Neurophysiological and neuropsychological correlates of gait in stroke survivors' rehabilitation: towards an integrated exoskeleton device for gait rehabilitation

Abstract

This proposal builds on the need to train a new generation of researchers with interdisciplinary skills to spearhead innovation in robotic neurological rehabilitation. PhD students will be tasked with the development of neurophysiological and neuropsychological modelling of correlates of robotic gait training in stroke survivors. This will be in the framework of a larger H2020 funded project aimed at prototyping a device with integrated EEG/EMG feedback and feedforward for stroke rehabilitation.

This will be obtained by an iterative, progressive process in which PhD individual projects dovetail each other. An ongoing project will provide data on the current state of the art in EEG/EMG modelling of post stroke gait by systematic review and metanalysis, and 3D modelling of gait as visualized gait analogue. PhD students will collect and model co-registered EEG-EMG over-ground gait and robotic walking in healthy participants and stroke survivors, defining the neurophysiological correlates of gait. The development and testing of virtual reality BCI gait training device and prototype integration with robotic software platforms will be a subsequent step run in collaboration with an international consortium. Thorough neuropsychological testing will personalize stroke survivors rehabilitative program; re-testing at trial end will provide insight into the interwinded effects of motor function restoration and cognitive recovery in stroke. EEG will be analyzed with advanced techniques to explore neurophysiological correlates of cognitive recovery.

The aims of the project are:
1. To advance the understanding of neural correlates of gait building on expertise in EEG/EMG analysis and 2D/3D limb movement trajectory decoding by multi-modal integration of bio-signals;
2. To explore the interdependency of motor and cognitive recovery in stroke survivors and **identify neurophysiological signatures** of this phenomenon.
3. To integrate EEG/EMG data into a bio-signal processing platform, to obtain **a robotic prototype with entrained EEG/EMG for personalised gait rehabilitation.**

REFERENCES (Max 5):

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Formaggio E, Masiero S, Bosco A, Izzi F, Piccione F, Del Felice A. Quantitative EEG Evaluation During Robot-Assisted Foot Movement. IEEE Trans Neural Syst Rehabil Eng. 2017:1633-1640.

Masiero S, Armani M, Ferlini G, Rosati G, Rossi A. Randomized trial of a robotic assistive device for the upper extremity during early inpatient stroke rehabilitation. Neurorehabil Neural Repair. 2014;28:377-86.

Rosati G, Gallina P, Masiero S. Design, implementation and clinical tests of a wire-based robot for neurorehabilitation. IEEE Trans Neural Syst Rehabil Eng. 2007;15(4):560-9.

PARTICIPANTS (PI and co-PIs):

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EXPERIMENTAL DATA:

To be acquired	X
Already acquired (ready to be used)	X

Participant recruitment: 20 healthy age matched volunteers will be recruited. 30 stroke survivors will be recruited at the in-patient rehabilitation wards.

Data collection:

EMG: Following orientation and familiarisation with the robotic gait procedure (EKSO Bionic Inc, Richmond, USA), EMG (Nautilus, G.Tec, Graz, A) signals from 8 predetermined LL muscles will be recorded during independent over-ground 10 meter walk test (10MWT) and during two 10MWT in full passive robotic mode. EMG will be collected by non-invasive surface electrodes applied on targeted muscles as in routinely clinical practice.

EEG: 64 channel EEG (Nautilus, G.Tec, Graz, A) will be simultaneously and non-invasively acquired during gait with synchronized EMG.

Neuropyschological testing: a testing battery investigating executive, visuospatial and memory functions will be administered to healthy volunteers in a single session and to stroke survivors before, to adjust training tasks level, and after a two weeks robotic training period.

Timeline: in the first six months after enrolment, first student will submit EC request, scope the literature and familiarize with the equipment. After month 8 (PhD1) or at month 3 (subsequent student), data from healthy volunteers will be collected during a single session (over-ground and robotic walking with EEG-EMG co-registration, neuropsychological testing). Data from stroke survivors will be collected before and after a 2-weeks gait rehabilitation program with exoskeleton. Data analysis will we be ad-interim and at collection end.

Equipment: already present @UNIPD. 64 EEG channels EEG is provided by G.tec in the framework of the funded project. A wireless 16 channels EMG (Cometa, IT) is part of the instrumentation of the Laboratory of Clinical Analysis and Biomechanics of Movement of the University Hospital of Padova, section of Rehabilitation. EKSO esokeleton is already in use in an affiliated facility of the Rehabilitation Unit of the University of Padova.

ETHICS COMMITTEE:

Obtained	
Conditioned submission*	Expected time response (in months): 4
Not required	

* request will be submitted only if a PhD student will be associated to the project