GAIT REHABILITATION STUDY PROTOCOL IN PATIENTS WITH LOW SPINAL CORD INJURY USING ABLE EXOSKELETON

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INTRODUCTION

The Spinal Cord Injury (SCI) is a catastrophic clinical event that, according to the National Spinal Cord Injury Statistical Centers' estimations (NSCISC), has an annual incidence of approximately 54 cases per million people in the United States (1). As for the local statistics, it is known that SCI affects around 24 cases per million in Spain (2) while in Catalonia it is reduced to and 12 cases per million people (2). This clinical event entails an important functional loss and reduced independency challenging the SCI population to adapt to a new life.

As a result of the mentioned lost functions, after an SCI most of the individuals will require a rehabilitation process before reengaging their social and leisure activities to create new movement strategies, in order to either compensate or substitute them. Upper extremity ability and dexterity training contributes to the individuals' independence during the Activities of Daily Living (ADL) and prevents the deterioration of the musculoskeletal system. On the other hand, training the walking ability is crucial to solve the general health issues triggered by the newly acquired sedentary life (such as osteoporosis, chronic pain, pressure sores, muscle spasms and cardiovascular, digestive and urinary problems). Keeping this on mind, rehabilitation after an SCI appears to be crucial in order to regain independence and enhance quality of life.

Many beneficial therapeutic options are being used at the moment for that purpose, and knowledge on the nervous system is growing every day, but there are still plenty of possibilities to study and numerous neurological processes we still do not fully comprehend. One of these processes is the neural plasticity of the central nervous system (CNS).

For the purpose of developing a task-specific, intense rehabilitation program, neurotechnologies can be the best approach towards gait recovery. During the last decade plenty of research on robotic gait training has emerged in order to assist both individuals with neurological conditions and clinicians to improve gait therapy and its results (3). Likewise, robotic exoskeletons constitute a clear example of neurotechnology applied to rehabilitation and assistance (4). Nowadays there are four wearable exoskeletons on the market: Ekso (Ekso Bionics, US), Rewalk (ReWalk Robotics, IL), Hank (Gogoa, SP), Indego (Parker-Hannifin, US) and Rex (Rex Bionics NZ). Nevertheless, the majority of the commercialized exoskeletons' models tend to cover most of the key points of the gait pattern on one device (such as trunk control, hip stability, knee flexion and ankle propulsion) in order to develop a universal solution. While doing so, they forget a wide range of SCI individuals who may not need such assistance and also create hardly affordable and unnecessarily bulky devices.

In order to help develop accurate solutions to assist the neurorehabilitation of the SCI, technical engineers and clinicians need to work hand to hand. Physical therapists' experience with gait rehabilitation, knowledge of the neurophysiology of the injury and human biomechanical functioning become the most suitable complement to the daily work of the engineers while developing a new device for gait assistance.

Resulting from this cooperation, a specific lower extremity powered exoskeleton prototype has been developed to assist gait training to paraplegic individuals below the tenth thoracic vertebra, called ABLE. The developed prototype consists of three modular components: an actuation system at the knee imitating an external muscle, an IMU sensor responsible of the intention of step

detection and the electronics and power supply (5). All components are located on the external side of the leg within a light and discrete design attached to the patients' orthoses. Through the inertial measurement unit (IMU) sensors, ABLE detects the stance-to-swing transition during gait and thanks to the motors it provides a personalized knee flexion-extension.

The aim of this master thesis is to define the protocol for a multicentric clinical study with SCI subjects including ABLE exoskeleton in their rehabilitation program. In order to do so, a description of the spinal cord anatomy and the rehabilitation of its injury will be presented, together with a state-of-the-art exoskeleton review including a description of their main features and clinical trials analysis.