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Hand Glove FES Device (Re-Grasp) in Neurological Patients Affected by Upper Limb Disability

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Abstract

Background: Severe neurological diseases are characterized by upper limb limitations especially related with motor weakness and spasticity. The aim of neurorehabilitation is increasing upper limb ability to help patients improving activities of daily living.

Methods: We explore the effects of a hand Glove FES Device (ReGrasp) in patients affected by different types of neurological disorders. We measured the Functional Independence Measure (FIM) and the Ashworth scale to assess mobility and spasticity at admission and after 4 weeks of treatment.

Results: Eight patients were consecutively admitted in our rehabilitation unit (Mean age: 45; M/F 5/3) suffering of Stroke (2 patients), Spinal Cord Injury (5 patients), and 1 patient affected by Multiple Sclerosis, have been treated using a FES hand glove for a mean time of 30 minutes three times per week for 4 weeks in our Occupational Therapy Program. After training we observed a reduction of spasticity using the Ashworth scale. We found improvement of wrist movement in patients affected by Stroke or Spinal Cord Injury with a reduction of 21% from admission to discharge. The FIM did not have a significant improvement considering the total score. Focusing on single items we found improvement of feeding process of about 14%, and transfers improved about 15%.

Conclusion: The use of FES hand glove is feasible and easy to use in different neurological patients. Considering the general improvement, the reduction of spasticity can be reflected by an improvement of single aspects of daily living like feeding and transfers, ameliorating the life of our patients.

Keywords: Spasticity; Rehabilitation; Hand glove

Introduction

After MIT Manus robotic studies, robotic rehabilitation has been largely studied to restore loss of motor function on upper limb paresis. Multiple studies suggested that robot-assisted training integrated into a multidisciplinary team resulted in reduction of motor impairment compared to usual rehabilitation [1,2]. Although stroke is the leading cause of disability and considering that 20% of patients present an upper limb deficit, many other studies showed robotic rehabilitation applied to upper limb in many other neurological diseases. In fact, the scientific literature about Multiple sclerosis and Spinal cord injury described a good recovery of arm motor function using technology, considering the enhancement of neural plasticity [3,4]. However, robotic rehabilitation is effective considering some factors, such as the frequency and intensity of training sessions, the use of feedback [5,6] and the possibility of using assist-as-needed algorithms, that allows the right quantity of assistance based on the patient's motor performance [7]. Several studies on the efficacy of robot-mediated rehabilitation on upper limb paresis in stroke have shown an increase in motor function, especially in the segment of the limb treated with robots in acute, sub-acute and chronic patients [8-11]. In particular, there is an improvement in functional reach and grasp movements, flexion of the forearm and abduction of the shoulder. Furthermore, these studies also revealed a significant reduction in spasticity in subjects treated with robotic rehabilitation compared to those treated with traditional methods [12]. This aspect is very important because spasticity is a significant complication that can interfere with motor recovery of the upper limb. It's important to maximize the active participation of the patients in order to induce neural plasticity, necessary for motor recovery Blank et al. [13], as demonstrated in studies on the efficacy of robot-mediated rehabilitation on upper limb in Multiple sclerosis, showing an improvement of upper limb coordination, manual dexterity, arm kinematics, functional abilities and reduced muscle tone [3]. The results of studies on robotic rehabilitation of upper limb in spinal cord injury patients are controversial [13]. The spinal cord injury can result in partial or complete paralysis of arms, wrists and finger and the severity of the paralysis depends on the location of the lesion, therefore the effects of neurorehabilitation may depend on the severity of the impairment. Some of these, for example, demonstrated small positive effects of robotic therapy on the recovery of arm motor function [14]. On the other hand, other studies asserted that the use of technology in rehabilitation program significantly reduces motor disorders and improves functional abilities and quality of life of the patients [15,16]. In conclusion, robot mediated-rehabilitation in patients with upper limb paralysis allows satisfactory benefits in the recovery of motor deficits because the robotic devices are able to

provide highly, repetitive, intensive, reproducible and challenging movement-based treatments that stimulate the mechanisms of neuronal plasticity and reduced the spasticity [2]. We aimed to study the effect of new hand glove "ReGrasp", in patients affected by different neurological disease, targeting activities of daily living and spasticity.

Methods

Patients consecutively admitted in our Neurorehabilitation Unit have been affected by different neurological disorders. Patients were evaluated by a neurologist recording the clinical aspects and were administered neurological scales at admission and at discharge. We used two different scales: The Functional Independent Measure (FIM) and the Ashworth Scale. Patients underwent rehabilitation program of the upper limb using the ReGrasp System (Rehabtronics Inc.) (Figure 1). ReGrasp is an intuitive FES hand device to improve hemiparetic upper extremity function, stimulate the muscles, prevent disuse atrophy, and reduce muscle spams. The use of the device requires positioning pads on the inside of the arm sleeve so as to properly target flexors, extensors, and thumb muscles. It's possible to modulate separately the intensity of opening and closing of the hand and thumb and select the exercise. An outside controller can be used to dictate when to open or close the hand. FES regulates stimulation of hand opened and hand closed. Exclusion criteria of the device's use are: open wound, rash or skin infection; swollen or inflamed area, presence of pacemaker or metal objects and diminished sensation. All of the patients completed the training using the FES hand glove, three times per week for 30 minutes for 4 weeks in our Occupational Therapy Program. We calculated the percentage of variation (Δ%) of FIM and the Ashworth Scale with IBM SPSS Statistics 20.0 to verify the differences between the score of patients at admission and at discharge to corroborate the effect of the rehabilitation program of the upper limb using the ReGrasp System.

Figure 1: ReGrasp device.

Results

We enrolled eight patients (Mean age 45 years; Male/Female 5/3) consecutively admitted in our Neurorehabilitation Unit. Five patients were affected by Spinal Cord Injury, one sustained a haemorrhagic stroke, one ischemic stroke and one suffered of Multiple sclerosis (Table 1).

Mean Age: 45	
Male/Female:5/3	
Patient	**Aetiology**
1	Spinal cord injury
2	Spinal cord injury
3	Multiple sclerosis
4	Spinal cord injury
5	Haemorrhagic Stroke
6	Spinal cord injury
7	Ischemic Stroke
8	Spinal cord injury

Table 1: Characteristics of patients.

Comparing the mean value obtained by patients in each item of the Ashworth scale, there are differences from admission with respect to the discharge only in the hand function, especially focused on wrist movements, where we found a reduction of spasticity of 21% with respect to admission (Figure 2). We didn't find any differences between shoulder and elbow.

Figure 2: Variation of the mean values obtained by patients using the Ashworth scale showing the reduction of spasticity between pre-training and post-training.

Regarding the FIM scale we did not observe a significant general improvement although patients had an improved score with respect to admission of about 2%. Focusing on single items we found an improvement of feeding process (14%), bed/chair/wheelchair transfers (15%), toilet transfers (6%), locomotion regarding walking/wheelchair (3%) and stairs (6%) (Figure 3).

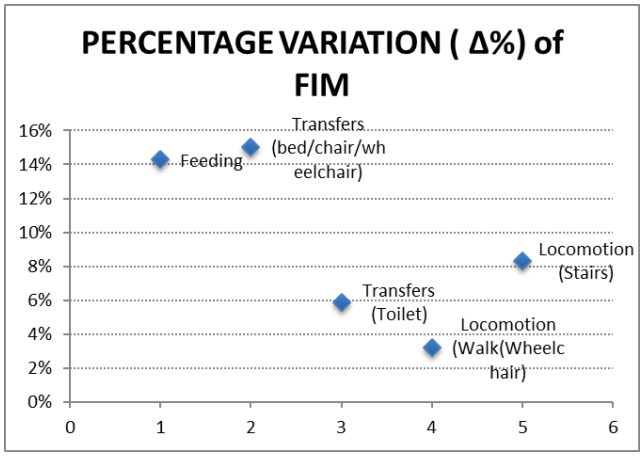

Figure 3: The percentage (%) of improvement shown by patients in items of the FIM scale after training with respect to admission.

Discussion

"ReGrasp" is a hand glove FES device which has demonstrated to be feasible and easy to use in patients with different aetiologies. Comparing with traditional therapies, the robot-assisted rehabilitation has the advantage of providing a greater number of repetitive movements, and therefore increasing somatosensory inputs to the paretic limb [17]. The results of the study showed the effectiveness of the upper limb rehabilitation treatment with ReGrasp to reduce the spasticity and improve the functional abilities in patients affected by Stroke, Spinal cord injury and Multiple Sclerosis. In particular, the reduction of spasticity is especially related with wrist movements, but no changes occurred in the muscle tone of the elbow and shoulder. This result is consistent with previous studies that have demonstrated a reduction of muscle tone and an improvement of motor function, especially in the segment of the limb treated with the robot device [9-11]. ReGrasp is a glove device that offered an intensive, repetitive and functional stimulation of the muscles of the hand, using functional electric stimulation, providing a possible explanation of the specific improvement of wrist movements. In fact, FES device allows to induce muscle contractions and joint movements that are not possible to practice with conventional therapy in patients affected by upper limb paresis, also improving the motor function and the muscle strength by activating the neuronal plasticity, necessary for motor recovery [18].

Moreover, the reduction of spasticity and motor deficits of the upper limb can be reflected in an improvement in the patients' functional ability. Upper limb motor deficits have a negative impact on patients' autonomy and independence, considering that the upper limb is implicated in numerous daily life activities, such as eating, dressing, washing, moving, and manipulating objects [19]. The results, in fact, showed a reduction in disability and an improvement in some aspects of daily living, like feeding and transfers, in which upper limb movements are involved, especially those of the wrist. We concluded that the rehabilitation made by ReGrasp FES hand glove, leading to a reduction of spasticity and the improvement of motor function of the upper limb, had positive effects on the ability of daily life and self-care. Our study highlights the relevance of using FES hand glove device in reducing the restriction on the autonomy and improves the quality of life of neurological patients affected by different aetiologies.

Our study has some limitations, such as the absence of a control group, the lack of randomization, a small sample size and the duration of the treatment. We should also consider the bias related with the heterogeneity of our patients.

Several studies have shown that greater motor recovery is achieved through intense, specific, functional, long-lasting and highly repetitive training, exploiting an explicit learning mechanism based on principles of neural plasticity [2,20]. Our future aim is to extend the duration of the treatment in order to increase the training and practice, promoting the recovery process of the upper limb, and consequently, the independent execution of ADL's. In future study we will also include a follow up to investigate the duration of outcome after discharge of patients, and to determine the maintenance of goal achieved on everyday life.

Conclusion

In conclusion, rehabilitative treatment of the upper limb with the ReGrasp FES hand glove device is effective in patients with different neurological aetiologies, is easy to use in patients with different levels of upper limb disability and can be used in different rehabilitation settings also thinking about a future use at home.

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