will enable clinical testing, while strong national and international partnerships with leading institutions in neuroengineering and rehabilitation ensure access to state-of-the-art expertise. By introducing a safe, non-invasive, and scalable neuromodulation protocol for stroke rehabilitation, this project aims to address an urgent clinical need, reduce the burden of disability, and open new perspectives in neuro-rehabilitation. At the same time, it will provide the doctoral candidate with a multidisciplinary training path in computational modelling, neurophysiology, and clinical rehabilitation, preparing her/him for future leadership in the neuromodulation field.
Educational objectives	- Neurophysiology, modelling and technologies for neuromodulation - Design of clinical trials; ethical procedures for ethical approval for clinical validation of MedTec technologies for neurorehabilitation - Conduction of experiments, data analysis and interpretation - Scientific communication (written and oral

	communication targetting conferences and journal publications)
Job opportunities	- R&D departments in MedTech industry (in Italy and abroad) - Post-doc positions in lab (in Italy andabroad)
Composition of the research group	2 Full Professors 3 Associated Professors 3 Assistant Professors 12 PhD Students
Name of the research directors	PROF. ALESSANDRA PEDROCCHI

Contacts
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Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents	--

Scholarship Increase for a period abroad	
Amount monthly	700.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
Educational activity: The student will be encouraged to attend to courses at POLIMI or abroad 2 / 3in International Schools. Teaching assistantship: There are various forms of financial aid for activities of support to the teaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations. Computer and desk availability: the student will be allowed to access facilities of the DEIB.