FINGER TRAINING ROBOTIC DEVICE (FTRD)

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ABSTRACT

A vast majority of people with significant stroke and significant disorders such as weakness and spasm have experienced severe impact on their daily activities. To evaluate hand performance, there are few criteria that are needed. The goal of this project with Finger Training Robotic Device (FTRD) is to help people with finger and hand disabilities to recover faster and to gain back their ability of finger movement. With robotic devices, rehabilitation can be increased in intensity and frequency, standardized, and provide a controlled multisensory stimulation to help patients move as they need while avoiding inappropriate movements.

Key Words :*Hand Recovery, Rehabilitation Robotics, Stroke, Finger Movements*

1. Introduction

Most stroke patients develop significant disorders such as weakness and spasticity that have a severe effect on their daily activities. The ability to perform Daily Life Activities (DLA) is highly dependent on hand function, and those who suffer from hand injuries are less able to perform DLA and thus reduce their quality of life. In severely ill patients, the injured hand often has difficulty along the fingers and no marked improvement over time, which makes restoring hand function one of the biggest challenges in stroke rehabilitation. Rehabilitation of finger function after stroke has changed significantly in recent decades. Robotic devices allow to increase the amount and intensity of treatment, standardize treatment, provide a complex but controlled multisensory stimulation. It helps the patient to perform the required task and at the same time prevent inappropriate movements.

2. Materials and Methods

Finger Training Robotic Device (FTRD) is an effective mechatronic robotic device that is specifically designed for hand treatment (Fig. 1).

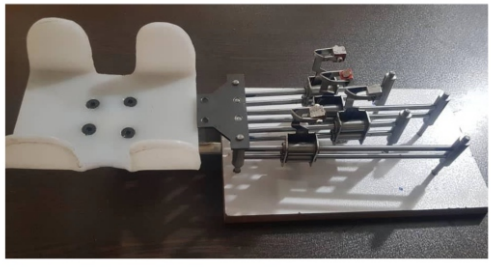

Fig. 1: Finger Training Robotic Device

It measures the patient's isometric strength for each finger separately as well as the strength of the hand. Furthermore, it improves finger or hand strength and reduces spasms. Thus, patients can regain a normal range of motion in their hands as much as possible. This robot can be used for various types of hand disabilities that have been described as follows.

2.1. Cerebral Palsy

This physiotherapy program is designed to help people with cerebral palsy control hand stiffness, perform voluntary movements, and prevent hand deformity with this device and physiotherapy knowledge.

2.2. After Hand Surgery

This device can be used to perform physiotherapy and rehabilitation after hand surgeries.

I Upper limb repair and transplant surgery:

Repairing and transplanting damaged nerves in the upper limbs, including the arm and shoulder, caused by stretching, tearing, stabbing, and similar injuries.

II Tendon repair and transplant surgery:

I For tendon repair and transplant surgeries (Tendon Replacement), physiotherapy is essential for quickly returning to pre-injury activities, moving limbs, and preventing premature adhesions.

III Fractures of the hands and fingers:

To improve the range of motion and opening of the fingers, return muscle strength to grasp objects, and improve the range of motion of the fingers after fractures of the hands or fingers, physiotherapy is required.

2.3. Paralysis of One or Both Sides of the Body, Stroke, and Brain Injury

These diseases lead to a loss of muscle control (Ataxia), laxity, and in many cases excessive stiffness, which results in unintended side effects, including reduced functionality, limited range of motion, and side effects.

Review of the purposeful movements of the mechatronic rehabilitation system for fingers and wrists (Fig. 2) [1].

I Radial deflection/wrist ulnar
II Bending/stretching the wrist
III Bending/stretching fingers
IV Forearm pronation/supination

3. The Main Parts of FTRD

Different parts in FTRD system are included as (Fig. 3):

1) Finger holder steel sheet

2) Finger holder magnet
3) Double-sided rail holder
4) Power transmission belt controlled by a stepper motor
5) Longitudinal motion guide
6) Step motor for each finger

I) Each of the mechanisms is used individually for each finger

II) FTRD has 6 servomotors - left and right hand

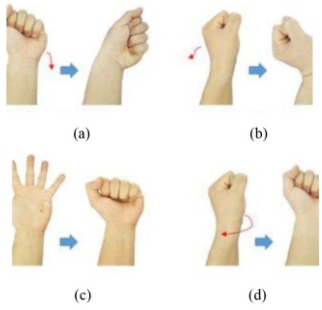

Fig. 2: a) Ulnar Deviation; b) Extension of wrist; c) Flexion of fingers; d) Supination

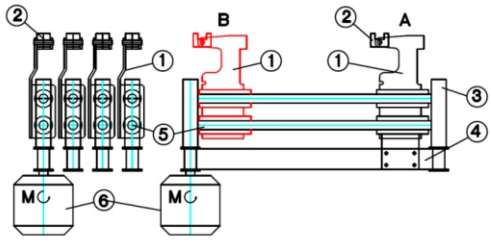

Fig. 3: Main Parts of FTRD

This device is designed so that a servomotor can control each movement mechanism at different speeds. It also has a reciprocating motion in the form of a rail and movement (guide bar and sliding liner). Each of the fingers of the device is moved by a mechanism that, by way of an independent servomotor, converts the pulley rotational motion into a reciprocating linear motion that causes the fingers to move. For each finger movement, a mechanism is designed that is converted to a reciprocating linear motion by a Foley-era servomotor, causing the fingers to move. With the PLC- programmable system of this device, each finger can get the desired amount of speed and power. A magnet is installed in each cubic block of the moving part of the device for each finger. To attach the fingers to the robot, a metal is taped to the fingers, which allows the user to attach to the mechanism and move the fingers correctly when the user places their fingers on the device. To hold the forearm, adjustable support has been installed in different directions (Fig. 4).

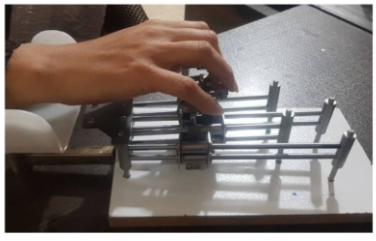

Fig. 4: Adjusting of FTRD with finger movement

4. Conclusion

A significant number of individuals with motor impairments are among the stroke survivors. In fact, in the initial motion, all post-stroke survivors and patients with hereditary conditions may experience hand function impairments. The hand is one of the foremost vital limbs of humans; it consists of five fingers and a wrist. In general, to manage the stroke's debilitating impact on patients' upper limbs, particular finger and wrist exercises may help. Robotic devices allow to increase the amount and intensity of treatment, standardize treatment, provide a complex but controlled multisensory stimulation. This device is an effective mechatronic robotic device specially designed to treat the hand. The proposed four-finger rehabilitation robot with simplified design and low manufacturing cost could be used in robotic applications in home care for disabled people.

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References

[1] https://www.researchgate.net/figure/Eight-motions-of-the-wrist-and-fingers-a-and-b-radial-and-ulnar-deviation-of-the_fig4_336527108