# CONCEPTUAL DESIGN OF PHYSIOTHERAPY SUPPORTING MACHINE

**Rusmay Abdullah[1], Abdul Aziz Abdullah[1], Kamaruzzaman Daud[1] & Choong Chee Guan[1]**

[1]Politeknik Ungku Omar
rusmay@puo.edu.my
azizulah@puo.edu.my
mandaud@puo.edu.my
dr.choong@puo.edu.my

## ABSTRACT

Physiotherapy supporting machine is a machine that helps the hemiplegia patient to rehabilitate their strength and movement of their curtain body part that cause by semi paralyzed also known as in medical term hemiplegia. The problem is that patient need to do more exercise in order to be well again, because the more the exercise are done, the shorter the time taken for the patient to be healthy again. However, without anyone help it would be very difficult for the patient to do a certain movement in an exercise. This project is designed as a wearable robot and it is function to help the movement of the hands and feet by using a program to help the movement through motors. By doing, this it will train the movement of the hand or foot and soften the limbs and it is called a passive movement, it is where the movement are 100% assisted by anyone or anything to help the patient move. Next, after the passive movement are done the patient body need to be strengthen in order to recover. By installing a fixed resistance, the patient can train while the machine provides support if in case the patient did not have enough strength to move by them self, this movement are called active movement where the strength of the patient is use to move while a resistance are used to help them regain their strength.

**Keywords**: hemiplegia, physiotherapy, passive movement, machine.

## 1. Introduction

Physiotherapy supporting machine is a machine that design for the semi paralyzed patient or known as hemiplegia. The function is to support and help to move the patient affected body by exercising them with basic movement physiotherapy. With this machine, there will be no excuse to not exercise in order to get well again. By using the concept of animatronic robotic hand, we are able to design a new type of machine that uses the exact concept but in a wearable form. Then, the machine is programmed to move with a basic movement of the physiotherapy. Hence, it will train the body to restore back their ability

Hemiplegia is a condition that affect one side of the body depending on the side affected ether right or left. It is cause by an injury at the parts of the brains that control movement of the limbs, trunk, face, etc.

Most common cause of hemiplegia is spinal cord injury, specifically Brown-Squared syndrome, traumatic brain injury, or disease affecting the brain. As a lesion that results in hemiplegia occurs in the brain or spinal cord, hemiplegic muscles display features of the upper motor neuron syndrome. Features other than weakness include decreased movement control, clonus (a series of involuntary rapid muscle contractions), spasticity,

exaggerated deep tendon reflexes and decreased endurance. Other causes include trauma, bleeding, brain infections and cancers.

Treatment is focused on improving sensation and motor abilities, allowing the patient to better manage their activities of daily living. Some strategies used for treatment include promoting the use of the hemi paretic limb during functional tasks, maintaining range of motion, and using neuromuscular electrical stimulation to decrease spasticity and increase awareness of the limb.

At the more advanced level, using constraint-induced movement therapy will encourage overall function and use of the affected limb. Mirror Therapy (MT) has also been used early in stroke rehabilitation and involves using the unaffected limb to stimulate motor function of the hemi paretic limb.

Results from a study on patients with severe hemiparesis/hemiplegia concluded that Mirror Therapy (MT) was successful in improving motor and sensory function of the distal hemi paretic upper limb. Active participation is critical to the motor learning and recovery process; therefore it is important to keep these individuals motivated so they can make continual improvements. Also speech pathologists work to increase function for people with hemiparesis/hemiplegia. Treatment should be based on assessment by the relevant health professionals, including physiotherapists, doctors and occupational therapists. Muscles with severe motor impairment including weakness need these therapists to assist them with specific exercise, and are likely to require help to do this (Barnes and Fairhurst, 2012).

The aim of this conceptual design is to help the patient to rehabilitate body movement. By wearing the physiotherapy supporting machine it will support the patient by assisting them to exercise and train the movement pattern of the body. Three objectives that have to be made in order to achieve the aim:

(i) To study the axis of servomotor for the movement of the hand and feet; and
(ii) To design a wearable robot that can support the patient while doing the exercise.

Nowadays, hemiplegia commonly caused by stroke and stroke are commonly suffer by elderly people. Keep in mind that cause of hemiplegia not just from stroke but they also cause by brain damage, bleeding etc. When a person whom suffers with hemiplegia, it usually takes time to recover. Nevertheless, in order to do that they first have to consult a physiotherapist every week and they usually teach them the basics exercise and then discharge the patient home so that they can do it by their self at home. The patient cannot move by their own, so they need a support or an assistant to guide them to do the exercise. The patient also has trouble remembering the basic simple exercises that they have done every day. So, in order to fix that the physiotherapist has made a time seclude to exercise which is at least 20 minutes 4 sets in every 2 hours at every day because "the more they exercise, the faster the rehabilitation" and without a support from anyone it is impossible for them to do that. Therefore, the Physiotherapy supporting machine is designed to overcome this problem.

## 2. Concept and Theory

Strengthening and active range of motion exercises can be done with stroke patients who have hemiparesis. Patients with more severe paralysis may have some small individual movements that can be strengthened as well. Many people do not feel that stretching is an exercise, but it most definitely is, and it can help improve arms and hands during stroke rehabilitation. Stretching helps relieve muscle spasticity that can occur post-stroke. With stretching as a foundation, range-of-motion exercises are also useful for the arms and hands. Some basic movements patient can complete are moving the arm to its full range of motion several times a day. This should feel like a slight pull or strain sensation, but comfortable enough that they are not causing injury. When holding a stretch, they should feel slight discomfort, but no numbness or serious pain. Stretches should be held for a minimum of 20 seconds.

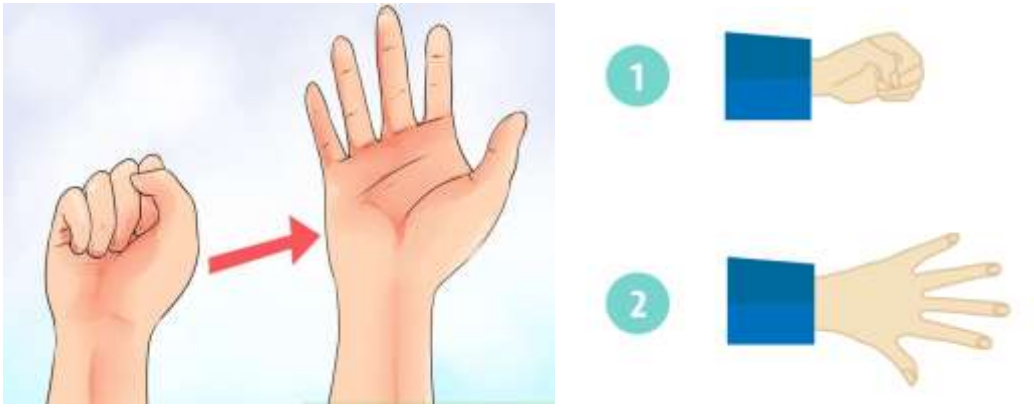



*Figure 1: Hand movement exercise*

When they are struggling to move their hands, start with this basic-level exercise, aimed at helping their brain re-learn how to control the most basic hand movement, if they are struggling to make a fist and release it (refer to **Figure 1**).

Stroke rehabilitation for hand and arm includes passive movements or exercises that are movements done with the help of a therapist. Stroke rehabilitation can be tiring. It may also help to be active during times of the day when they have more energy. They can do simple exercise like arm movement.

Exercises for the leg muscles are just as important in patients with paralysis as they are in able-bodied individuals as shown in **Figure 2**. Depending on the cause of the paralysis, gaining muscle strength is not always an option. However, keeping the muscles, tendons, ligaments and joints as healthy as possible is essential to avoid contractures in the paralyzed legs. Contractures occur when the normally stretchy tissue loses its flexibility and makes movement difficult. This causes joints to lock up and increased pain. Without the ability to move the legs, passive range-of-motion exercises performed by a caregiver increase circulation and keep their legs as healthy as possible.

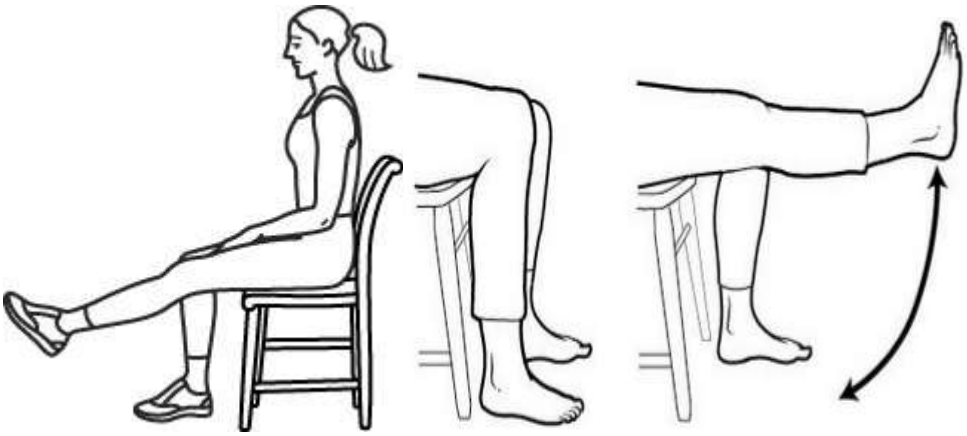


*Figure 2: Leg movement exerciser*

Balance and coordination are often lost after a stroke. This can make simple actions, like standing and walking. In addition, weakness can occur around the muscles on the exterior of the hip area. Exercises for standing and balance are vital to helping you regain your quality of life after a stroke. When performing these exercises, always hold onto a table or similar stable surface to avoid a fall (Annie, 2015).

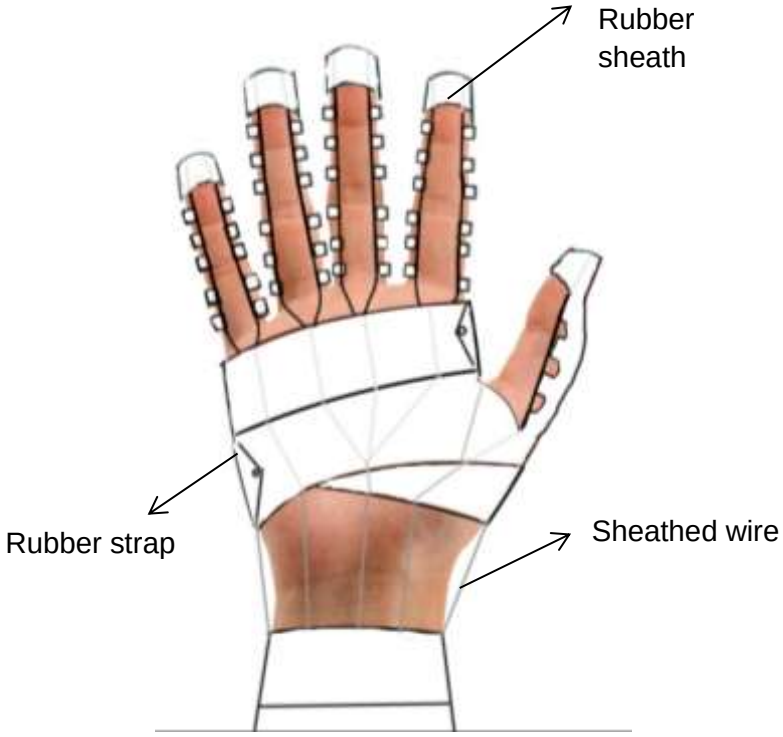
The concept of physiotherapy supporting machine is the same as transcutaneous electrical nerve stimulation as shown in **Figure 3**. Transcutaneous electrical nerve stimulation is a back pain treatment that uses low voltage electric current to relieve pain. Transcutaneous electrical nerve stimulation is typically done with a transcutaneous electrical

nerve stimulation unit, a small battery-operated device. The device can be hooked to a belt and is connected to two electrodes. The electrodes carry an electric current from the transcutaneous electrical nerve stimulation machine to the skin.

*Figure 3: Transcutaneous electrical nerve stimulation*

## 3. Proposed Design and Prototype

Physiotherapy supporting machine was inspired by the Arduino robot hand that made the concept of the animatronic which is a device that emulate human or animal that integrate anatomy, robot, mechatronic and puppetry resulting in life like animation (Stephen, 2007), which in this case hands and feet that can be wear in **Figure 4**.



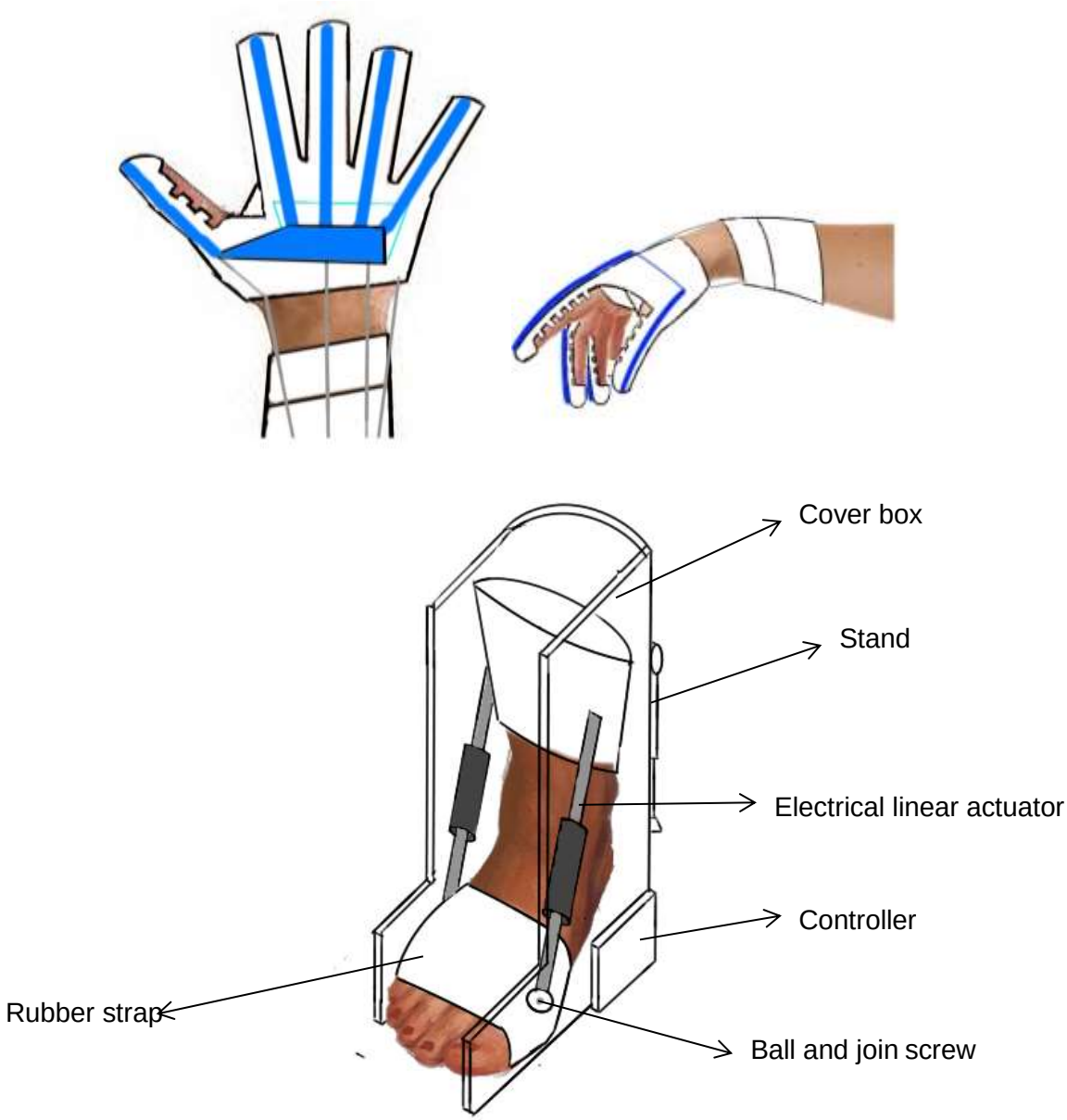



*Figure 4. Proposed design of prototype*

For the design of the physiotherapy supporting machine a light material has been selaected for the comfort of the patient (Angele and Jan Carel Diehl, 2013). Firstly, rubber sheath is the selected material for this project. It is because the rubber sheath is soft and easy to stretch; also it is light in weight. It also designed to fit the finger. Next are the rubber strap, this project are use on a human body so the rubber strap is a great choice of material because of the different sizes of a person's body. It is also adjustable so it can be tighten so that it will grip the patient carefully. Then, sheathed wire is used to protect the wire so that it will not go out of it track. Also the wire it self is thin and strong so that it can handle the tension of the motor (Barber, 1980).

As mentioned earlier in order the patient to regain their strength back the patient need to do some active movement so for that we have install a fix resistance for the patient to do their exercise. The resistance is in a form of rubber because when a person who suffers from hemiplegia their strength has actually decrease compare to a healthy person so the rubber that we have install must have just enough elasticity for them to exercise.

## 4. Expected Result

The designed machine consists of components and functions as shown in **Table 1** and the full layout of the physiotherapy supporting machine for hand is shown in **Figure 5**:-

*Table 1: List of components and functions*

| Component | Function |
|---|---|
| Rubber sheath | To fit the finger |
| Rubber strap | To grip the patient's hand carefully |
| Sheathed wire | To protect wire so that it will not go out of it track. |
| Rubber resistance | To do some active exercise.<br>To give some resistance to do exercise |
| Cover box | To cover the foot |
| Stand | To give some space for the foot when it flex downwards. |
| Electrical linear actuator | To creates motion in a straight line.<br>Enough to support a foot. |
| Controller | To control the movement of the machine |
| Ball and join screw | To connect the joint |

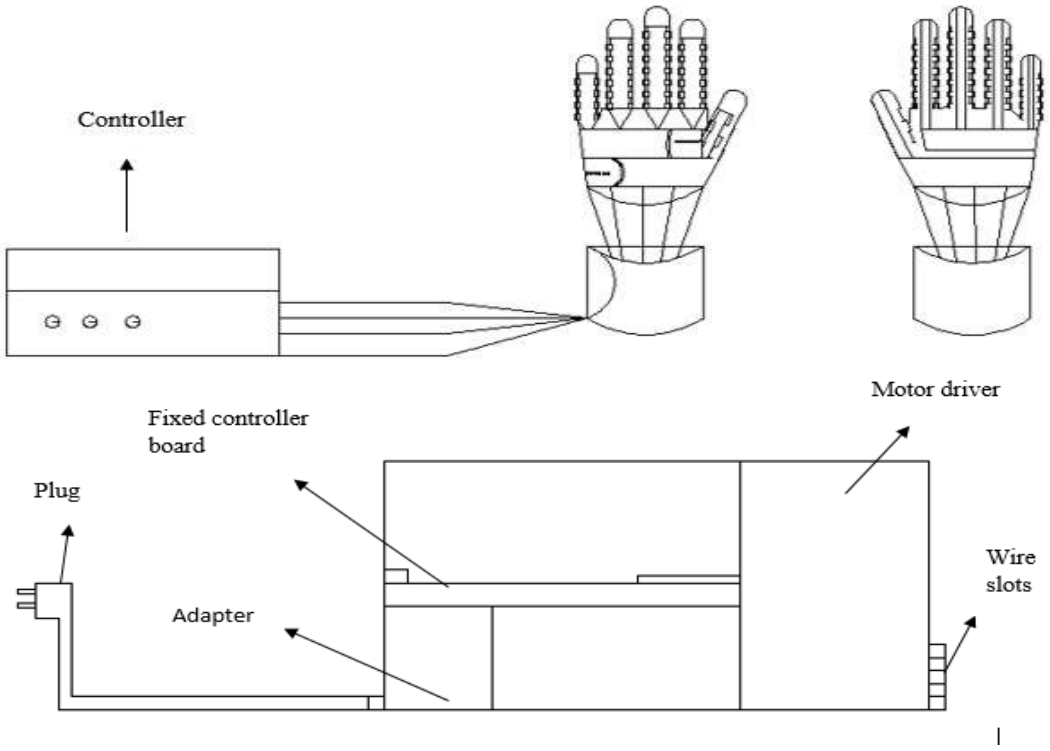



*Figure 5: Full layout of physiotherapy supporting machine (hand and controller)*

From observation and study, the axis of each human finger is almost the same because each of the fingers has the same axis. Although, the most basic movement for the patient can do is in the **Figure 6** below. This movement are called gripping where the patient grip and expend their hand continuously.

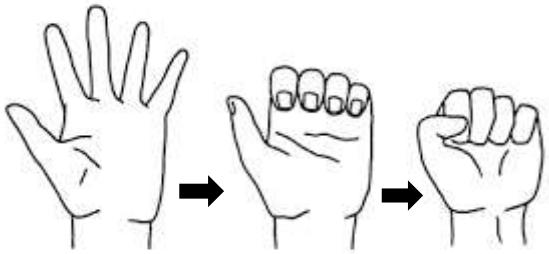


*Figure 6: Movement of the fingers*

The movement of the wrist flexion 80°-90° bend wrist so palm nears lower arm and extension 70° bend wrist in opposite direction is shown in **Figure 7**.

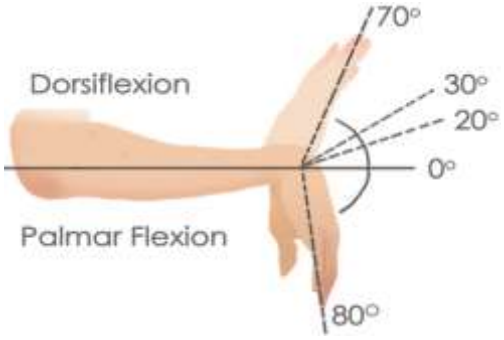



*Figure 7: Movement of wrist*

The ankle joint is a synovial hinge joint permitting two movement's plantar flexion (=flexion), in which the feet is pointed downwards dorsiflexion (=extension), in which the foot is raised. Dorsiflexion is a more limited movement normal range: 10-30° than plantar flexion normal range 20-50° (refer to **Figure 8**).

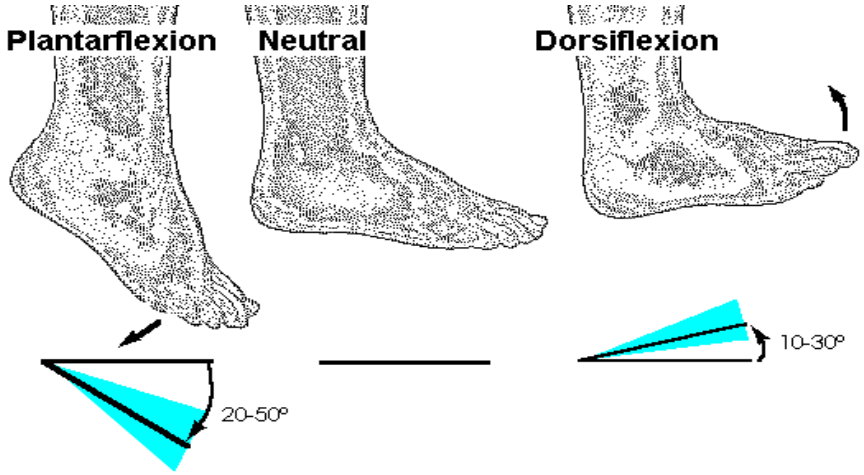



*Figure 8: Movement of ankle*

**Figure 9** shows the basic steps for physiotherapy supporting machine. When the machine is turned ON, it has to choose which program is suitable for the patient. Next, the controller will recognize the program and control the motor driver which connected to the patient. The movements of the patient are indicated by the sensor which is used to set for the limit and error of the machine.

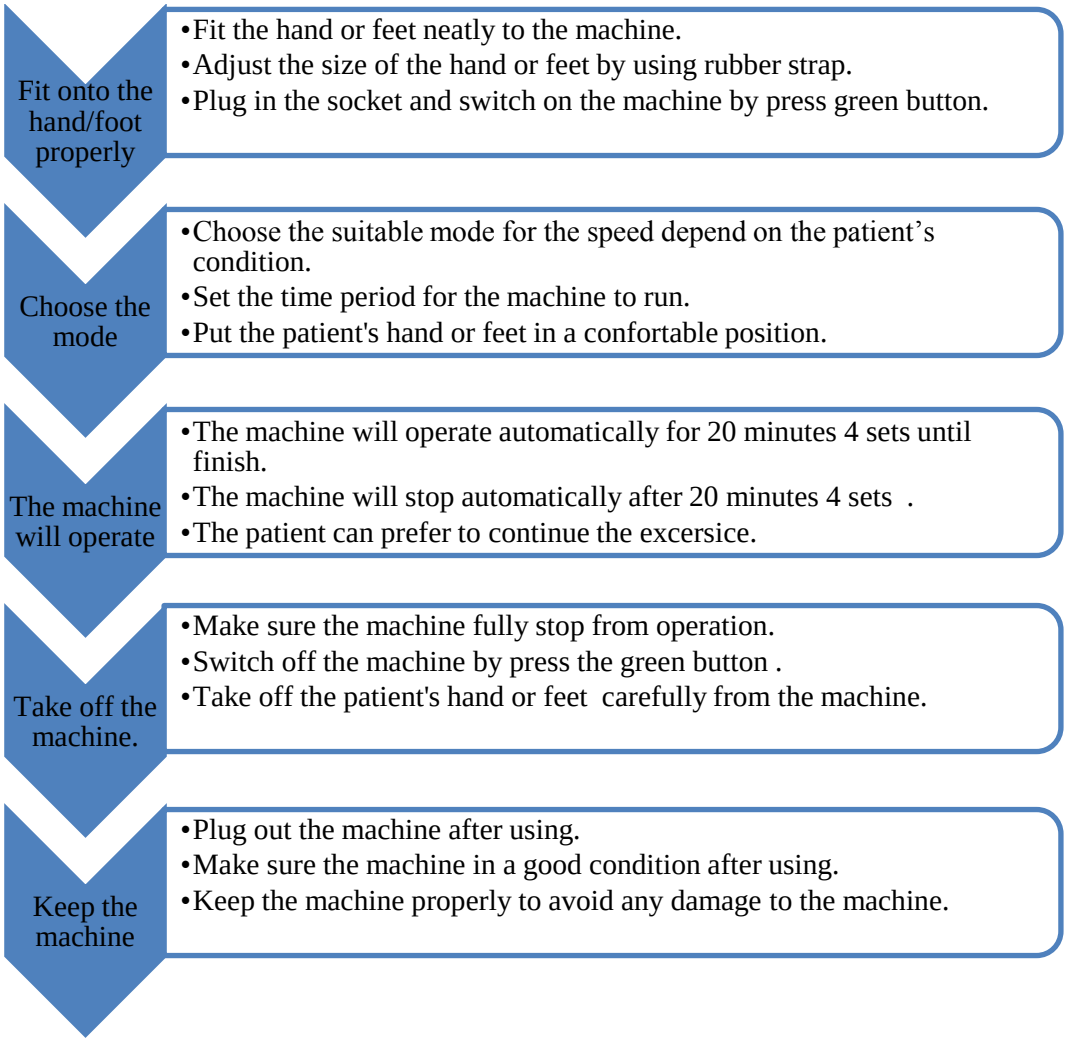



*Figure 9: Basic steps for physiotherapy supporting machine*

## 5. Conclusion

With this idea of physiotherapy supporting machine, a new kind of exercise method has put the hemiplegia patient at ease where the patient not only could exercise their limb conveniently in terms of portability, this project could also make hemiplegia patients to gain easy access in term of time period hence the additional cost could be reduced. Physiotherapy supporting machine could also be potentially commercialized as it has the potential to be marketed in the business industry and facilities for hospital because of its function as convenience toward the hemiplegia patient.

Physiotherapy supporting machine could also potentially be made as research or thesis project toward the other undergraduates and those people who would like to make their own self-exercise limb and just need a little help from other people. Physiotherapy supporting machine could overcome hemiplegia issue where for the patients it is deemed as an issue, thus increasing the likelihood of this product being commercialized successfully in the marketing industry. Finally yet importantly, physiotherapy supporting machine is an environment friendly product and it plays a very important role in order to achieve a healthy life.

## References

Angele, H.R. and Jan Carel Diehl, H.B. (2013). The Power of Design: Product Innovation in Sustainable Energy Technologies. The Atrium, Southern Gate, Chichester. West Sussex, PO19 8SQ. United Kingdom: John Wiley & Sons, Ltd. (ISBN: 978-1-118-30867-7)

Annie, Stuart. (2015). Arm and Hand Exercises for Stroke Rehab. Retrieved from: *http://www.webmd.com/stroke/features/arm-and-hand-exercises-for-stroke-rehab*

Barber, Alfred W. (1980). Experiment's Guide to Solid State Electronics Projects. West Nyack, New York: Parker Publishing Company, Inc. (ISBN: 40-13-295469-9)

Barnes, L. and Fairhurst, C. (2012). The Hemiplegia Handbook. Retrieved from: *http://www.hemihelp.org.uk/hemiplegia/what_is_hemiplegia*

Stephen, S. (2007). Electronic Components and Technology (3rd Ed.). CRC Press: Taylor & Francis Group, LLC. (ISBN: 978-0-8493-7497-5)