# ABSTRACT

Today, brain attack disorders are one of the most life-threatening areas in the medical era, which the mankind is facing nowadays. Globally, more than 10, 00,000 people are subjected to brain attack disorders like hemiplegia and tremor, every year, where two-thirds of them survive. Among the survival community, more than 80 per cent of them are subjected to long-term impairment of their upper extremity. In order to treat the impairment, the survival group is subjected to medications and rehabilitation in order to improve their daily living. But the facilities are very limited in fast-developing countries like India when compared to western standards. The rehabilitation given in corresponding with medications during the treatment period in hospitals does not give a complete recovery from disability. People from rural background could not meet their rehabilitation requirements even in the hospital during treatment and also when they are discharged to home after treatment from hospitals due to financial constraints and reachability.

In order to motivate the survival group to fulfil their daily living and improve their lifestyle, this thesis is focused on home-based rehabilitation at low cost, reliability, and affordability. Two major movement disorders namely Upper Arm Hemiplegia and Tremor were taken into account for our doctoral study and visited few major hospitals around Coimbatore and Chennai for literature study. The facilities available in various hospitals and their drawbacks were analysed. Based on the studies conducted at hospitals and taking advice from therapists, an innovative low-cost home-based rehabilitation device using Electro-Mechanical systems has been developed to support patients who were used to impaired living even after treatments. To support Upper Arm Hemiplegia patients, five devices were developed and experimented. All the five devices hold different functionalities like

Pneumatic based, Motor based and Hydraulic based. To support tremor, a portable sensor based suppressor device was developed.

Device 1 is a Pneumatic actuated rehabilitation system with compressor, solenoid valves and a cylinder for immense exercise on wrist and fingers. The proposed system is composed of an air compressor of 300PSI, a 2 way solenoid valve with a relay circuit, embedded with an Atmega 328 Arduino controller to enable a two way miniature cylinder of 145 PSI. The pneumatic circuit is designed for rehabilitation therapy and operated in such a way that the cylinder is attached to the affected arm using two holders one is for thumb and a separate holder for rest of the 4 fingers together, which is made up of a fibre glass. The relay drives the 4 solenoid valves by letting the air to pass on through 5/32" nycoil tubing by receiving the air flow from the compressor. Solenoid valves 1 and 2 were used for air inlet and outlet during flexion and valves 3 and 4 were used for air inlet and outlet during extension of the wrist and the fingers, by receiving the control signals from the controller. Thus the cylinder which is connected to the patient's arm is operated by actuating the solenoid valves with the help of control signals.

Device 2 is designed and operated using a motor based simple smart glove using one micro DC motor for improving the kinematics for wrist and fingers. It works with the help of 6 V, 0.5 A DC motor, which drives the operation of the glove. The glove is tailored with strings on a leather base, which is connected to the motor. Device 3 is another motor based rehabilitation system using gripper motors with the Arduino 328P controller to facilitate automated kinematics of wrist and each finger. A fabric glove is wore by the affected arm, in which 5 gripper motors are strapped on the wrist and connected using nylon threads which is tailored on the glove. The gripper.motors actuate the fingers to which it is connected and thus enabling rehabilitation

Device 4 and 5 is a Hydraulic based rehabilitation system where one is an automated and the other is a non-automated system for improving the motion functionalities of shoulder, elbow, and wrist. Experiment 4 is composed of 20 litre hydraulic tank, 3ϕ, 0.5 hp, 1440 rpm induction motor. The cylinder is of 25 mm driven by 5/2 double acting valve. The device is focused on an average human hand in which two chairs and 3 metal segments based setup is provided to facilitate kinematic motion on each joints of the upper arm. Experiment 5 operates on 0.25 hp, 1440 rpm induction motor. Three cylinder pistons are driven by solenoid valves and operated by the Arduino 328P controller at 3 joints of the upper arm at shoulder, elbow and wrist. The operation and the applicability of the devices were based on the severity of the impairment in the patient.

Device 6 is an accelerometer sensor based suppressor device using Pneumatic mechanism to suppress tremor. Tremor being a movement disorder after a brain injury, a portable device to suppress tremor and improve muscle coordination in the upper arm is focused. The proposed device is composed of GY-61 Accelerometer sensor, Atmega 328 Arduino controller, and a hand cuff with Non Return Valve. The patient subjected to tremor will wear the hand cuff and once when the vibration is being sensed by the accelerometer, the solenoid valve facilitates the inflation pump to pass air into the cuff with the help of the signals received from the Arduino controller. When the air through the cuff is uprooted into the cuff, the vibration gets reduced where the trials can be repeated to reduce suppression and thus the effect is being measured using an oscilloscope in terms of voltage and magnitude.

All the above mentioned medical devices were designed based on low risk factor module representing Class A standards of Indian Medical Association. All the devices would also meet the ISO 13485 standard as per Quality Management Systems procedure of medical devices. Before trial, the

devices were subjected to testing on electrical safety and functional aspects. Patients who undergo home based rehabilitation were approached with the help of physiotherapists to perform trial with them. After the consent, the devices were applied to different patients based on their disorder and their need of rehabilitation. Keen attention was given to the patients, considering their safety and comfort during the trial therapy. The patients were subjected to rehabilitation using the devices with the help of physiotherapists for about 10 weeks and various parameters of arm kinematics and the improvements were observed by the therapists. The performance analysis of Pneumatic, motor based and Hydraulic actuated devices supporting Upper Arm Hemiplegia of different patients was done using the Fugl Meyer Assessment and the data were recorded in terms of pre, mid and post-assessment. The obtained data is subjected to ANOVA analysis using the R tool and the results obtained from this analysis concludes the difference between pre and post assessment shows reasonable improvement in the kinematics of the upper arm, which reveals that the prototypes shall be applied to patients for motion recovery from paralysis. The tremor suppressor using Pneumatic mechanism is also applied to a patient and it is measured in terms of voltage magnitude and the suppression of tremor is justified. Hence the results of the various proposed systems seems to be helpful in bringing noteworthy improvements in the lifestyle of patients with neurological deficits who cannot afford for rehabilitation at hospitals