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PORTABLE ASSISTIVE GLOVE TO FACILITATE HAND REHABILITATION

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Abstract

Stroke patients often have flexor hypertonia and finger extensor weakness, which makes it difficult to open their affected hand for functional grasp. Because of this impairment, hand rehabilitation after stroke is essential for restoring functional independent lifestyles. The goal of this study is to develop a passive, lightweight, wearable device to assist with hand function during performance of activities of daily living. The device, HandSpring Operated Movement Enhancer (HandSOME), assists with opening the patient's hand using a series of elastic cords that apply extension torques to the finger joints and compensates for the flexor hypertonia. Device design and calibration are described as well as functional and usability testing with stroke subjects with a wide range of hand impairments.There was some decrease in grip strength with the HandSOME device at the subject's ideal setting.Overall HandSOME shows promise as a training tool to facilitate repetitive task practice for improving hand function in stroke patients. HandSOME can be used as part of a home-based therapy program, or as an orthotic for replacing lost function.

Keywords: stroke; Hand rehabilitation; recovery time; Microcontroller.

1. INTRODUCTION

Stroke has significant detrimental effects on motor function in the affected limbs. At three months poststroke, only 12% of stroke survivors report no difficulty with hand function and 38% of survivors reported major difficulty with hand function[1]. In stroke survivors, hand function is often lost due to flexor hypertonia (increased resistance to passive finger extension) and weakness in finger extensors. Unfortunately, reasonably precise motor function of the hand is necessary to perform. activities of daily living (ADL) and thus stroke patients are often very dependent on compensatory strategies. The goal of this study was to develop a lightweight, passive, wearable device that assists with hand function during performance of ADL. The long term goal is to incorporate this device into a home-based training protocol for stroke survivors. Repetitive use of the affected limb is an effective way to improve motor function [2]. As a result, many devices have been created to assist with hand movement and therapy. Available hand rehabilitation devices vary greatly in structure and mechanical properties but all have the general purpose of assisting with finger extension. The majority of devices currently on the market are active systems powered by electric or pneumatic motors. This leads to an increased device weight due to the inherently large weight of motors and power supplies relative to the weight of the human hand. These factors prevent current active systems from being used during ADL task training with stroke survivors, where proximal arm weakness is common. Many of these actively actuated devices utilize internal grasp structures [3]–[5], but this diminishes the possibility of use with real world objects, and can limit range of motion (ROM). Most of the current actively powered external grasp devices are exceedingly bulky and limit the type of grasp and hand orientation that can be used for task practice (see [6] for a complete review). The passive (nonpowered) hand device field is relatively small, although several passive arm rehabilitation devices have been developed to aid with stroke recovery. These devices provide arm weight compensation using overhead pulley systems [7], [8], spring-based arm orthotics attached to wheelchairs [9], [10], and passive exoskeleton rehabilitation devices [11], [12]. The Saeboflex is an example of a passive hand rehabilitation device that has been successful in assisting with opening the grasp of stroke patients and is commonly used for tone management therapy [13]. However, this device is not intended for functional grasp of diverse objects, as it was designed only for picking up objects 3–4 in diameter and smaller objects cannot be grasped. The springs that are connected to the distal phalanx of each finger provide increasing force with increasing finger flexion, which makes it difficult to obtain and maintain full flexion even with low force springs, limiting ROM. Another passive hand device used for motor training is a cable driven orthotic by Fischer et al. [14]. However, this device requires the subject to use shoulder and elbow movement to assist with finger extension, which decreases the ability for normal movement kinematics in reach and grasp task training.

We have developed the Hand Spring Operated Movement Enabler (HandSOME), a passive, lightweight hand rehabilitation device that overcomes many of the limitations of current devices. HandSOME provides a large ROM and allows grasp of both small and large real world objects in even severely impaired subjects. This was accomplished by basing the design on the biomechanics of the hand after stroke. Kamper et al. examined the torque required to extend hypertonic finger joints and found a nearly linear relationship between metacarpophalangeal (MCP) joint extension angle and applied extension torque.

2. EXISTING SYSTEM

A human–exoskeleton interface was also presented to show the feasibility of CAREX on human subjects. The goals of this paper are to 1) further address issues when CAREX is mounted on human subjects, e.g., generation of continuous cable tension trajectories.

2) demonstrate the feasibility and effectiveness of CAREX on movement training of healthy human subjects and a stroke patient. In this research, CAREX is rigidly attached to an arm orthosis worn by

human subjects. Traditional rehabilitation suffers from aplenty downfalls, they are costly and time consuming. Robotic rehabilitation has the potential to be a better substitute. Recent evidence suggests that there is a pressing need to employ the patient muscle effort to control the assistive robot, otherwise the patient may fully depend on the robot, and this leads to slackness and deteriorated muscle functionalities**.**

Fig 1. User wearingCAREX.

3. PREVIOUS WORK

Some of research works carried out for monitoring the Stroke patients often have flexor hypertonia and finger extensor weakness, which makes it difficult to open their affected hand for functional grasp and methods were used past discussed in this section. A portable and wearable upper limb exoskeleton device

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attached to the patient's arm which assists the elbow flexion and extension motion for rehabilitation. This can be achieved by using an accelerometer and a string-motor mechanism. The goal of this study is to develop a passive, lightweight, wearable device to assist with hand function during performance of activities of daily living.

4. PROPOSED SYSTEM

The device is attached with the patient's arm to assist the flexion-extension of the elbow joint. This is achieved by using an accelerometer and a string-motor mechanism. The accelerometer is placed on the caliper that monitors the patient's initial effort by measuring the partial angular bending. When the patient effort stops, the band motor system assists to attain the given range of motion. The assist level (the support level) of the device can be decided for each patient based on rehabilitation phase.

5. BLOCK DIAGRAM

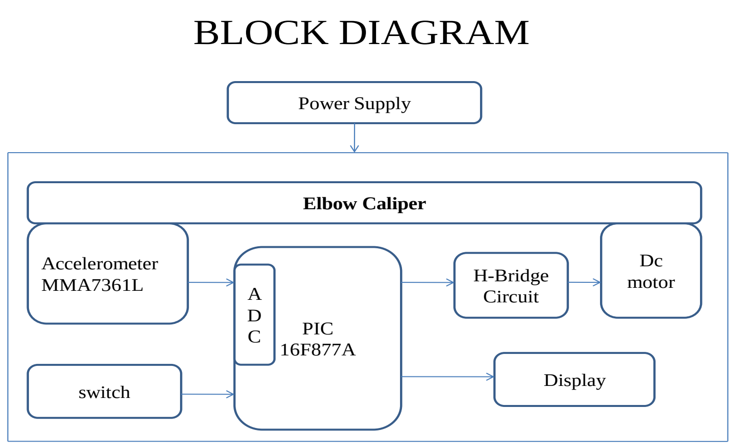

Fig 2.Block Diagram of Proposed System

6. RESULT AND ANALYSIS

Eight stroke subjects with a relatively wide range of functional ability were tested. The subject feedback on the Hand-SOME device was positive. Subjects commented that the device was generally comfortable and did not have any pressure points. Subjects produced smooth movements in the device both in flexion and extension although the time for the extension movement was much larger than for flexion. In flexion, subjects peak velocity increase fromshowed a significant degrees per second with the degrees per second with theunassisted hand to HandSOME device. Velocity in extension also increased

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from degrees per second with the unassisted hand to degrees per second with the HandSOME deviceand this difference approached significance shows the ROM data of a single representative subject. The goal of the block lifting task was to determine if using HandSOME increased the size of the largest object that could be lifted while not impairing the ability to lift smaller objects that subjects could already lift unassisted. Group analysis found that using the HandSOME device increased the size of the largest .All subjects had im-block that could be lifted provements in the functional block testing with the HandSOME.

Fig 3.Displayed Output For Hand Rehabilitation

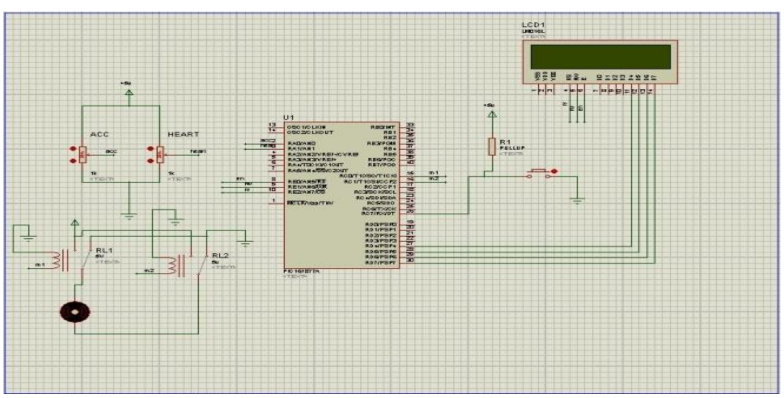

Fig 4.Stimulation output for Hand Rehabilitation

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CONCLUSION

HandSOME can assist stroke survivors with hypertonia to regain functional grasp ability. The newest version of the device has very low weight, which should allow for arm transport with the device and ADL use even in subjects with shoulder weakness. In summary, the general benefits of the device are:1) passive, lightweight, wearable hand rehabilitation device, 2) small device profile with no internal grasp structures for use in ADL, 3) a linkage for improved coordination of the fingers and thumb, 4) allows for nearly full ROM in pinch-pad grasp, and 5) adjustable torque profile and magnitude to best match the subject's hypertonia for accurate and optimal compensation. Subjects showed large increases in active ROM with the device as well as increased ability for functional grasp of objects. This improved ability should help encourage stroke survivors to use the affected limb in everyday activities, which may lead to improvements in hand function without the device. Future efforts will examine the ability of stroke patients to independently don the device, develop a method for finer adjustment of assistance magnitudes, and explore the device's potential use in the home environment. For home use, we envision a training program based on a version of HandSOME that has a wireless sensor recording movement and a game interface to further motivate practice. Whether or not using the device provides added value over an equivalent amount of practice without the device is an empirical question that will have to be answered in future studies. However, given that the device can potentially be very inexpensive, justification for its use might be based solely on its role as a motivator for increasing home practice.

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