

# DEVELOPMENT OF REHABILITATION TECHNOLOGY PROJECTS

**VOLUME 1**

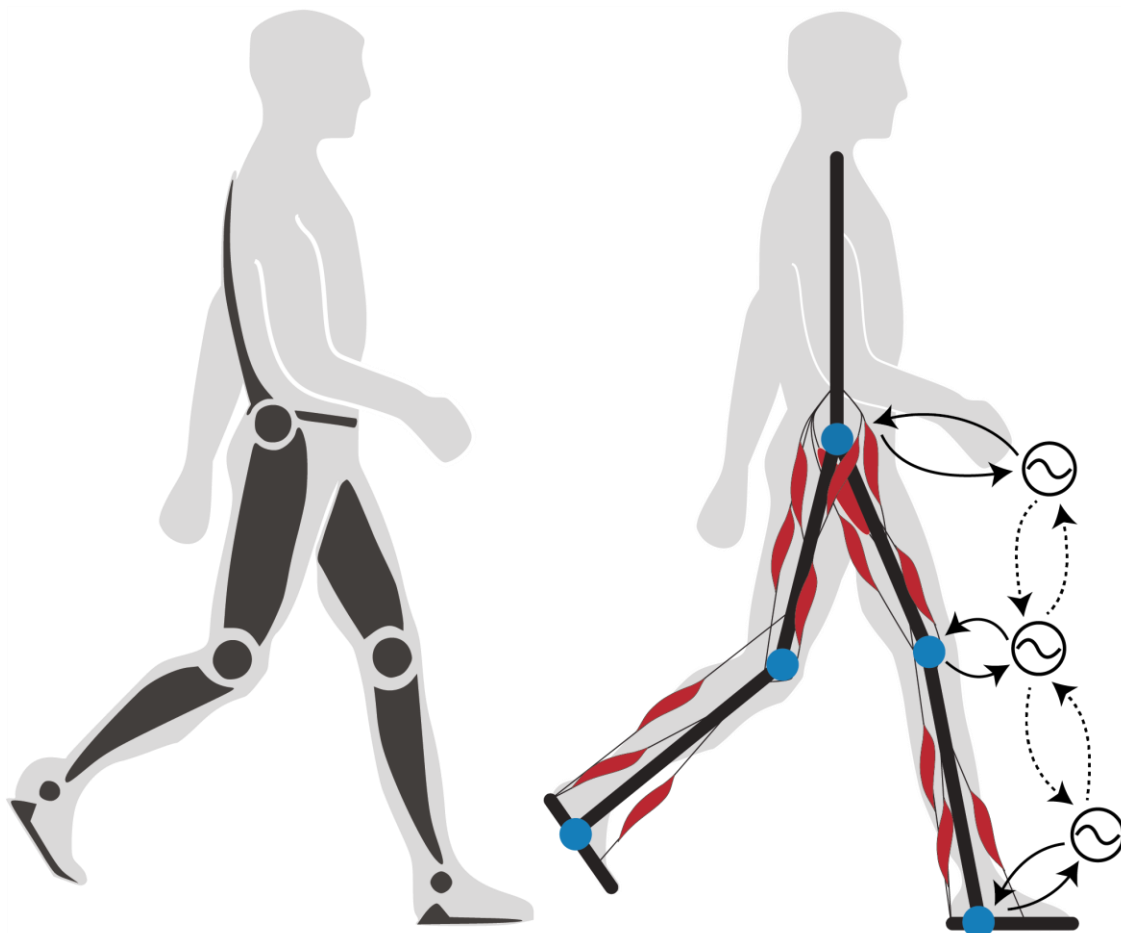
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# **DEVELOPMENT OF REHABILITATION TECHNOLOGY PROJECTS**

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**DEVELOPMENT OF REHABILITATION TECHNOLOGY PROJECTS  
VOLUME 1**

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DEVELOPMENT OF REHABILITATION TECHNOLOGY PROJECTS VOLUME 1

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## **PREFACE**

Rehabilitation technology is a crucial and increasingly relevant field in today's world. As medical electronics engineering advances, biomedical sciences are also gaining prominence day by day. Therefore, one of the academic contributions in this field is the production of chapter books. These books serve as a valuable resource for academia, researchers, professionals in the biomedical field, and individuals interested in engineering. Through the publication of this book, I, as the writer, aim to share my experience and expertise in the realm of rehabilitation technology

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Zunuwanas Bin Mohamad*

## **Development of Pedal Exerciser for Parkinson Disease**

### **Introduction**

Pedal exerciser is one of rehabilitation device that help patient with upper and lower extremity problem. The pedal exerciser is use for arms and legs. It is portable and resembles crank pedals of traditional bicycle. While motions used for the pedal exerciser and the stationary bike a similar, the two pieces of equipment are very different in function, design and features. Pedal exercisers are used by types of person such as Parkinson's patient, stroke patient, patient that have been through accident and need legs or arms exercise and patient with artificial legs and arms. Normal people can use pedal exerciser too for workout. Pedal exerciser can increase the heart rate and breaking a sweat isn't just good for blood circulation, but when incorporated regularly it can improve mood, help to stave off obesity and even improve heart's health.

From the survey by collecting data through interviewing the physiotherapy, nurses and technical person, beside than doing research, there are some problem statements that have been found and need improvement in existing pedal exerciser. Common problem with pedal exerciser are slipping of floor while pedalling. Rather than looking on the technical problem, there are also treatment problem solving included. In this research, Parkinson disease is the disease that has been focused. A research study by Jay Alberts (PhD), he is a biomedical engineer from Cleveland Clinic, shows that a forced exercise can help as a Parkinson's disease therapy treatment. Each and every day, people with Parkinson's disease awaken, trapped in their bodies. Their limbs are stiff, their hands shake and their legs won't follow their brain.

## **Problem statement**

From the survey by collecting data through interviewing the physiotherapy, nurses and technical person, beside than doing research, there are some problem statements that have been found and need improvement in existing pedal exerciser. Common problem with pedal exerciser is slipping of floor while pedaling. Rather than looking on the technical problem, there are also treatment problem solving included. Pedal exercisers are often moving to front during patient's exercise session. Same goes to the chair that has been used, it is sliding while pedaling. Some pedal exerciser is having this problem because of the leg's rubber, it is not gripping well on certain type of floor. This situation causes uncomfortable feeling to the patient.

Rather than looking on the technical problem, there are also treatment problem solving included. There is a fact that by using tandem bicycle, Parkinson's disease can be heal, so that one of the purposes in this study is to help Parkinson's disease patient do exercise whenever they want without have to goes out from home. Tandem bicycle has the same cycling theory of pedal exerciser, so it is should be fine if therapist use pedal exerciser to help Parkinson's disease patient.

## **Objectives**

The main objective of this project is: -

- (i) To upgrade the existing pedal exerciser to become an adjustable speed and resistance, comfortable to use, easy to handle and easy to carry.
- (ii) To analysis about the material of pedal exerciser and leg's rubber on pedal exerciser.
- (iii) To study the relationship between Parkinson's subject and the use of pedal exerciser as their therapy.

## Significant of study

This study is to analysis the problems that always occur on the pedal exerciser and find a solution to solve it. Besides, modification of pedal exerciser is to help the Parkinson's disease patient which is stated that fast pedalling will help to short the time recovery of them. Pedal exerciser can be used in various levels of ages of human (fig 1& 2).

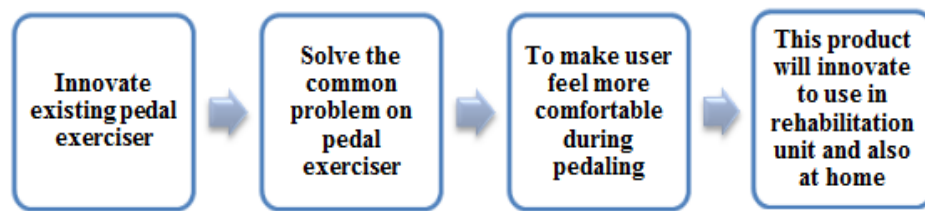


Figure 1: Significant of study

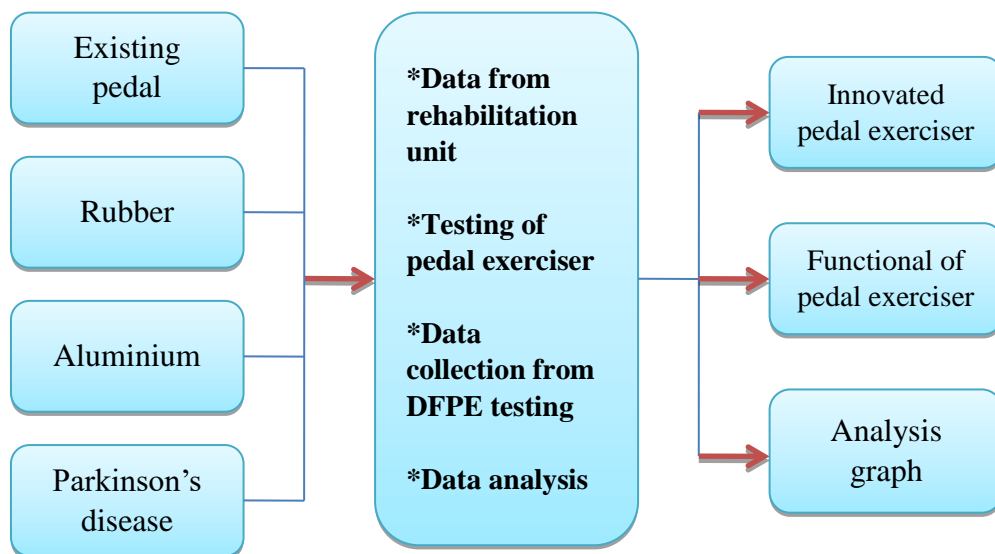


Figure 2: Theoretical of study



## **Pedal exerciser**

Pedal exerciser is rehabilitation equipment that can be found and used in the gym or at home. This exerciser is indicated for people with a problem at upper and lower limb. It is used for arm and legs. A pedal exerciser lets user perform the pedalling action while sitting on a chair or on a couch. The application of pedal exerciser can be similar like cycling, but it is without having to get on a bike (Fig 3.).



*Figure 3: Pedal exerciser*

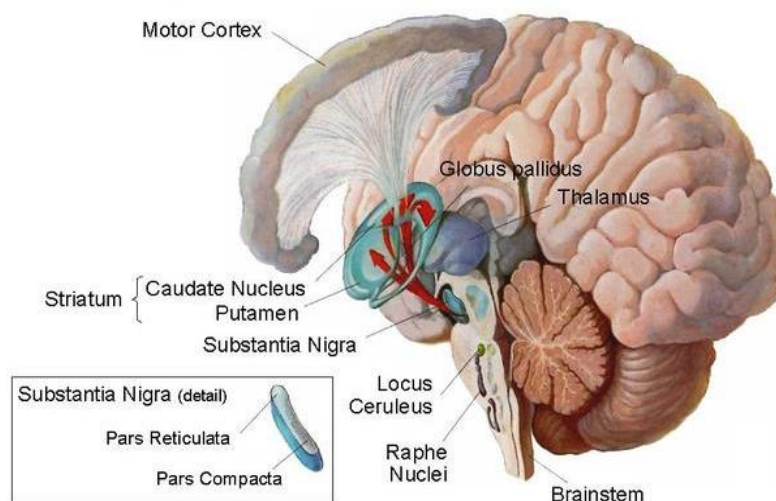
This is a helpful way to achieve for human legs when they are unable to stand for long periods. The pedal exerciser is used while user are in sitting position and provides a good workout for improving the strength in both patient legs without the difficulty of losing body balancing while standing.

There are several benefits from using a pedal exerciser. Pedal exerciser can be used during aerobic workout which is help to get a low impact and easy to the joint. Pedal exerciser also can help to increase the heart rate and breaking a sweat, which is not just good for blood circulation, but also when incorporated regularly it can improve human mood, stave off obesity and even improve heart's health. The price of pedal exerciser also is cheaper compare to the larger pedal bikes, so that it is affordable to be owned by the patient.

## Parkinson's disease

The Global Declaration for Parkinson's disease 2004 predicted that there are 6.3 million people who are diagnosed with the Parkinson's disease. Parkinson's disease (PD) is an illness that will affect and causes the motion of a human body. The symptoms of PD are including tremors, speech disorders, rigidity, slowness and postural instability[5]. There are two main causes of PD which is genetic and environment factor, where the symptom affects the production of dopamine from neurons which is important for movement coordination.

PD is a chronic neurodegenerative condition that leads to progressive disability, it is said by Poewe and Mahlknecht (2009). Referring to Weintraub et al (2008) and Kaltenboeck et al (2011), PD reduced health-related quality of life and it is high healthcare costs. It is expected that more than 8 million people worldwide may develop PD in this coming decade, said Dorsey et al (2007). PD causes tremor and reduces mobility and functional performance. People with PD also have reduced strength compared to age-matched controls. Progressive resistance exercise improves strength but it is unclear how large this effect is and whether functional performance is also improved. PD is a chronic and progressive degenerative disorder of the central nervous system. It affects all age groups, but is most commonly found in the elderly population (Fig. 4 & 5). PD can be considered the second most common senile neurodegenerative disease, affecting approximately 1% to 2% of the population above 65 years of age[6], and occurs in different races and social classes in both genders, but prevalent in males[7].



*Figure 4 : Brain regions affected by Parkinson's disease*

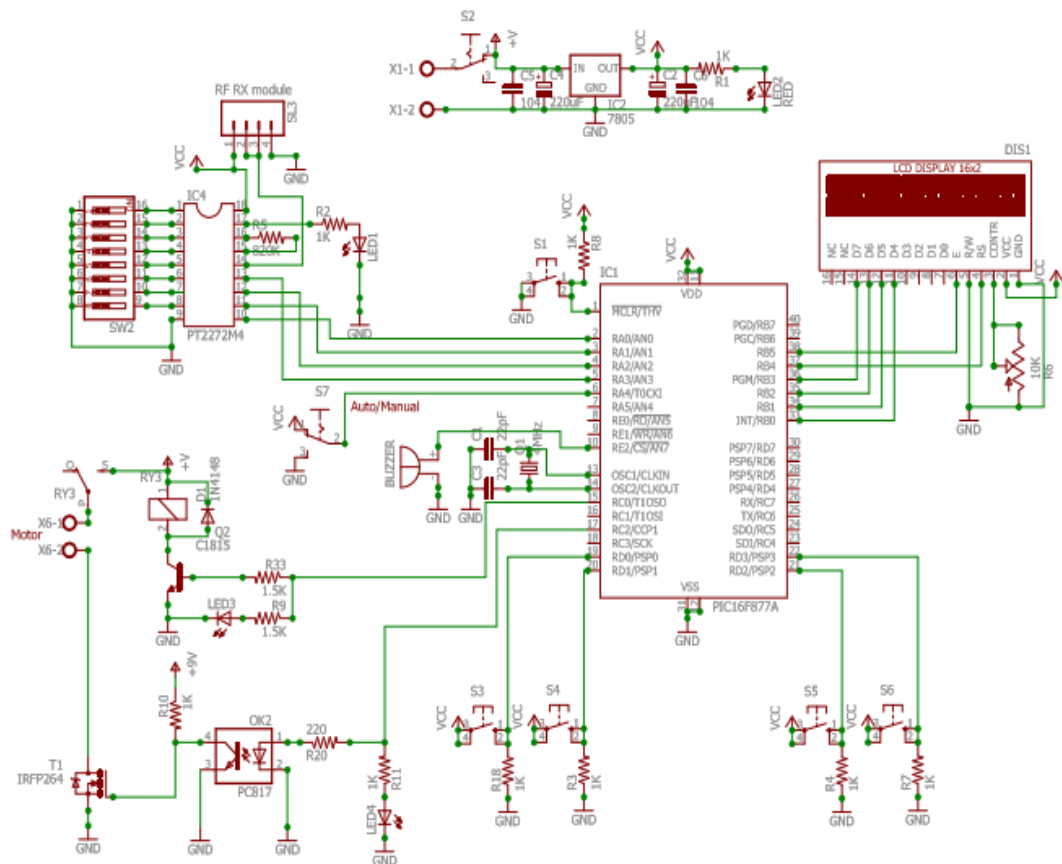
Early symptoms of PD are subtle and occur gradually. In some people the disease progress more quickly than in others. As the disease progresses, the shaking or tremor, which affects the majority of people with PD may begin to interfere with daily activities. Other symptoms may include depression and other emotional changes; difficulty inswallowing, chewing and speaking; urinary problem or constipation; ski problem; and sleep diisruption.



Figure 5: Hoehn and Yahr staging theory

### Requirement of hardware and software

In this session, investigator will decide the components to use inside the board. To do this planning, hardware was designed by using Autocad and software designed by using Eagle application. The purposes of doing product design are to get the better output if we planned well besides to save cost by just run the circuit by using application software (Fig. 6).



## Ethics of study

The basic concept and fundamental principles of decent humans conduct. It includes study of universal values such as the essential equality of all men and women, human or natural rights, obedience to the law of land, concern for health and safety and increasingly, also for the natural environment. In this study, things to consider regarding ethical issues with participants are:

- a) Consent forms (which state overall purpose and any risks or benefits of participating).
- b) Potential risks that could be involved in any questioning (emotional distress, dignity).
- c) Confidentiality of participants (anonymity).
- d) Feedback of results to participants.
- e) Indebted reciprocity should be reasonable

### **Project testing**

Project testing is done by tested the pedal exerciser on subjects. The subjects were divided into 2 groups. That is subject with health problem and the other group is random subject. Subject with health problem are including Parkinson disease, tendon and ankle problem. 3 persons used for this type of subject. These subjects were from 2 different hospital included private and government hospital. 20 persons of random subject were taken for the evaluation session. 20 persons of random subject were from the population of Premier Polytechnic of Sultan Salahuddin Abdul Aziz Shah, Shah Alam student, focusing on students for Electrical Department. During the testing, measurement taken according to the comfortableness, effectiveness, speed, foot print base and paddling. This measurement was taken by completing the evaluation form (Fig 7 & 8).



*Figure 7: Clinical test on a Parkinson's disease patient*



*Figure 8: Clinical test on subject with ankle problem*

### **Relationship between speed and number of cycle**

The table and graph below shows the relationship between the speed that measured in repetitions per minute (RPM) and number of cycle. Through the analysis, shows that, the relationship between speed and number of cycles is directly proportional to each other, which is the slower the speed, the lesser the number of cycles during pedalling session. It is measured in 1-minute time duration (figure 9). When the speed is higher, then the number of cycle will increase which is helped Parkinson's patient to recover fast by pedalling. With an input voltage of 12V, it is strong enough to support the load and motor (Table 1).

Table 1: Relationship between speed and number of cycle per minute

Input Voltage	Speed Level	Speed (RPM)	Time Duration (minute)	Number of Cycle
12 V	1	30	1 minute	50 cycles
	2	40	1 minute	80 cycles
	3	60	1 minute	100 cycles
	4	70	1 minute	120 cycles
	5	80	1 minute	150 cycles

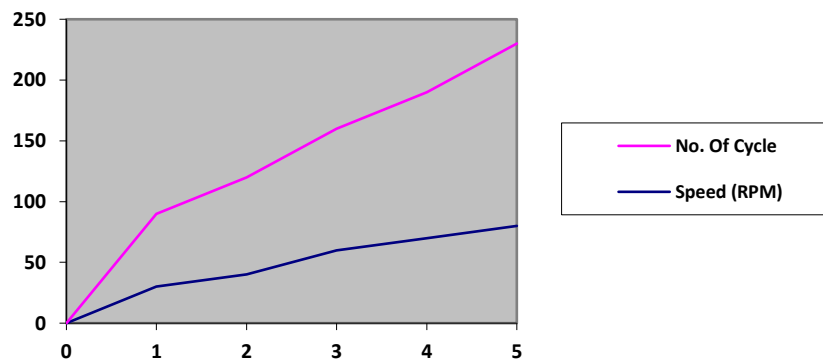


Figure 9: Graph Relationship between speed and number of cycle for 60seconds

### Evaluation test referring to comfortableness

Table 2: Evaluation test on comfortableness

Comfortableness	Strongly agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
1(a)	8	8		1	
1(b)	4	5	4	4	
1(c)	8	8		1	

## Conclusion

In conclusion, most of the objective in which is 90% of this project was achieved. At the end, the innovation of this project may help Parkinson's disease patient with adjustable speed controller. The usage of DC Series motor was succeed to move the pedal exerciser with suitable speed that has been control through programming by register the coding inside the PIC. This project also innovate some simple thing that sometime people not care about at all, which is the feet cover rubber. The replacement of old feet covers rubber to thermoplastic elastomer helped user to feel more comfortable when using pedal exerciser.

As a recommendation for future, the motor still can be improve to the other motor that have more better feature and function. In addition, the design of pedal exerciser also can be improve so that it will look more interesting in feature. This product are made up of moderate costing but good quality, so that the price would be affordable for user to buy to be use at home. It functions also helpful to patient not just who with Parkinson's disease, but also can be used by stroke patient, patient with knee and ankle problem and etc.

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Zunuwanas Bin Mohamad*

## **Development of Elbow Joint Rehabilitation Device**

### **Introduction**

Stroke is the second largest cause of death in Malaysia. A study of Umami Nadiyah Yusof find out that stroke is the second largest causes of Year of Life Lost in Malaysia, which ischaemic heart disease (17.1%) is the first causes, follow with stroke (9.6%) and the third causes was road traffic injuries (8.3%). Brain injury from a stroke may affect Hemiparesis (weakness on one side of the body) or hemiplegia (paralysis on one side of the body). When the stroke patients is in hemiparesis, they're not able to move their hands freely, and their joints not able to move in the normal range of motion.

According the observation of the L. D. Schelosky & J. Scott, 25% stroke patients suffer from spasticity within the first 6 weeks of the study. They have observed that spasticity primarily affects the elbow (79% of patients), the wrist (66%) and the ankle (66%) [2]. Spasticity of the elbow joint will causes the arm's muscle weakness and the elbow joint stiffness. Besides that, joint stiffness also will occur after joint trauma and with the Continuous passive motion (CPM) exercise, the joint stiffness can be reduces and also maintain the range of motion (ROM) of the joint.

A study of K. Kang, which the development of rehabilitation robot for post-stroke forearm and wrist also provided the Continuous Passive Motion exercises for stroke patient. Elbow Joint Rehabilitation Device provides Continuous passive motion (CPM) exercises to the patients who have Neurological problems such as stroke and traumatic brain injuries are a highly prevalent condition that results in high cost to the individuals and society[4]. Besides that, it is used during the first phase of rehabilitation process following an elbow injury or elbow that has undergone surgical procedure.

A rehabilitation program support the findings of Gates et al (1992) that post-operative use of CPM improves total range of motion and therefore function. Thus, Continuous Passive Motion exercises are important to the patient's elbow recovery from stroke, traumatic brain injuries and also from elbow injury. By using this device, patients can do their treatment anytime and anywhere and patients can heal in a short period of time. But the existing devices are too complex, large, and difficult to be carried to anywhere. Besides that, the current device most with a wheel stand and some of it are with a fixed chair, so the device are difficult to carried, and also it's not stable while the device is in used. Furthermore, current devices are operating in AC power supply, so every times the user need to place the devices close to AC power supply to do their treatment.

### **Problems Statement**

Existing devices of the elbow rehabilitation therapy are large are too big, complex and difficult to be carried anywhere. Because of the size, the patients should be hospitalized for the elbow rehabilitation therapy. Besides that, the current device those with wheel stand are not stable while the patients are doing the treatment. While the patients using the device, the device may move, and it may probably effect the treatment.

Furthermore, current devices need to operate in AC power supply. Which means the patients or the users need to find an AC power supply to operate the device every times of the treatment.

## Objectives

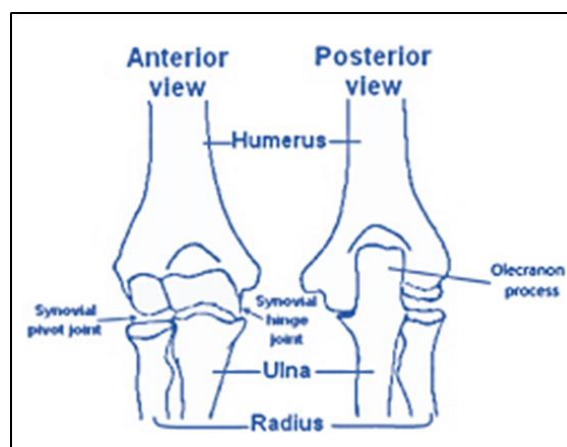
The main objective of this study is:-

1. To develop a lightly and hand ability elbow joint rehabilitation device for stroke patients.
2. To design the control speed circuit for guiding continuous passive motion exerciser and able to operating in a rechargeable battery.

## Elbow Joint

The elbow is the joint connecting the proper arm to the forearm. It is marked on the upper limb by the medial and lateral epicondyles, and the olecranon process. Structurally, the joint is classed as a synovial joint, and functionally as a hinge joint.

The elbow joint is a compound synovial joint, which means that it is a large working structure that is made up of several smaller moving parts, or separate articulations. A synovial joint, otherwise known as a diarthrosis, is the most flexible type of joint, seeing as it achieves its range of movement at the point of contact between the articulating bones. This mechanical area forms the meeting point between the radius and ulna of the forearm with the humerus of the brachial region. It is deemed a compound joint because the joint cavity is continuous with the radioulnar joint, as well as the contact points between these bones and the humerus respectively (Fig. 1)



Figures 1: The structure of the elbow joint.

Every joint in our human body have its own range of motion, the Figure 2 is the normal range of motion for the elbow joint. The orientation of the bones forming the elbow joint produces a hinge type synovial joint, which allows for extension 0 degrees (straighten out lower arm) and flexion 140 degrees (Bring lower arm to the biceps) of the forearm [6].

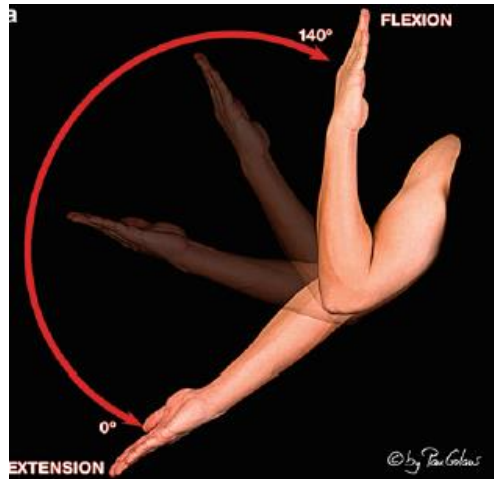
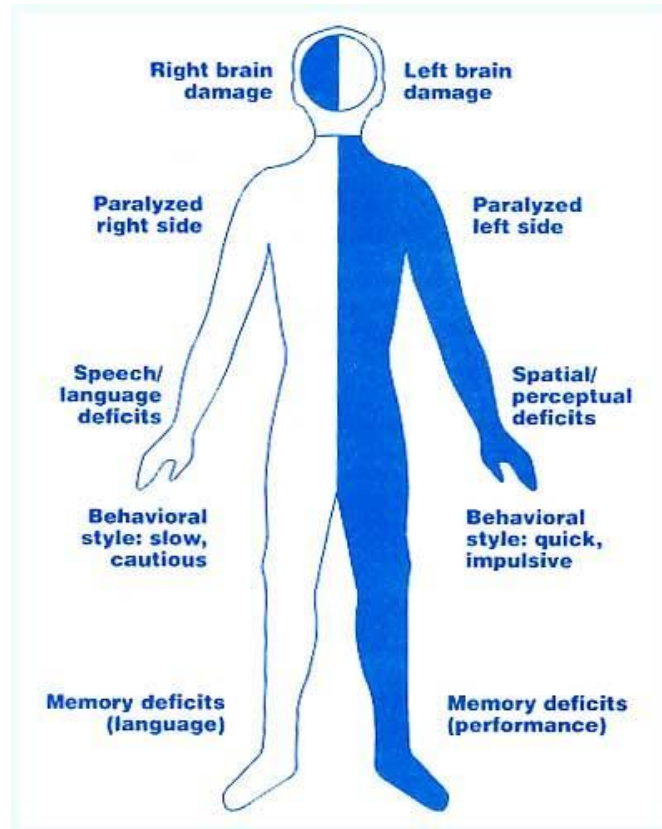


Figure 2: The normal range of motion of elbow joint

### **Effect of stroke**

The effects of a stroke vary from person to person, depending on which part of the brain is damaged and the extent of that damage. For some, the effects are relatively minor and short-lived; others are left with more severe, long term disabilities. Common problems include weakness or paralysis, Cognitive Problems, Problems Using Language and also Vision and Perception Problems (Fig. 3)



*Figure 3: Effect of stroke*

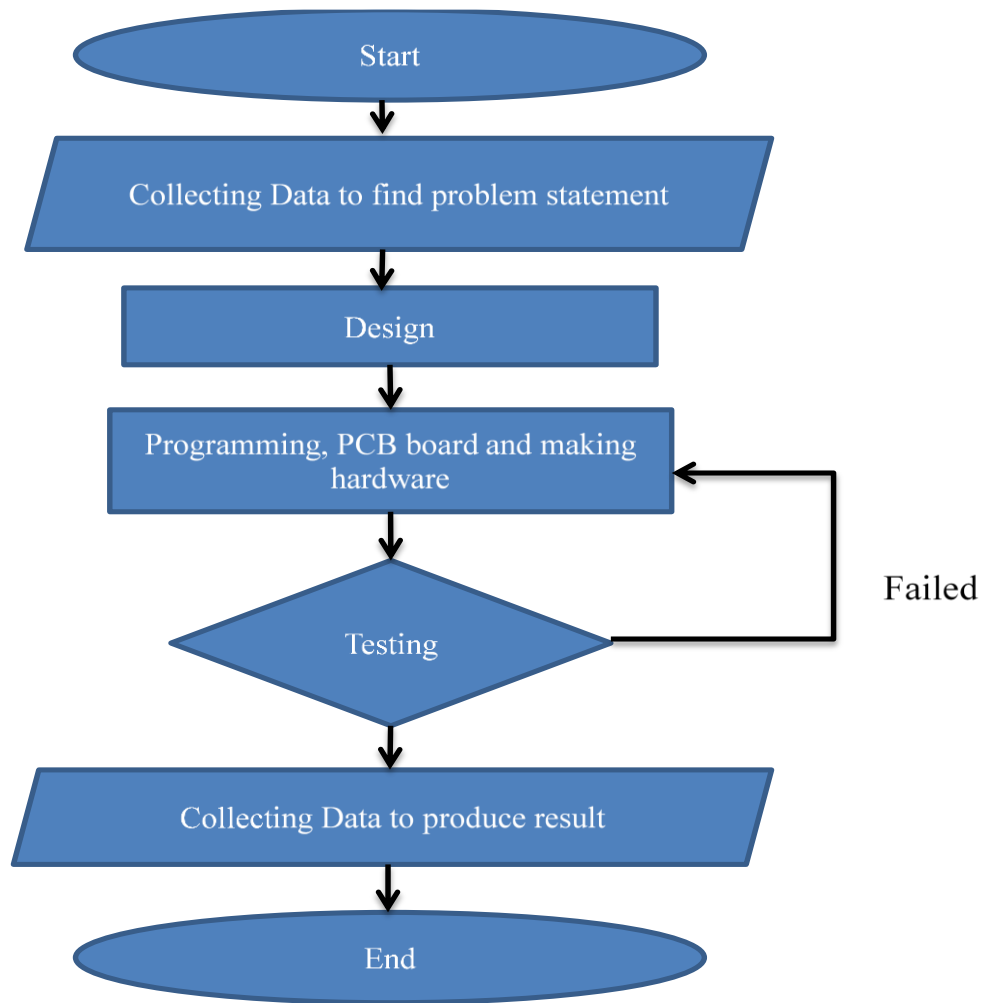
The most common effects of stroke are weakness or paralysis. Weakness (hemiparesis) or paralysis (hemiplegia) may affect one whole side of the body, or just an arm or leg. The weakness or paralysis is on the side of the body opposite the side of the brain injured by the stroke. This leads to problems with balance or coordination, because the weight of the weak side pulls against the strong side. It can make it difficult for the stroke patients to sit, stand, or walk, even if his or her muscles are strong enough to perform these activities.

To start this study, data collection was the first step of this study. To collect the data, the interview and attribute questionnaire (APPENDIX 1&2) to the physiotherapist and patients were performed. After that, evaluate the data that collected, then find and create the problems statement.

After problems statement was created, design the shape and the device. Design the elbow joint rehabilitation devices/machine to overcome the problems. Design the suitable shape of the device according the problems statements. Determine the suitable materials, hardware or software that will be use. Planned the software that suitable used to control a motor driver is Peripheral Interface Controller (PIC), because it provides almost all of the many features found in microcontrollers that are made by the many suppliers of these small yet comprehensive logic engines (Fig 4). This use offers advantages such as lower voltage drop when turn on and the ability to control motors [19]. Besides that, DC geared motor was used in this study, because it variously used in the industrial and widely used in robotics, used to control the movement of a robots.

Follow with the step of Programming, making PCB board and hardware. During this process, we will create a PCB board which the electronic part of the device. During the process of making PCB board, programming can be launch simultaneously. Peripheral Interface Controller (PIC16F877A) used to store the programming, and control the devices/machine. PICs are act as a CPU in this device, and it used to control the motor movement in forward and reversed according the human settings. Besides that, designing and making the hardware for the devices/machine also can be executing.

When the hardware is done, test the Elbow Joint Rehabilitation Device. Test the device, ensure the device is functioning and working in good and safe aspect. (If testing failed, return to the step before, redo the process, testing again the devices). Last step of the whole project process is testing and collects data. Test the device on 30 subjects (20 public and 10 stroke patients) for the clinical testing and usability testing. Then, collect the data from patient by distribute questionnaire and analysis the data by using SPSS. Discuss and conclude the result that had analysed.



*Figure 4: Flow chart process development project*

## **Discussion**

The Elbow Joint Rehabilitation Device that has developed. This device provided 5 degree selections which are 10°, 20°, 30°,50°and 70°. Besides that, this Elbow Joint Rehabilitation device also have count setting, which used to set the number of count the device move upward and downward, the maximum number of count can be set are 50 count. This device have two levels selection which the level 1 has provided 10 degree movement, and the level 2 has provided 20°,30°,50° and 70° movement (fig. 5).

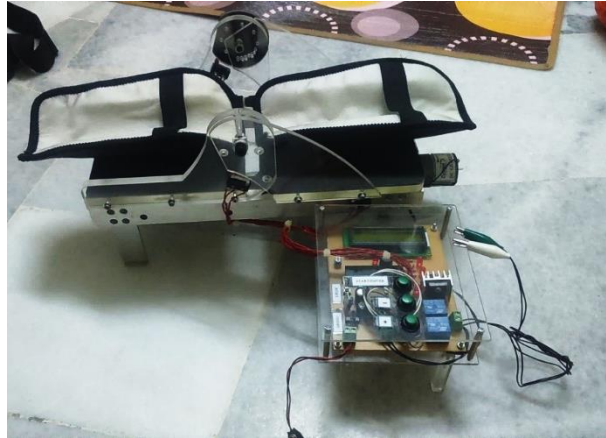
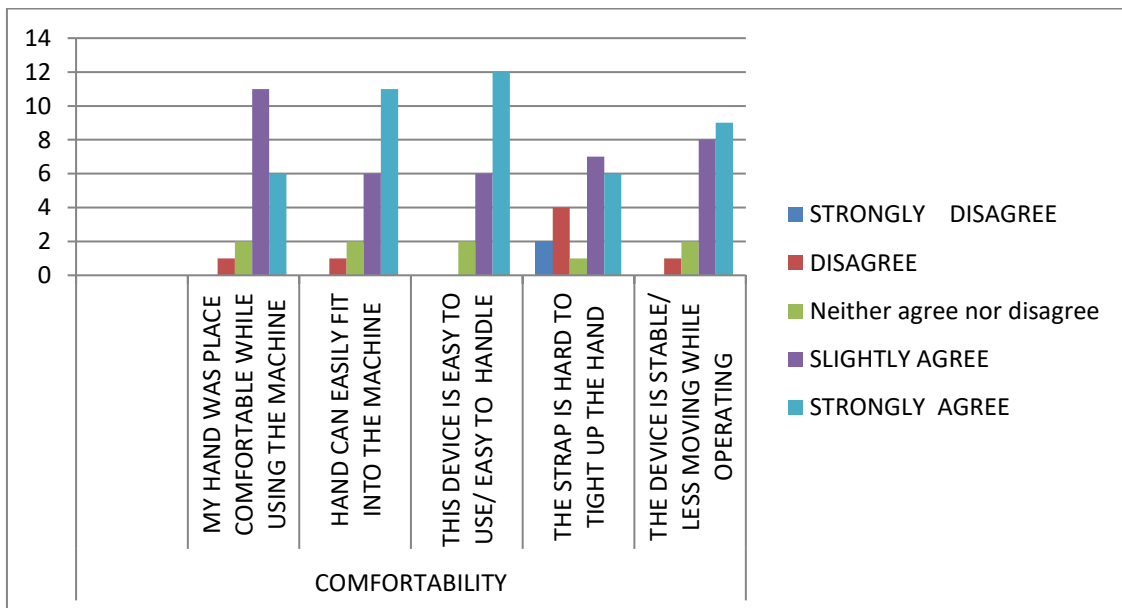


Figure 5: Prototype Elbow Joint Rehabilitation

During this usability testing, 20 normal subjects were tested, and questionnaires were distributed to them. Usability testing have consists of 4 main items which are Comfortability, Strengthens, Speed and Design. These 4 main items data was collected through the usability test, which the subject have tested the developed Elbow Joint Rehabilitation Device, then answered questionnaire (Table 1).

Table 1: Graph of the Comfortability





## Conclusion

As a conclusion, the Elbow Joint Rehabilitation Device is developed, and it have achieved the objective, which the primary objective is to develop a lightly and hand ability elbow joint rehabilitation device for stroke patients. The second objective is to design the control speed circuit for guiding continuous passive motion exerciser and able to operating in a rechargeable battery. A usability test was done, 20 normal subjects was used to measure the comfortability, strengthens, Speed and also Design of the device. During this test, the device was tested on the willingly of the 20 subjects, and the data was collected by distributed questionnaire. Once the testing was done, the data will be analysis by using Microsoft Excel. And the result finding that, the developed device is comfortable to be used. Besides that, it is also well operating with less moving. Furthermore, the developed device is operating in DC batteries, and it was able to move the subject's forearm upward and downward

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## **Development of Spectra Knee CPM Moving Train Walk**

### **Introduction**

According to V. S. Nikolaou, Total Knee Arthroplasty (TKA) or Total knee replacement (TKR) is a widely used operation that has radically improved the quality of life of millions of people suffering from symptomatic Knee Osteoarthritis (OA) during the last decades. Studies have shown that 15% of the world population suffers from osteoarthritis which includes 39 million people in the European countries and more than 20 million of Americans. The number of patients affected is on the rise and by 2020 this figure would have probably multiplied. In Malaysia, 9.3% of adult Malaysians have knee pain and more than half of them have clinical evidence of OA. The prevalence ranges from 1.1% to 5.6% in the various ethnic groups in Malaysia. TKA is one of the most common procedures performed during hospital stay, and according to the national registries, there is a continuously increasing number of operations performed worldwide each year.

In addition, although TKA is common for the management of arthritis but can cause knee stiffness. Knee stiffness can make it difficult to perform certain activities including standing up from a seated position. Continuous passive motion (CPM) is an option to providing regular movement to the knee through a device. The CPM device is a rehabilitation device that utilizes to prevent the stiffening of joints and allow recovering patient full functionality after surgical interventions.

There is a different kind of CPM device for variety joints which is knee, elbow, shoulder, Ankle, wrist & hand. A CPM device can assist the duty of physiotherapist and accomplish such routine physical movements without the assistance of physiotherapist. Therefore, a CPM device is actually widely used for knee rehabilitation because it can increase recovery of knee range of motion (ROM) and able to make the joint back to normal motion as soon as possible.

Besides that, a knee CPM device will passively and repeatedly moves the joint through a specified range of motion (ROM) to gently flex and extend the knee joint. It will be used after surgery to allow the knee joint to slowly bend. By placing the knee in this machine soon after surgery, it will generate increased blood flow and nutrition to the injured site while moving the limb or joint. In other than that, It also is capable to eliminate the problem of stiffness, reduce pain and swelling, reduce scar tissue formation, increase range of motion and flexibility of knee. Thus, it can significantly increase the knee flexion amount of patient by the time after discharge from hospital.

### **Problem Statement**

The use of CPM machine is usually advised by doctor and it will perform all the exercises that a physiotherapist prescribes. Therefore, physiotherapists will use the knee CPM machine on patient to eliminate the problem of stiffness. After I studied the existing device there are some problems identified. First, a knee CPM machine is a large and heavy machine. It will cause the user difficult to carry it. Second, the existing device is only operating in AC power supply. Thus, the user has to look for an AC power supply before the treatment start and it can cause inconvenience for user. Third, an existing device on market is costly. It remains unaffordable for many because it can cost more than thousand US dollar in current market.

## Objective

1. To design a knee CPM machine that can reduce the pain and discomfort of patient when using the machine.
2. To develop a portable knee CPM machine that can easier the patient and physiotherapist to carry and uses.
3. To analyze the usability of knee CPM machine.

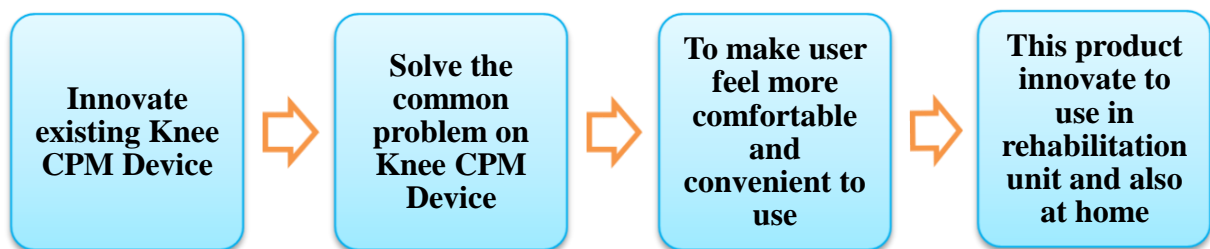


Figure 1: Scope of study

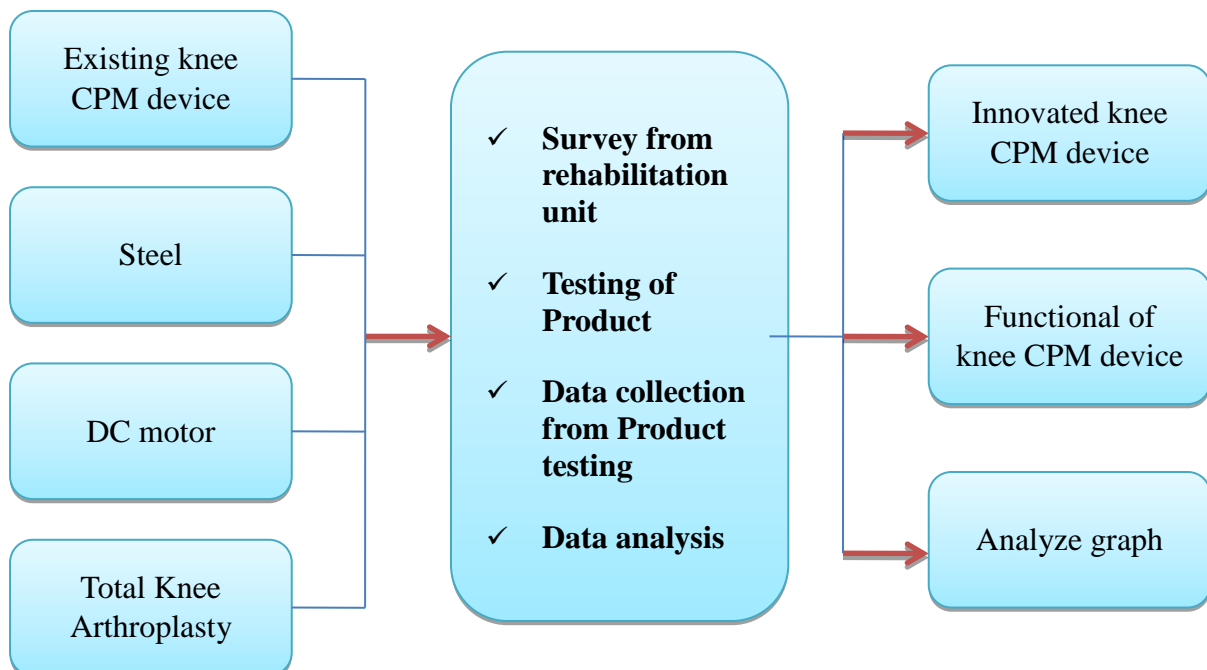


Figure 2: Theoretical of study

## **Knee Joint**

Based on the Arthritis Research UK, knee joint is the largest joint in the body and also most important joints in the human body (fig. 3). It was the strongest joint to take our weight and must lock into position so we can stand upright. It allows the lower leg to move relative to the thigh while supporting the body's weight.[8] According to E. M. Parsons in May 2010, movements at the knee joint are essential to many everyday activities, including walking, running, sitting and standing.[3] The knee joint is also known as the tibiofemoral joint, is a synovial hinge joint formed between three bones: the femur, tibia, and patella. Two rounded, convex processes (known as condyles) on the distal end of the femur meet two rounded, concave condyles at the proximal end of the tibia. [8]

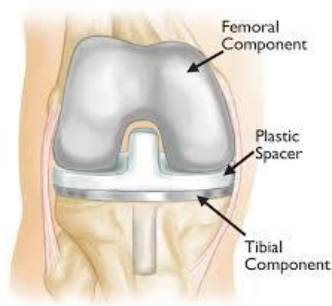


*Figure 3: Knee Joint*

## **Total Knee Arthroplasty (TKA)**

According to The Bay of Plenty District Health Board, Total Knee Arthroplasty (TKA) is an operation where removing natural knee and replaced by an artificial one (fig. 4). The reasons for replacing a knee are varied but the most common is degeneration due to osteoarthritis. The operation is designed to reduce pain and increase mobility. The replacement parts will consist of a metal cap placed on the end of the femur and a plastic cap placed on the top of the shin bone. Sometimes, a plastic insert is used to replace the kneecap.

Besides that, a proper rehabilitation after a TKA is essential to the recovery. Physical therapist will help patient regain much of knee range of motion through Rehabilitation therapy. So the physiotherapists will tailor range-of-motion exercises, progressive muscle-strengthening exercises, body awareness and balance training, and activity-specific training to patient specific needs.[9]



*Figure 4: Total Knee Arthroplasty*

### **Range of Motion (Rom)**

Range of motion (ROM) is a term commonly used to refer to the movement of a joint from full flexion to full extension (fig. 5). It is also known as joint movement, full flexion and full extension. According to Q. Mourcou, exercise physiologist and physiotherapist's measure range of motion in a joint with an instrument called a goniometer that measures joint range of motion in degrees from the starting position. Extension is a physical position that decreases the angle between the bones of the limb at a joint. It occurs when muscles contract and bones move the joint into a bent position. The opposite movement, flexion, bends the joint so that the joint angle shortens.

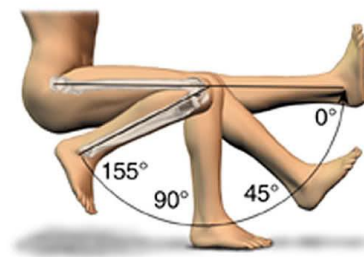
Injuries to the soft tissues surrounding a joint often reduce range of motion due to swelling and tissue damage. Based on A. Tendon and I. Active, regaining range of motion in a joint is one of the first phases of injury rehabilitation, and physiotherapists often prescribe specific ROM exercises for each joint.

For example, decreased knee flexion or extension ROM has been reported following anterior cruciate ligament (ACL) reconstructions, total knee arthroplasties, arthrofibrosis of the knee, and other musculoskeletal injuries involving the knee joint. Loss of knee flexion has been shown to bring altered gait pattern affecting the ankle and hip, limited functional squatting, and difficulty negotiating stairs and sitting. The loss of knee extension can cause altered gait pattern influencing the ankle and hip, powerlessness to achieve the closed packed position of the knee, and difficulty running and jumping.

According to D. Renata and D. Ireneusz, there are three primary types of exercises specific to range of motion which is passive, active-assistive and active ROM. The passive ROM is typically practiced on a joint that is inactive. The physiotherapists may use this exercise on a client who is paralyzed or unable to mobilize a specific joint. This type of exercise can help prevent stiffness from occurring. During this exercise the patient does not perform any movement, while the physiotherapist stretch the patient's soft tissues.

Active-assistive range of motion exercises is more dynamic, intended for the client to perform movement around the joint, with some manual assistance from the physiotherapists or from a strap or band. These exercises can often feel painful, and the muscles can feel weak. Increasing range of motion with these exercises ought to be a steady headway.

Active range of motion exercises are highly independent, performed solely by the client. The physical therapist's role might be basically to give verbal prompts.



*Figure 5: Knee Range of Motion*

The purpose of this study is to solve three problems remaining in current Knee CPM machine, which is designing to minimize discomfort of patient, easy to lift and use, and reduce production costs. Besides that, ensure the device appearance, stability and safety was also required. In order to come out a best solution there are four methods should applied which is proposed, designed, verified and implemented.



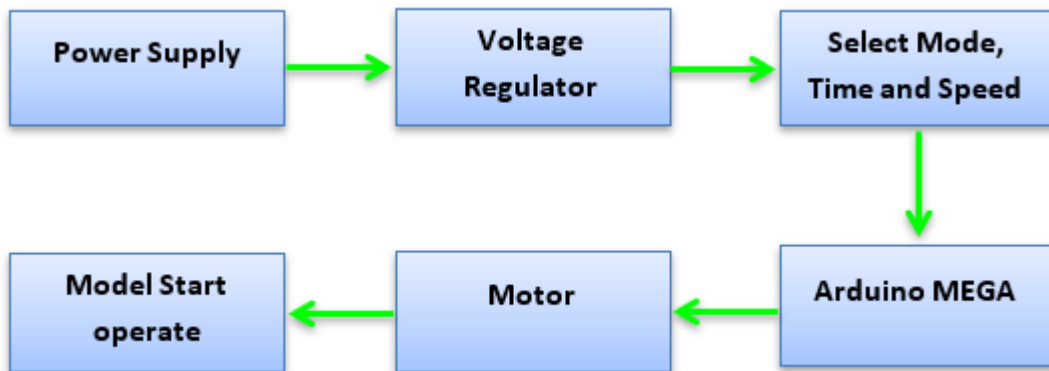


Figure 6: Block Diagram

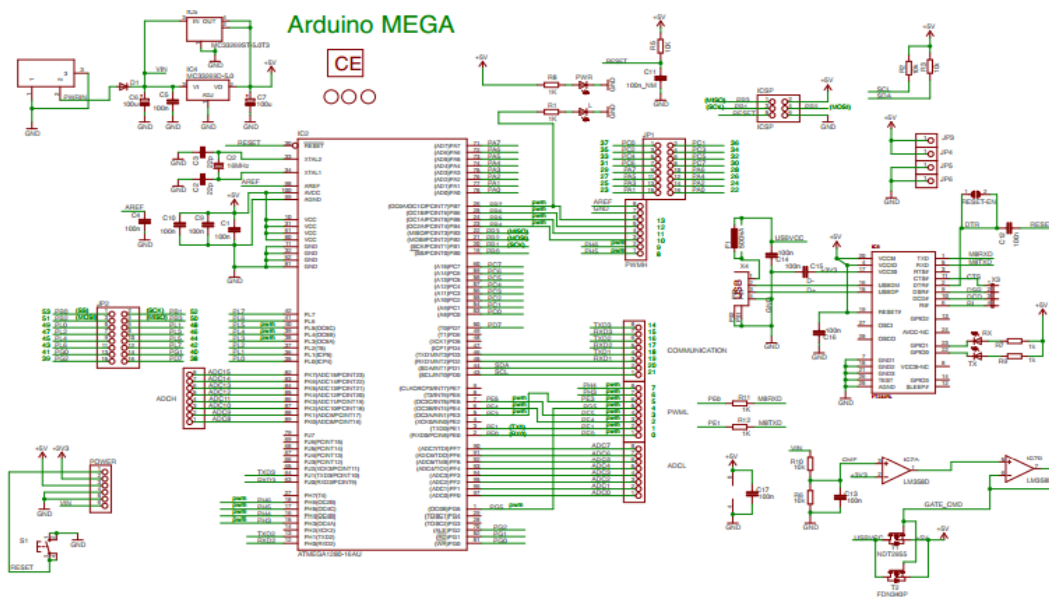


Figure 7: Circuit diagram

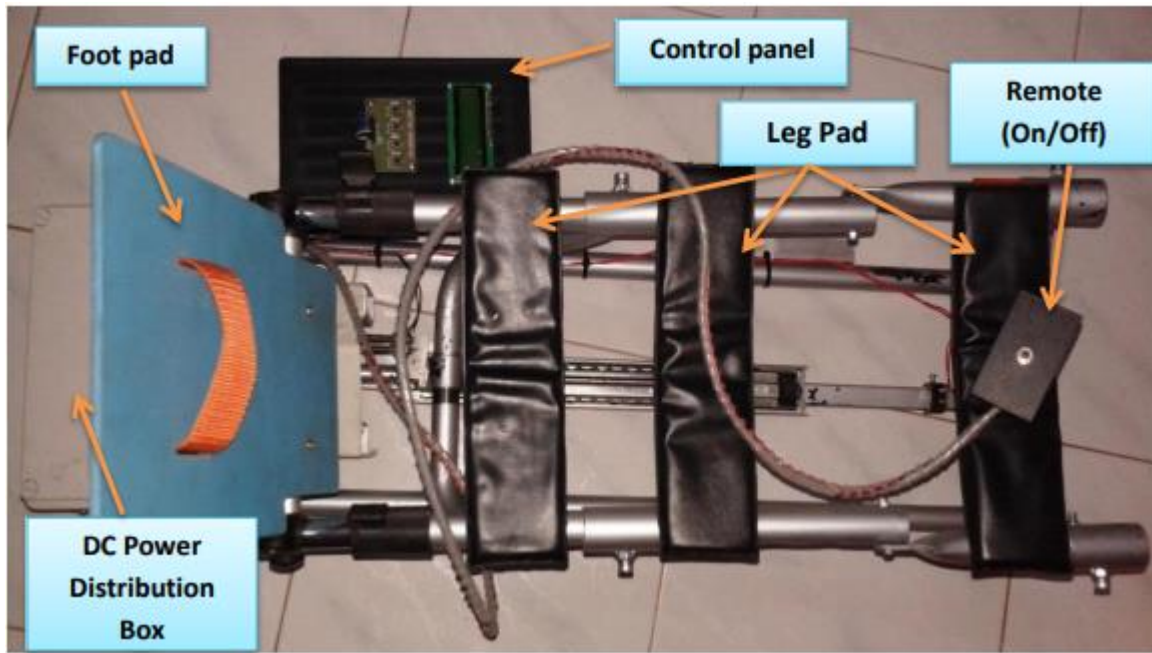


Figure 8: Prototype project

## Discussion

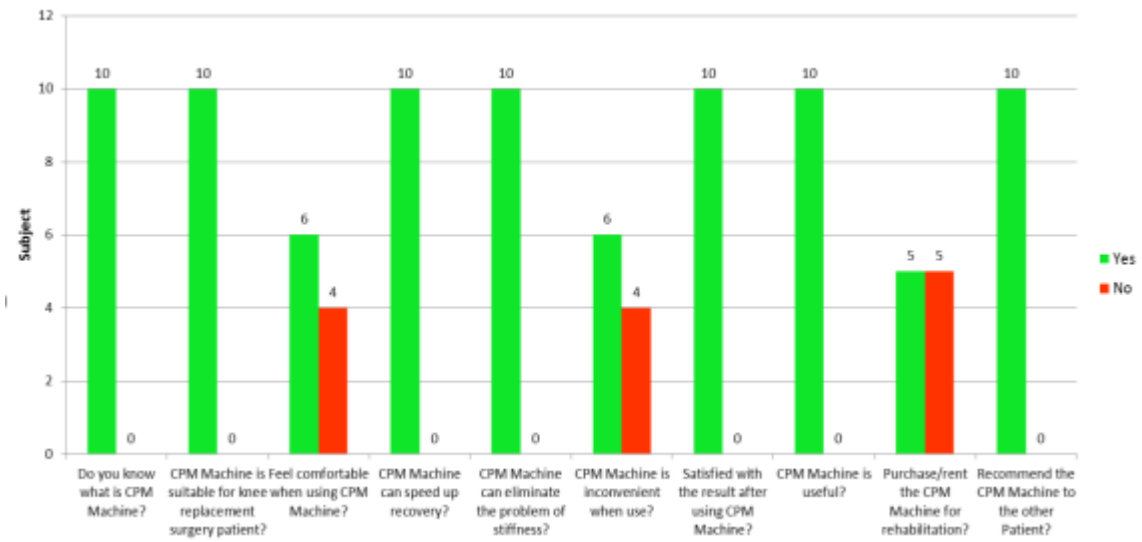
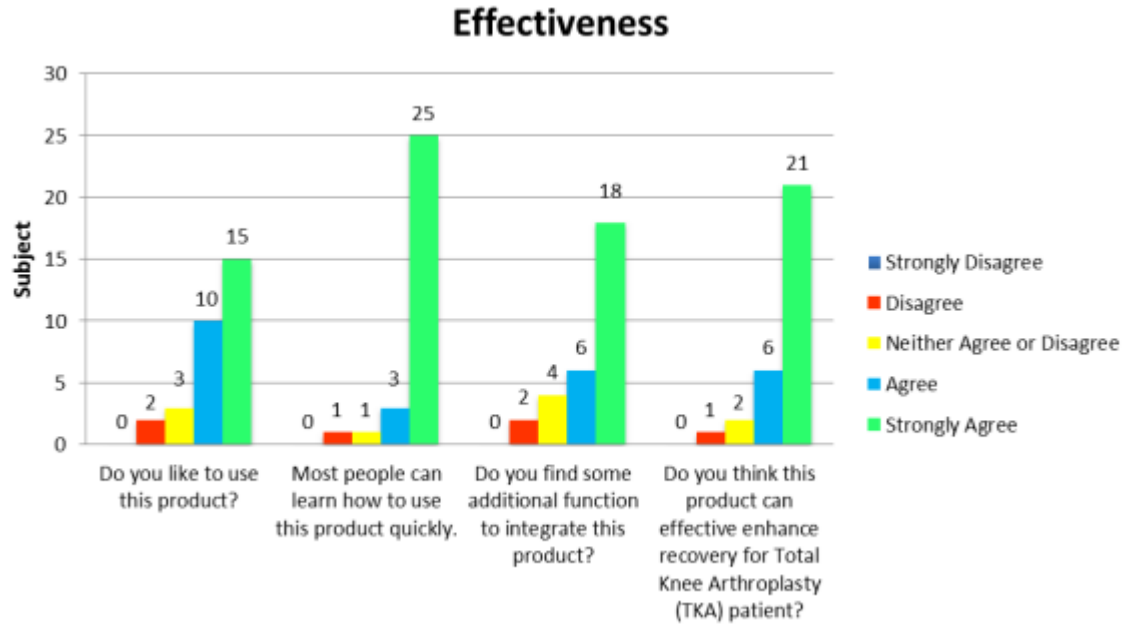


Figure 9: Pre-survey



*Figure 10 : Graph of Effectiveness*

The developed device, there are total 5 parts which is Effectiveness, Comfortableness, Speed, Range and Time, Design and Final Satisfaction Review were tested with difference subjects.

The results obtained from this project will summarize in below:

1. In the effectiveness of the device, there are total 65.8% was strongly agree and 20.8% was agree with the device effectiveness.
2. In the comfortableness of the device, there are total 59.2% was strongly agree and 27.5% was agree with the device comfortableness.
3. In the speed, range and time of the device, there are total 75% was strongly agree and 18.3% was agree with the device speed, range and time.
4. In the design of the device, there are total 59.7% was strongly agree and 27.5% was agree with the device design.
5. In the Final Satisfaction Review, there are total 70.8% was strongly satisfied and 19.2% was satisfied with the device.

## Conclusion

The Spectra Knee CPM device for Total Knee Arthroplasty (TKA) patient is developed. This device contains two main sections, which include a control panel and the mechanical framework. There is a usability test was conducted on subjects to measure the Effectiveness, Comfortableness, Speed, Range and Time, Design and Final Satisfaction Review of the device. During the usability test, the developed device was tested in willingly by the subjects and the data was collected by distributed questionnaire to the subject. Developed device has been recognize by most of the subjects in effectively, comfortable and easier to use. In addition, those subjects were satisfied with this developed device. In conclusion, the developed device has achieved the first objective which to design a knee CPM device that can reduce the pain and discomfort when operate and the second objective to innovate a portable knee CPM device that easier to carry and uses.

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## **COLLABORATION**



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