HAL Exoskeleton Training

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Abstract—The hybrid assistive limb (HAL) exoskeleton provides rehabilitation of the motor skills of chronic spinal chord injury (SCI) patients as well as alleviation of chronic neuropathic pain (CNP). The HAL device uses bioelectric signals to activate robotic support of voluntary movement during bodyweight supported treadmill training (BWSTT).

I. INTRODUCTION

Chronic spinal chord injury causes patients to lose various levels of locomotive ability depending on severity. These injuries require extensive rehabilitation in order to achieve neurological recovery. Severe SCI can sometimes include lesion of the central nervous system, causing patients to experience chronic neuropathic pain (CNP). CNP is a neuropathic pain, not a muscular-skeletal pain and has proven to be treatment-resistant in most cases. Attempts to treat this pain have included both pharmacological and non-pharmacological methods. Conventional methods for SCI rehabilitation limit the recovery to only that of functional motor skills and do not improve ability to support body weight for walking. Fortunately, studies on BWSTT with the HAL exoskeleton show that this new method has the ability to recover the patients’ locomotive skills, and has even proven successful in alleviating CNP. [1]

II. METHODS

One study was done on 10 participants with chronic SCI, two of whom suffered from CNP. BWSTT sessions were done 5 days per week for 12 weeks. The two CNP patients were given a SF-36-questionnaire (SF-36) at the baseline and at the end of the 12 weeks in order to assess health related quality of life (HRQoL). The weekly average of severity of pain (SP) was assessed by averaging the 5 numerical rating scale (NRS-11) taken before each training session in a 1-week period. The values of the means ±standard deviation for 30-minute functional testing assessed mobility through a 10-meter walk test with no exoskeleton as well as the walking distance on the treadmill with the exoskeleton. [1] Another study consisted of a 12 week intervention with BWSTT sessions conducted 3 days per week for 4 participants and the results were assessed via walking index for spinal chord injury II (WISCI II) as well as fMRI scans. [2] Additionally, a third study of a 90-day (5-day/week) measured lower extremity motor score (LEMS) by adding impairment scores (0-5) of lower extremity key muscles. [3]

III. RESULTS

Both patients with CNP experienced decrease in pain severity (NRS) resulting in decrease in mandatory baseline medicine intake, which is shown in the left figure show below. [1] In the second study, fMRI results display a major correlation with activation of the cortical and cerebellar and the improvement in locomotive ability in the patients. [2] The third study exhibited increased in speed and endurance as a result of the treadmill training paired with HAL exoskeleton, which is displayed via lower extremity motor scores of patient 1 in the figure on the right shown below. [2]

IV. DISCUSSION

The results from the three different interventions show strong implications that the locomotive training with the HAL exoskeleton significantly improve speed, gait, and distance for over-the-ground walking. However, more research is needed in order to determine whether cortical regeneration can occur as a result of this training. [1] In addition, there was a reduced need for walking assistance and increased muscle strength. However, the number of patients was not large enough to show definite evidence and there was an inconsistency in severity regarding whether the injury was an complete or incomplete SCI. [2] The fMRI images suggest a correlation between the increase in cerebellum activation and the improvement of walking ability. Unfortunately, there are various factors that could affect cerebellar activation making it not yet possible to prove the validity of this hypothesis. [3]

In conclusion, BWSTT with the HAL exoskeleton is a promising method for chronic SCI patients to recover locomotive ability as well as decrease CNP, and more research is needed to further validate its abilities.

REFERENCES