DEVELOPMENT OF SPEED IN PEDAL EXERCISER FOR PARKINSON'S DISEASE PATIENT

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This Report Is Submitted In Partial Fulfillment Of The Requirements For Bachelor Of Electronic Engineering Technology (Medical Electronic) With Honours

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ENDORSEMENT

"I hereby acknowledge that I have read this report and I find that its contents meet the requirements in terms of scope and quality for the award of the Bachelor Of Electronic Engineering Technology (Medical Electronic) With Honours"

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ABDUL AZIZ SHAH

DECLARATION

"We hereby declare that the work in this report is our own except for the quotation and summaries which have been duly acknowledge"

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ABSTRACT

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. Pedal exercisers are portable and resemble crank pedals of traditional bicycle. In this study, pedal exerciser are innovated from manual pedaling to pedaling with the help of motorization, the function are including the speed. The purpose of this project is to upgrade the existing pedal exerciser with new material which is thermoplastic rubber of pedal exerciser rubber feet so that it can grip well and non-slip during pedaling session. In addition, this innovation is come with an adjustable speed to conduct the study about relationship between Parkinson's disease subject and the use of pedal exerciser as their therapy. The movement of speed will work by stepper motor while the software will be help by Peripheral Interface Controller (PIC). This project will be conduct in two ways of data collection, that is in technically and evaluation. 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 pedaling will help to short the time recovery of them. As a result, shows that the tactic and the used of pedal exerciser is relevant to the Parkinson's disease patient and also to the other user.

ABSTRAK

Pedal exerciser adalah salah satu daripada alat pemulihan untuk membantu pesakit yang mempunyai masalah otot anggota atas dan bawah badan manusia. *Pedal exerciser* boleh digunakan untuk tangan dan kaki. *Pedal exerciser* adalah alat pemulihan yang mudah alih dan berkonsepkan seperti basikal. Kajian ini adalah bertujuan untuk menghasilkan satu inovasi yang mempunyai sistem kayuhan automatik dengan bantuan motor berarus terus dimana kelajuan adalah sebagai pembolehubah. Kajian ini bertujuan menaik taraf *pedal exerciser* yang sedia ada dengan bahan getah baru untuk digantikan pada tapak peralatan tersebut, ini adalah supaya cengkaman pada pelbagai jenis lantai adalah lebih kuat dan tidak menggelongsor semasa sesi kayuhan. Di samping itu, inovasi ini dihasilkan dengan kelajuan boleh laras bagi mengkaji hubung kait antara penyakit Parkinson dengan penggunaan *pedal exerciser* sebagai terapi. Pembolehubah pada kelajuan dibantu oleh *stepper motor* dan sistem perisian menggunakan *Peripheral Interface Controller (PIC)*. Kajian ini terbahagi kepada 2 kaedah pengendalian, iaitu kajian secara teknikal dan juga klinikal yang melibatkan pesakit sebenar. Objektif memfokuskan menganalisis masalah yang sentiasa terjadi selain mencari jalan penyelesaiannya. Selain itu, pengubahsuaian pada kelajuan alat ini bertujuan membantu pesakit Parkinson seperti yang dinyatakan dalam sebuah artikal bahawa kayuhan yang laju iaitu sekurang-kurangnya 80rpm boleh membantu memendekkan masa pemulihan pesakit tersebut. Diakhir kajian ini, didapati bahawa kaedah penambahbaikan serta penggunaan pedal exerciser berkesan kepada pesakit Parkinson dan juga kepada pengguna yang lain.

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Introduction

1.1 Background of study

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[1]. 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[2].

1.2 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 are 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 are having this problem because of the leg's rubber, it is not gripping well on certain type of floor. This situation cause 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 purpose in this study is to help Parkinson's disease patient do exercise whenever they want without have to goes out from home. Tandem bicycle have the same cycling theory of

pedal exerciser, so it is should be fine if therapist use pedal exerciser to help Parkinson's disease patient.

1.3 Objective

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.

In order to achieve the main objective, the sub objectives are as below:-

(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.

1.4 Study population

In this study, the subjects are consists of public with or without ankle, foot or knee pain for the usability test and Parkinson's disease patient who are desire to heal. The population of subjects are among the Polytechnic Premier Sultan Salahuddin Abdul Aziz Shah, Shah Alam, focusing in Electrical Engineering Department. For Parkinson's disease patient, they are from Salam Hospital Shah Alam and Hospital Tengku Ampuan Rahimah, Klang.

This study have its own inclusion and exclusion criteria, which is for inclusion criteria, the scope of this study is focusing on the individual that can still make legs movement and walking around but not really well, and the Parkinson's disease patient in level 1 to level 3. For exclusive criteria, it is criteria which is not included and also not suitable in this study. Exclusive criteria are included individual that cannot even move their legs and can't afford to walk at all, and also the Parkinson's disease patient of level 4 to level 5.

1.5 Sample size and sampling technique

In this study, Krejcie and Morgan theory has been used to determine the sample size. The population of limitation for this study is 30 subjects, so that the sample size will be 28 subjects including Parkinson's disease patient and individual with ankle, knee and legs pain for the analysis of technical and evaluation test.

N	S	N	S	N	S	N	S	N	S
10	10	100	80	280	162	800	260	2800	338
15	14	110	86	290	165	850	265	3000	341
20	19	120	92	300	169	900	269	3500	346
25	24	130	97	320	175	950	274	4000	351
30	28	140	103	340	181	1000	278	4500	354
35	32	150	108	360	186	1100	285	5000	357
40	36	160	113	380	191	1200	291	6000	361
45	40	170	118	400	196	1300	297	7000	364
50	44	180	123	420	201	1400	302	8000	367
55	48	190	127	440	205	1500	306	9000	368
60	52	200	132	460	210	1600	310	10000	370
65	56	210	136	480	214	1700	313	15000	375
70	59	220	140	500	217	1800	317	20000	377
75	63	230	144	550	226	1900	320	30000	379
80	66	240	148	600	234	2000	322	40000	380
85	70	250	152	650	242	2200	327	50000	381
90	73	260	155	700	248	2400	331	75000	382
95	76	270	159	750	254	2600	335	1000000	384

Note: N = Population Size; S = Sample Size *Source: Krejcie & Morgan, 1970*

Table 1.1 : Krejcie and Morgan table for determine sample size

1.6 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.

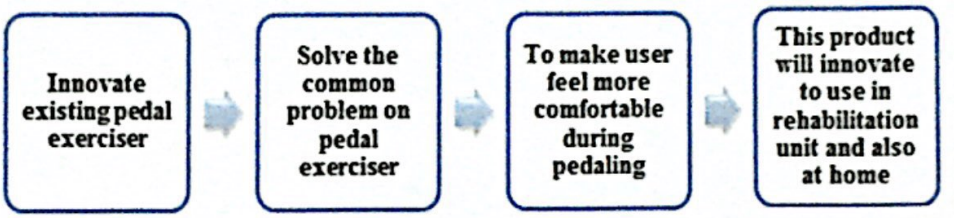

Figure 1.1 : Significant of study

1.7 Theoritical of the study

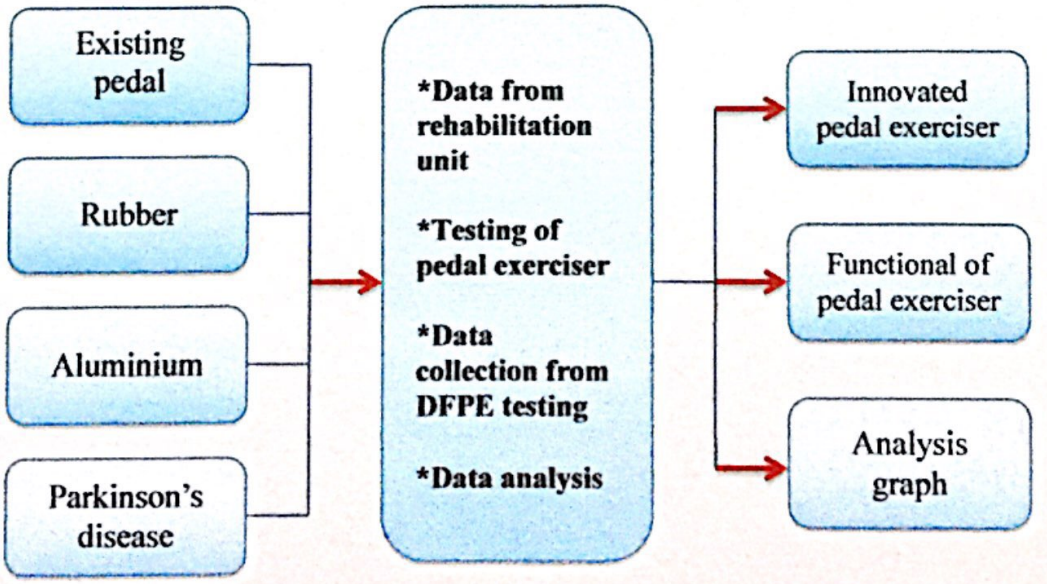

Figure 1.2 : Theoretical of study

Chapter 2

Literature Review

2.1 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.

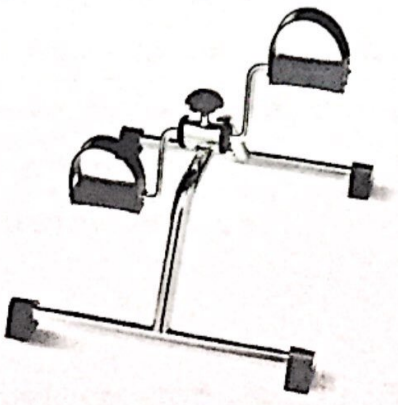

Figure 2.1 : Pedal exerciser

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[3].

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.

2.2 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[4]. 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) [5]. 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 decades, said Dorsey et al (2007) [5]. 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. 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].

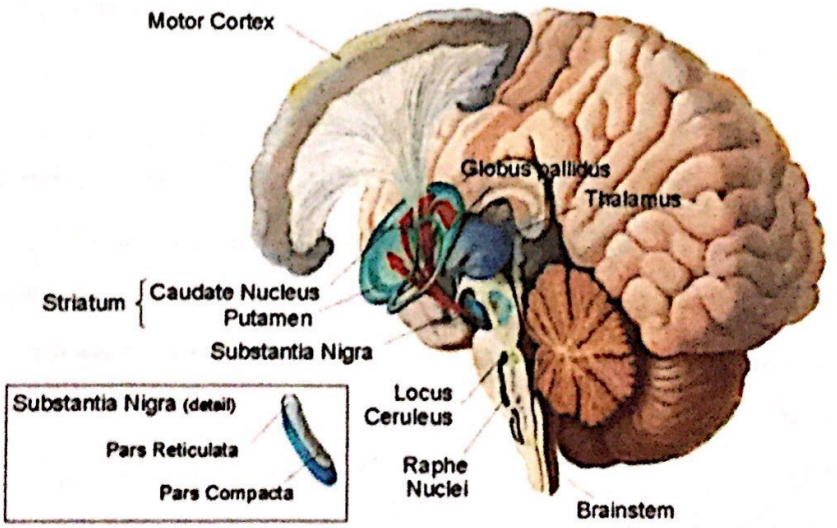

Figure 2.2 : Brain regions affected by Parkinson's disease

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.

2.2.1 Symptoms of Parkinson's disease

Symptoms of PD can be divided into two main parts, which is motor symptom and non-motor symptom. Motor symptom is a symptom that typically involved a loss of motor coordination or lead to restricted mobility. Non-motor symptoms of PD are those that do not involved movement, coordination, physical tasks or mobility. PD patient that having non-motor symptom are "invisible" which is they family and friends may not be able to see their symptom, it is can actually be more troublesome for some people than the motor impairments of PD[8].

Motor symptoms of PD can be classified into two, which is primary and secondary. Primary motor symptom of PD can be identified by its cardinal motor symptoms: tremor, bradykinesia, muscle rigidity and gait instability[9]. While for secondary motor symptoms, it is an addition to the cardinal sign of PD, there are many other motor symptoms associated with the disease: freezing (freezing of gait is an important sign of PD that is not explained by rigidity or bradykinesia), micrographia (this term is the name for shrinkage in handwriting that progresses the more a person with Parkinson's writes. This occurs as a result of bradykinesia, which causes difficulty with repetitive actions), mask-like expression (face may appear less expressive than usual, can occur because of decreased unconscious facial movements.), unwanted

acceleration (These unwanted accelerations are especially troublesome in speech and movement.).

Currently, therapist act mainly on the dopaminergic system, with the overall goal of improving motor symptoms and preserving independent function by enhancing dopamine tone. However, intrinsic non-motor symptoms of PD are increasingly recognized as being critical to identity and treat because of their impact on quality of life in PD, perhaps having an even greater impact than motor symptoms. Most common symptom of non-motor PD are autonomic dysfunction cognitive abnormalities, sleep disorder, mood disorder, pain and sensory disorder[9].

2.2.2 Level of Parkinson's disease

PD strikes people in many different ways, leaving them to experience a broad range of symptoms. Though symptoms may be mild or severe or occur frequently or infrequently, Parkinson's disease appears to have five different stages[10]. The time spent at each stage varies, and the skipping of stages, from stage one to stage three, for example, is not uncommon. Parkinson's disease stages include five main stages.

Stage one of PD, a person usually experiences mild symptoms, such as tremors or shaking in a limb. During this stage, friends and family can usually detect changes caused by Parkinson's, such as poor posture, loss of balance, and abnormal facial expressions. In stage two, the person's symptoms are bilateral, affecting both limbs and both sides of the body. The person usually encounters problems walking or maintaining balance, and the inability to

complete normal physical tasks becomes more apparent. Stage three symptoms of Parkinson's disease can be rather severe and include the inability to walk straight or to stand. There is a noticeable slowing of physical movements in stage three.

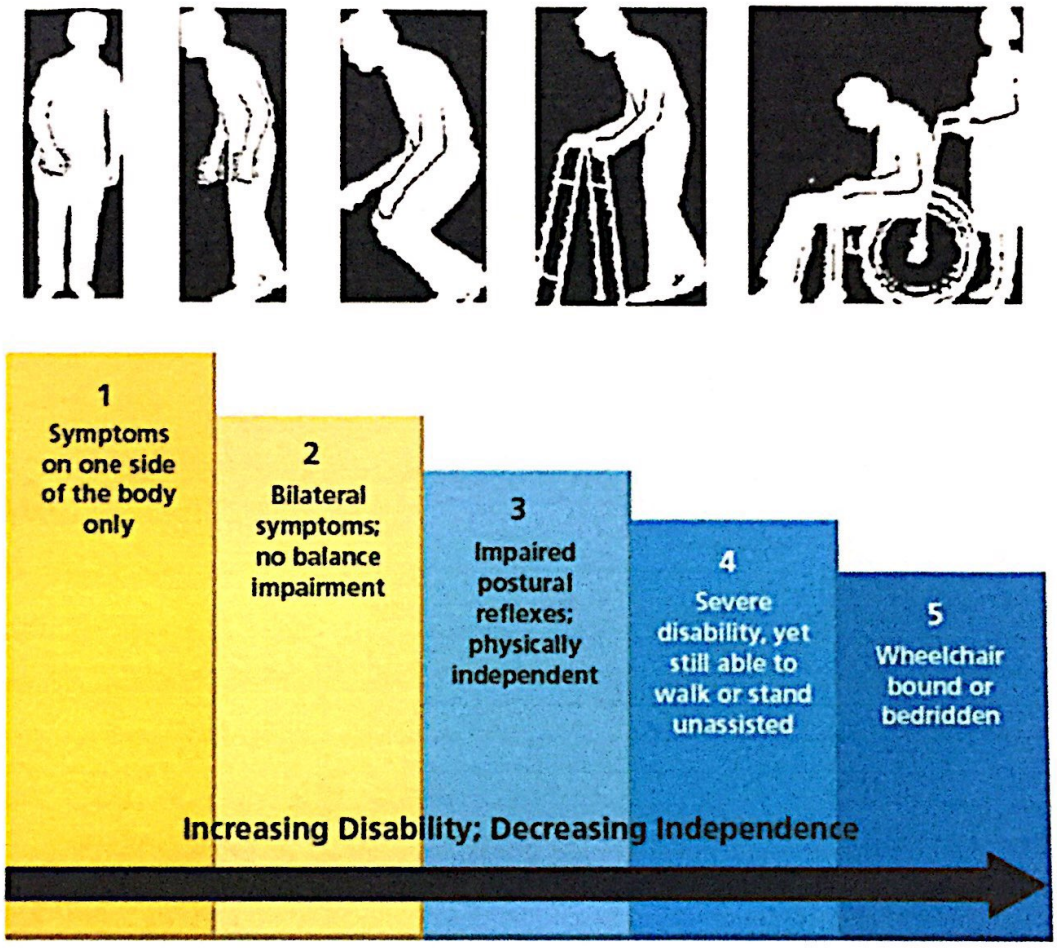

Figure 2.3 : Hoehn and Yahr staging theory

During stage four, the disease is accompanied by severe symptoms of Parkinson's. Walking may still occur, but it is often limited, and rigidity and bradykinesia, the symptoms sometime will slow of movement and are often visible. During this stage, most patients are unable to complete day-to-day tasks, and usually cannot live on their own. The tremors or shakiness of the earlier stages of the disease, however, may lessen or become non-existent for

unknown reasons during this time. In the last or final stage of Parkinson's disease, that is stage five, the person is usually unable to take care of their self and may not be able to stand or walk. A person at stage five usually requires constant one-on-one nursing care.

2.2.3 Difficulty walking consequences and tremor of Parkinson's disease (PD)

The brain has a remarkable ability to repair itself and can learn to use the return movement from the brain healthy. Muscle memory also can be related with bloom's taxonomy that is divided into 3 domains that is cognitive, affective and psychomotor. Cognitive is a mental skill that is involved knowledge and the development of intellectual skills (bloom, 1956). This includes the recall or recognition of specific facts, procedural patterns, and concepts that serve in the development of intellectual abilities and skills. There are six major categories of cognitive, starting from the simplest to the most complex; knowledge, comprehension, application, analysis, synthesis and evaluation. Cognitive control the brain, brain is the controller of all brain's activity. When cognitive did not done it function well, brain cannot interpret and send signal to do movement. This condition will cause psychomotor failure and movement in Parkinson's disease patient tremor.

PD is known as a multi-symptomatic syndrome which is almost of the patients will experience tremor at a given time in the disease process[11]. PD causes certain brain cells to die. These are the cells that help control movement and coordination. The disease leads to shaking (tremor), trouble walking and moving when the brain cells die. Nerve cells use a brain chemical called dopamine. It is function to help control muscle movement. With PD, the brain cells that produced dopamine will slowly die. Because of

no dopamine production, the cells that control movement cannot send messages to the muscle. This causes it hard to control muscle then slowly, over time, the damages gets worse. There is no prove yet on what causes these brain cells to waste away.

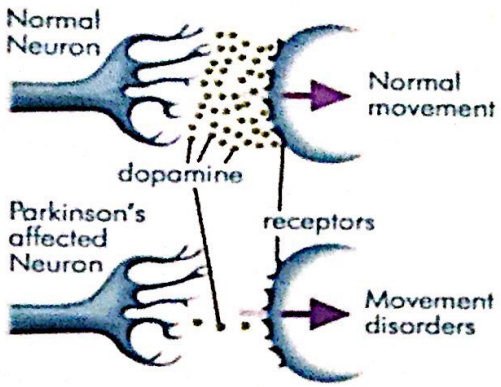

Figure 2.4 : Dopamine levels in a normal and a Parkinson's affected neuron

Parkinson's disease occurs when nerve cells, or neurons, in an area of the brain that controls movement become impaired and/or die. Normally, these neurons produce an important brain chemical known as dopamine, but when the neurons die or become impaired, they produce less dopamine. This shortage of dopamine causes the movement problems of people with Parkinson's.

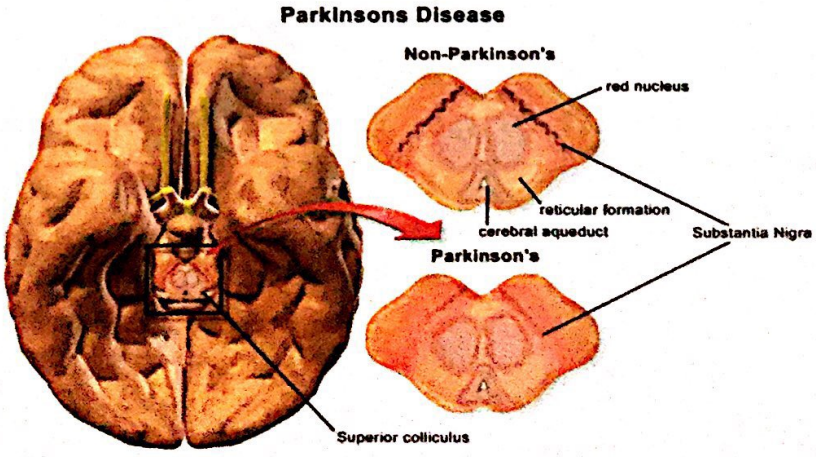

Figure 2.5 : The different between normal human brain and the brain with PD

Dopamine is a chemical messenger, or neurotransmitter. Dopamine is responsible for transmitting signals between the substantia nigra and multiple brain regions. The connection between the substantia nigra and the corpus striatum is critical to produce smooth, purposeful movement. Loss of dopamine in this circuit results in abnormal nerve-firing patterns within the brain that cause impaired movement.

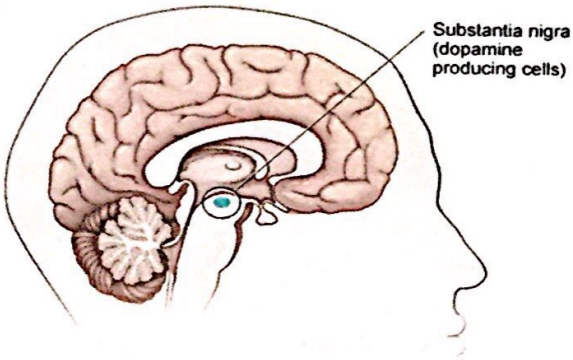

Figure 2.6 : The placement of substantia nigra in human brain

Here is the dopamine pathway for the motor system. Dopamine signals travel from the substantia nigra to brain regions including the corpus striatum, the globus pallidus, and the thalamus in order to control movement and balance. In Parkinson's disease, most of the dopamine signals from the substantia nigra are lost[12].

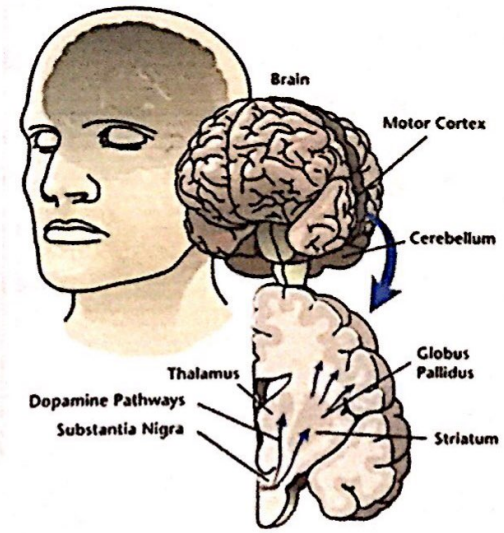

Figure 2.7 : Dopamine pathway from substantia nigra

2.2.4 Relationship between pedal exerciser (cycling activity) and Parkinson's disease

Recently, the efficacy in the field of Parkinson's disease management has been proved their physical therapy strategies[13]. It shows that higher speed during cycling may help Parkinson's disease patient in healing process. Force exercise can be as a Parkinson's disease therapy treatment (Jay Alberts, PhD, Biomedical Engineer from Cleveland Clinic). In 2003 Dr Alberts pedalled the lead position on a tandem bicycle with a woman that has Parkinson's disease during a 200 miles group bicycle trip across Lowa[1].

The relationship between cycling activity and the healing process of Parkinson's disease can be described in the situation below. Normally, the woman with Parkinson's disease would pedal at speed of 50-60 repetitions per minutes (RPM), but during this trip she was forced to pedal at rate of 80-90 RPM with Dr Alberts. Before the ride during the trip, the woman with Parkinson's disease was suffering from worst hand tremble (tremor). After the two session pedalled throughout the day, the woman noticed her tremor went away while she was pedalling on the tandem bicycle. Fast pedalling than the patient can achieve voluntarily may be driving the central nervous system of the PD patient which may help in an increase in the release of dopamine[14]. Fast pedalling was the key factor related to these improvements. It appear that a key factor in improving motor function and pattern of activation in the brain is to pedal at a relatively high rate – for example, greater than 80 rpm[14].

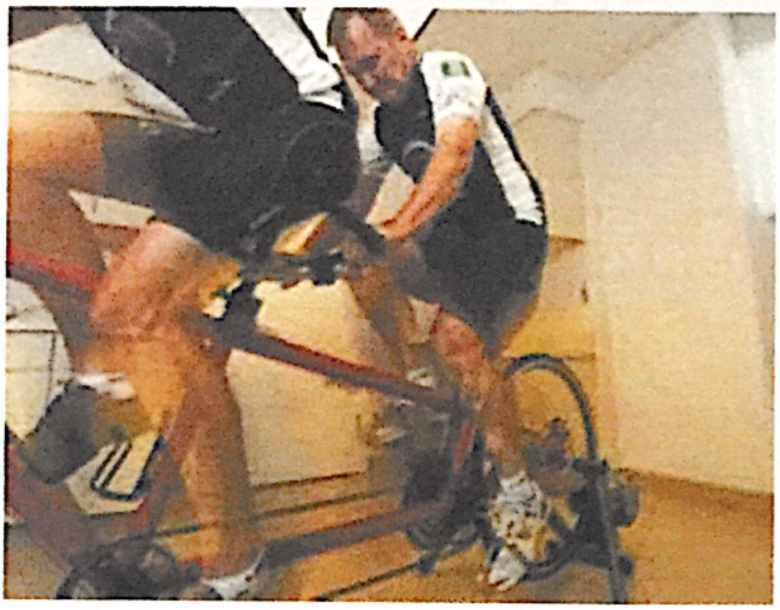

Figure 2.8 : Tandem bicycle cycling activity by PD patient

The healing progress can be measure by using Electromyography (EMG) technique. EMG is an easy to use technique and has been commonly used in measurement and vast range of research on muscle physiology[13]. During EMG process, it is involves two types of electrode which is surface and intramuscular fine wire. To run this procedure, it requires needle insertion into muscle that causes pain to the subject.

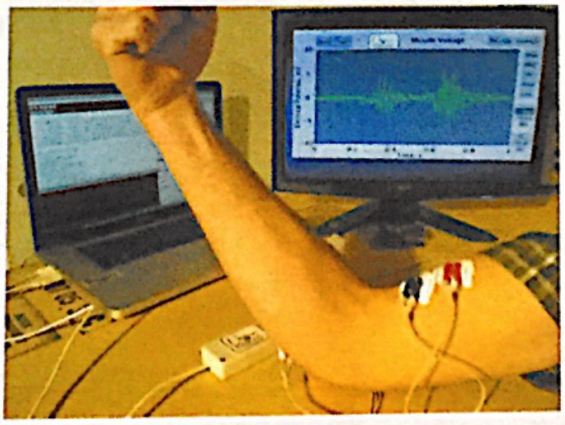

Figure 2.9 : Electromyography (EMG) technique

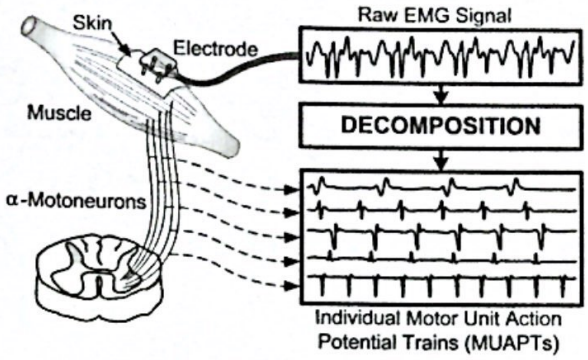

Figure 2.10 : The procedure of EMG

Forced exercise, in this case, is defined operationally as a mode of aerobic in which exercise rate is augmented mechanically to assist the participant in achieving and maintaining an exercise rate that is greater than what their preferred voluntary rate of exercise. It is important to note that forced exercise, the participant is contributing actively to the exercise; they are not being moved through the motion passively[15].

Effectiveness of forced exercises can be proved through the experiment by biomedical engineer, Jay Alberts, PhD. PD patient in forced exercise group had on average a 30-percent improvement in their symptoms, if compared to the patient in the voluntary exercise group. After two weeks of the study, PD patients in the forced exercise group still had about a 20-percent improvement[1].

2.3 Thermoplastic Elastomer (TPE)

Thermoplastics are extremely useful in the production of handle grips, appliance feet and other non-slip products. This resilient material is used in applications across the spectrum, and manufacturers find that is more

economical and has a longer lifespan than thermoset rubber. Because of its ability to absorb shock, thermoplastic elastomers are often used as handlebar grips for bicycles and motorcycles, but also on high-vibration power tools. Thermoplastic elastomer blends were prepared by melt mixing in an internal mixer, at 180°C and 50 rpm of rotor speed[16].

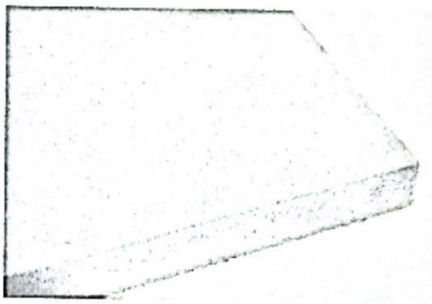

Figure 2.11 : Thermoplastic Elastomer (TPE)

Thermoplastic elastomers are flexible, rubber-like materials that are highly stretchable and useful in a variety of industries. They can be stretched to more than twice their original size and shape while still maintaining their structural integrity. Thermoplastic elastomers are true thermoplastics and do not require vulcanization or curing. Especially thermoplastic polymer reinforced composites exhibit significant strain rate dependent deformation behavior, where stiffness and strength are highly rate dependent[17]. Thermoplastic elastomers are used in a variety of processes from injection molding to 2-shot molding, blow molding and extrusion. On the hardness scale, they range from rigid and firm to soft and gel-like.

Thermoplastic elastomers are the most commonly used polymer in gripping plastic like those that are commonly found in exercise equipment. Thermoplastic elastomers dominate products all around us. The rubber grips on toothbrushes, dog chew toys and the handles on garden tools are all examples of thermoplastics in action. This versatile polymer is great for a variety of uses and can be customized for manufacturing needs. The

properties of thermoplastic elastomers are highly sensitive to chemical and physical structure of the material, that are potentially under the control of the synthesis[18].

2.3.1 Comparison between thermoplastic elastomer and thermoset rubber

Thermoplastics and thermosets sound alike but in fact, they have very different properties and characteristics. They are ideal materials for different applications. Understanding what sets them apart starts with understanding chemistry and processing. This knowledge will help in making an informed sourcing decision and select a suitable material that will improve products[19]. Thermoplastic elastomers can be repeatedly melted and also cooled. Throughout this process, the elastomer becomes liquid at a certain temperature level but retains its shape when it is become cool. Thermoplastic elastomers are soluble in particular solvents and will burn if heated above s certain temperature. Person in charge must be alert during processing and molding to avoid degradation and ignition of material, however, thermoplastic elastomer material can be continually reused.

Thermoplastic elastomers are alike as spaghetti. Then, when allowed to cool, they stay interwoven and hold their form and shape tightly. Similarly, the molecular chains of thermoplastic elastomers become soft and slippery when heated, reaching more of a liquid stage and allowing the material to flow easily. At this stage, they can be molded into just about any shape and size; once cooled, they will maintain that shape. Additionally thermoplastic elastomers, once cooled, can be repeatedly stretched and then will regain their shape. Thermoplastic elastomers, in essence, go through a physical change when being processed.

Process of thermoplastic needs the pellets become more fluid and soften as more heat is applied. There is no chemical bonding during the process; therefore, can be reversed and the material can be remolded or reshaped as needed without affecting the quality. This allows for use of waste and scraps. Thermoplastics can be moled into very small detailed parts. They are also capable of retaining intricate surface designs. They have a wide performance offering but commonly have high strength, are shrink resistant, and can be used in both low and high stress parts. As well, everything in this earth have its pros and cons, here goes to the thermoplastic elastomers which is prove its advantages in recyclable, excellent impact resistance, capable of being remolded or shaped, superior aesthetic finishes, thick to thin wall parts and chemical resistant. While its disadvantages is can melt if heated above melt point.

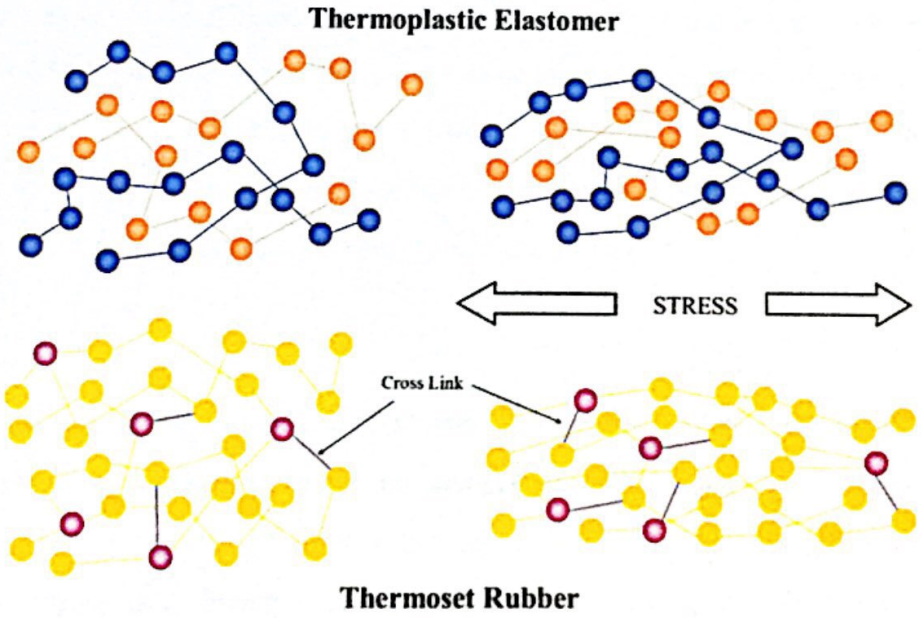

Figure 2.12 : Comparison of chemical bonds between thermoplastic elastomer and thermoset rubber

Thermoset rubbers, on the other hand, can be likened to cake. Once the ingredients are mixed and baked, they hold a particular shape, but the finished cake cannot be poured into another pan and reshaped after it is

cooked. In a similar way, when thermoset elastomer material is processed, it goes through a curing or vulcanization process, where the molecules cross-link, causing them to be permanently insoluble and infusible and affecting many characteristics and physical properties. Thermoset rubbers cannot be repeatedly melted and cooled, because, unlike thermoplastic elastomers, Thermoset rubbers go through a chemical change during processing. This chemical change translates into more waste and the inability to reuse, remold or recycle the material. Common thermoset rubbers include neoprene, nitrile, rubber latex, silicone, and butyl.

During the curing process thermoset polymers create chemical bonds called cross-linking. This cross-linking is not reversible and products will resist melting when heat is applied. The natural resistance to heat makes thermosets ideal for high-heat applications in appliances and electronics. Thermosets have a high heat resistance and structural integrity. They are used in high heat applications to avoid deformation. The advantages of thermoset rubber are resistance to higher temperatures, excellent aesthetic appeal, flexible design, high level of dimensional stability and thick to thin wall design. While the disadvantages are not recyclable, cannot be remolded or shaped, more scrap or waste from processing and difficult to surface finish.

As a conclusion, thermoplastic elastomers are much better comparing to thermoset rubber. Thermoplastic elastomers offer numerous advantages, which is: it is recyclable and more environmentally friendly, shorter processing time and lower production costs, simpler processing, greater design flexibility, broader range of physical properties, tighter control of product quality which increase the consistency of the end product.

2.4 Peripheral Integrated Circuit (PIC)

Peripheral Interface Controllers (PIC) is one of the advanced microcontrollers developed by microchip technologies. These microcontrollers are widely used in modern electronics applications. A PIC controller integrates all type of advanced interfacing ports and memory modules. An integrated circuit, more often called an IC, microchip, silicon chip, computer chip, or chip is a piece of specially prepared silicon or another semiconductor into which a very complex electronic circuit is etched using photographic techniques. Silicon chips can contain computer processors, memory and special devices. The chip is very fragile and so is normally surrounded by a tough plastic package, and electrical contact with the chip is provided through metal legs sticking out of the package.

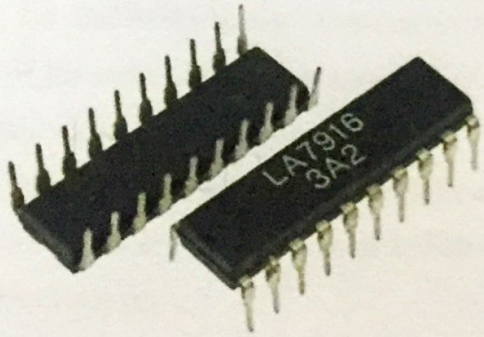

Figure 2.13 : Peripheral integrated circuit (PIC)

There are two main advantages of ICs over discrete circuits: cost and performance. Cost is low because millions of transistors are printed as a complete unit by photolithography and not constructed as one transistor at a time. Performance is higher since the components switch quickly, consuming little power. ICs are designed for different purposes. A chip may be designed as a calculator, which only works as a calculator. Integrated circuits can be classified into analogue, digital and mixed signal (both analogue and digital on the same chip).

2.4.1 PIC16f877A

The PIC microcontroller PIC16f877a is one of the most renowned microcontrollers in the industry. This controller is very convenient to use, the coding or programming of this controller is also easier. One of the main advantages is that it can be write-erase as many times as possible because it use FLASH memory technology. It has a total number of 40 pins and there are 33 pins for input and output. PIC16F877A is used in many pic microcontroller projects. PIC16F877A also have many applications in digital electronics circuits.

PIC16f877a finds its applications in a huge number of devices. It is used in remote sensors, security and safety devices, home automation and in many industrial instruments. An EEPROM is also featured in it which makes it possible to store some of the information permanently like transmitter codes and receiver frequencies and some other related data. The cost of this controller is low and its handling is also easy. It is flexible and can be used in areas where microcontrollers have never been used before as in coprocessor applications and timer functions etc.

2.4.2 Pin configuration and description of PIC16F877A

As it has been mentioned before, there are 40 pins of this microcontroller IC. It consists of two 8 bit and one 16 bit timer. Capture and compare modules, serial ports, parallel ports and five input/output ports are also present in it.

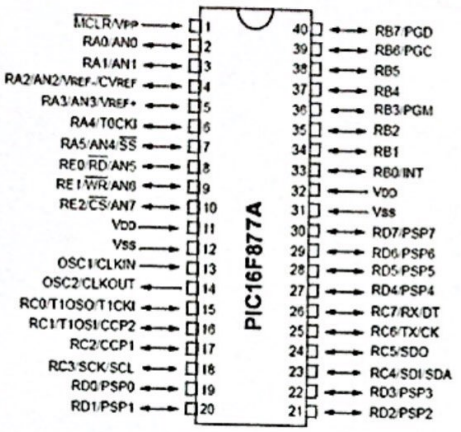

Figure 2.14 : 40pins of PIC16F877A

PIN 1: MCLR

The first pin is the master clear pin of this IC. It resets the microcontroller and is active low, meaning that it should constantly be given a voltage of 5V and if 0 V are given then the controller is reset. Resetting the controller will bring it back to the first line of the program that has been burned into the IC.

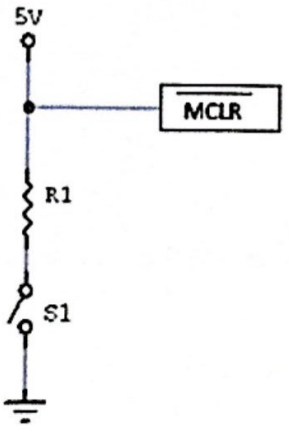

Figure 2.15 : Pin number 1of PIC16F877A

A push button and a resistor is connected to the pin. The pin is already being supplied by constant 5V. When we want to reset the IC we just have to push the button which will bring the MCLR pin to 0 potential thereby resetting the controller.

PIN 2: RA0/AN0

PORTA consists of 6 pins, from pin 2 to pin 7, all of these are bidirectional input/output pins. Pin 2 is the first pin of this port. This pin can also be used as an analogue pin AN0. It is built in analogue to digital converter.

PIN 3: RA1/AN1

This can be the analogue input 1.

PIN 4: RA2/AN2/Vref-

It can also act as the analogue input2. Or negative analogue reference voltage can be given to it.

PIN 5: RA3/AN3/Vref+

It can act as the analogue input 3. Or can act as the analogue positive reference voltage.

PIN 6: RA0/T0CKI

To timer0 this pin can act as the clock input pin, the type of output is open drain.

PIN 7: RA5/SS/AN4

This can be the analogue input 4. There is synchronous serial port in the controller also and this pin can be used as the slave select for that port.

PIN 8: RE0/RD/AN5

PORTE starts from pin 8 to pin 10 and this is also a bidirectional input output port. It can be the analogue input 5 or for parallel slave port it can act as a 'read control' pin which will be active low.

PIN 9: RE1/WR/AN6

It can be the analogue input 6. And for the parallel slave port it can act as the 'write control' which will be active low.

PIN 10: RE2/CS/A7

It can be the analogue input 7, or for the parallel slave port it can act as the 'control select' which will also be active low just like read and write control pins.

PIN 11 and 32: VDD

These two pins are the positive supply for the input/output and logic pins. Both of them should be connected to 5V.

PIN 12 and 31: VSS

These pins are the ground reference for input/output and logic pins. They should be connected to 0 potential.

PIN 13: OSC1/CLKIN

This is the oscillator input or the external clock input pin.

PIN 14: OSC2/CLKOUT

This is the oscillator output pin. A crystal resonator is connected between pin 13 and 14 to provide external clock to the microcontroller. ¼ of the frequency of OSC1 is outputted by OSC2 in case of RC mode. This indicates the instruction cycle rate.

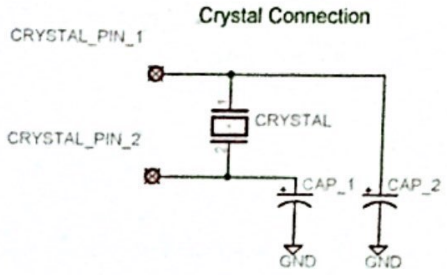

Figure 2.16 : Pin number 14 of PIC16F877A

PIN 15: RC0/T1OCO/T1CKI

PORTC consists of 8 pins. It is also a bidirectional input output port. Of them, pin 15 is the first. It can be the clock input of timer 1 or the oscillator output of timer 2.

PIN 16: RC1/T1OSI/CCP2

It can be the oscillator input of timer 1 or the capture 2 input/compare 2 outputs/ PWM 2 output.

PIN 17: RC2/CCP1

It can be the capture 1 input/ compare 1 output/ PWM 1 output.

PIN 18: RC3/SCK/SCL

It can be the output for SPI or I2C modes and can be the input/output for synchronous serial clock.

PIN 23: RC4/SDI/SDA

It can be the SPI data in pin. Or in I2C mode it can be data input/output pin.

PIN 24: RC5/SDO

It can be the data out of SPI in the SPI mode.

PIN 25: RC6/TX/CK

It can be the synchronous clock or USART Asynchronous transmit pin.

PIN 26: RC7/RX/DT

It can be the synchronous data pin or the USART receive pin.

PIN 19,20,21,22,27,28,29,30:

All of these pins belong to PORTD which is again a bidirectional input and output port. When the microprocessor bus is to be interfaced, it can act as the parallel slave port.

PIN 33-40: PORT B

All these pins belong to PORTB. Out of which RB0 can be used as the external interrupt pin and RB6 and RB7 can be used as in-circuit debugger pins.

2.4.3 The programming of input and output for PIC16F877A

5 input and output ports namely PORTA, PORTB, PORTC, PORTD and PORTE which can be digital as well as analogue. We will configure them according to our requirements. But in case of analogue mode, the pins or the ports can only act as inputs. There is a built in A to D converter which is used in such cases. Multiplexer circuits are also used.

But in digital mode, there is no restriction. We can configure the ports as output or as input. This is done through programming. For PIC the preferable compiler is mikro C pro which can be downloaded from their website.

There is a register named as 'TRIS' which controls the direction of port. For different ports there are different registers such as TRISA, TRISB etc. If the TRIS register was set to 0, the corresponding port bit will act as the digital output. While when it is set a bit of the TRIS register to 1, the corresponding port bit will act as the digital input.

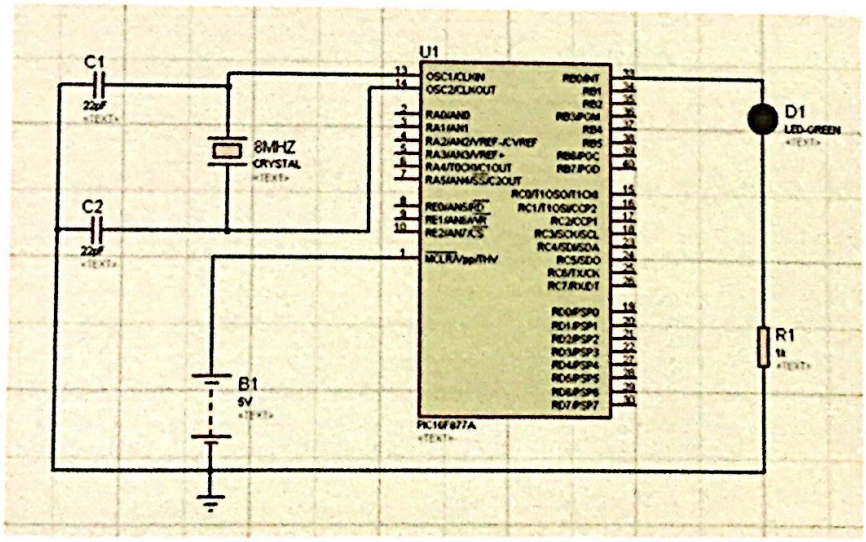

Figure 2.17 : Example of application by using PIC16F877A (Flashing LED)

Design this circuit in proteus. Connect the pins with the source, ground and oscillator as explained in the pin description section. An LED is connected on pin 33 RB0, a resistor is used to limit the current and to prevent the LED from burning up. Write and compile the program in mikro C pro. Burn the controller with the hex file by double clicking on the controller in proteus and run the circuit successfully. Best way to learn any microcontroller is to check its data sheet.

Chapter 3

Methodology

3.1 Introduction

This section describes the investigative focus, research methodology and specific methods used in this study. The methodology used was a mixed methods research framework encompassing both quantitative and qualitative methods and measures. This section also explains the design and construction of the course as well as describing the measures which were used to provide informational perspectives toward gaining an understanding of it. This research study was conducted based on the methodology. This methodology plays an important role in implementing this research study accordingly. The details of the methodology are explained in detail in this chapter.

This part will cover the explanation of methodology that is being used to make this project complete and working well. The method is use to achieve the objective of the project that will accomplish a good result. In order to evaluate this project, there are three major phase, which is planning,

implementing and data analysis. This project also included 2 parts in implementation which is hardware and software.

3.2 Planning

In this part, planning must be in a proper manner in the way of identifying an information and requirement, such as hardware and software. Planning is also sometime can be the way for investigator to identify the problem statement as a reason to proceed with the study. For this project planning phase are done by data collection and requirement of hardware and software. Usually for this early stage, the method of planning was by primary collection, which is more to interview and meeting with outsider to get information.

3.2.1 Data collection

The questionnaires of data collection are distributed to the staff of physiotherapy unit, staff nurse, and neurology specialist doctor. By data collection, requirement for hardware and software can be plan as well. At this stage, project resources and requirements, literature studies and schedule to get more information in this study are planned. All materials are collected from journal, internet, research paper, and text books.

Refer appendix for questionnaire form

3.2.2 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.

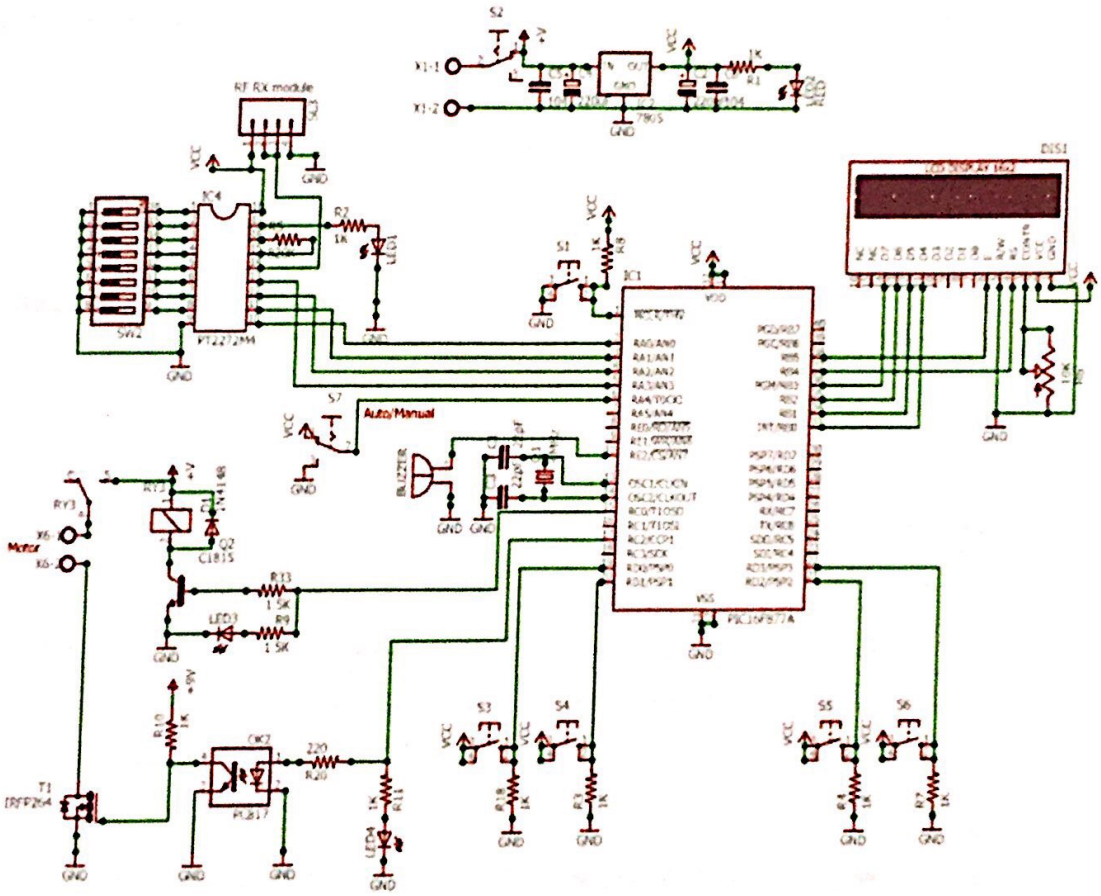

Figure 3.1 : Schematic diagram for main board of pedal exerciser

3.2.3 Informed consent process

Patients shall be informed of the study during their therapy visits. They will be requested to response to investigator if they are interested. An appointment will be made where the patient information sheet will be provided and explained to them. If they are willing to participate, the consent forms will be signed and dated. If they need to, they are allowed to take the information sheet home to consult their family members and another day for getting consent arranged.

Refer appendix for the consent form.

3.2.4 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

3.3 Implementing

This phase is where the making of hardware and software happened. The making up of pedal exerciser are including some steps which is, etching, soldering, welding, etc. After hardware and software done, it will be test on Parkinson's patient and a few person as a subject for evaluation.

3.3.1 DC Series Motor

A shunt DC motor connects the armature and field windings in parallel or shunt with a common D.C. power source. This type of motor has good speed regulation even as the load varies.

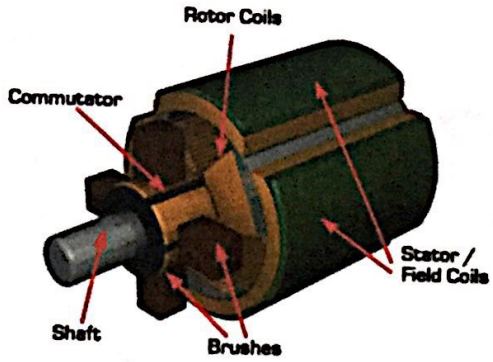

Figure 3.2 : Feature of DC Series motor

This type of motor used in this project as a speed controller which is help by the programming for the adjustable movement. It can support high load, that's mean it can carry heavy load such as in this case, human's leg.

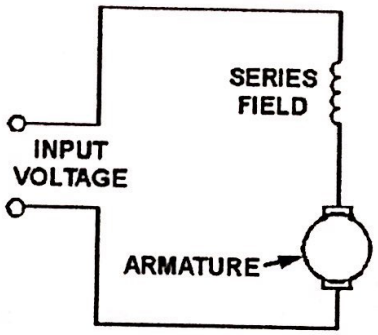

Figure 3.3 : Basic circuit of DC Series motor

3.3.2 Peripheral Interface Controller (PIC16F877A)

There is a lot of PIC type in industries. In this study, PIC16F877A are chosen to be used. This type of PIC are also popular between industries and always be used in application.

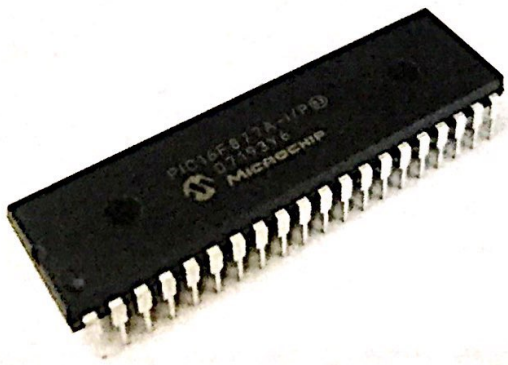

Figure 3.4:PIC16f877A

The function of this PIC in this pedal exerciser is to register an dset all programming for the speed movement in pedal execiser. Beside speed as a function, PIC also used to set the counter during the pedalling session.

3.3.3 Thermoplastic Elastomer (TPE)

These types of rubber are class of copolymers or a physical mix of polymer which consist of materials with both thermoplastic and elastomeric properties. In the other way, the material is consists of a plastic and a rubber. TPR has been prove that its material can grip well and reduce slipping. So that the material have been used in some application such as shoes material.

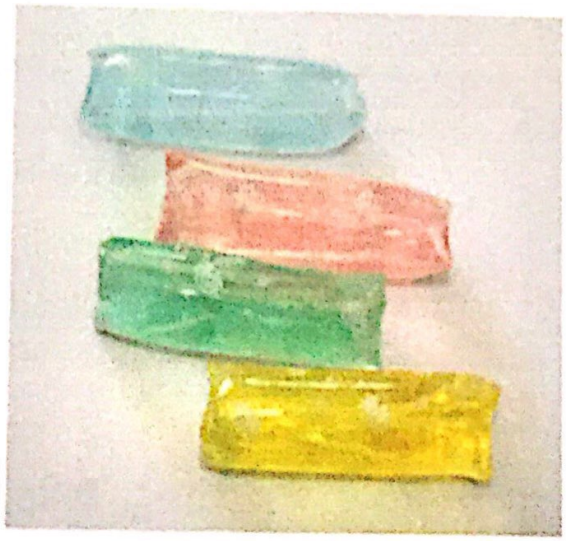

Figure 3.5 : Thermoplastic Elastomer Rubber before shaping process

The material has been used to replace the original rubber on the pedal exerciser feet for the purpose of reducing slipping on the floor during pedalling.

3.3.4 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.

Figure 3.6 : Clinical test on a Parkinson's disease patient

Figure 3.7 : Clinical test on subject with ankle problem

3.4 Data analysis

After the implementing phase done, data analysis is the last phase to process. Which all the findings during the study have to analyse to get results and to measures the successful of the study. In this phase there another type of software application that has been used, which are Statistical Package for Social Science (SPSS). Data are provided from the subject of PD patient and individual with ankle, knee and leg pain. Analysis divided into three parts, which is clinical test, technical test and evaluation test. Clinical test are performed by the patient itself and the result are depends on their recovery improvement. Technical test are included the relationship between severity, speed, number of cycle and time. While evaluation test are referring to comfortableness, speed usability and effectiveness.

3.4.1 Statistical Analysis Plan

Data analysis will be done by using Statistical Package for Social Science (SPSS). The data collection will be done by doing testing on a public and patient, the data will be measure by the questionnaire which is distributed after the cycling session. For evaluation form, there are 3 main things to analysis, which is comfortableness during pedalling, the speed usability and the effectiveness of pedal exerciser application. While for technical test, 4 criteria to be study about, is it about severity of PD patient, level of speed, number of cycle and the time of pedalling session. Beside, technical part of analysis done by referring to the motor and material used on pedal exerciser.

3.4.2 SPSS

It is one of the most popular statistical packages which can perform highly complex data manipulation and analysis with simple instruction. SPSS function as an application to help in producing statistic for evaluation test by the subjects. In this study, SPSS were used to do pilot study. Pilot study is a method to measure the quality of our questionnaire before we distribute it to subjects.

Through SPSS also, investigator can do descriptive and analysis directly right after key in the data. This method also show the weakness of our study by showing the range of effectiveness, in other way, it is helpful to improve our study.

3.5 The timeline of study

Stage	Progress	Duration
1	Collecting pre-processing data and interview to identify the problem statement.	3 weeks
2	Process of designing and upgrading hardware (pedal exerciser)	3-4 months
3	Build up software	1 month
4	Product testing and data collection	2-3 months
5	Data analysis	1-2 months

Table 3.1 : Timeline of study

3.6 Flowchart of methodology

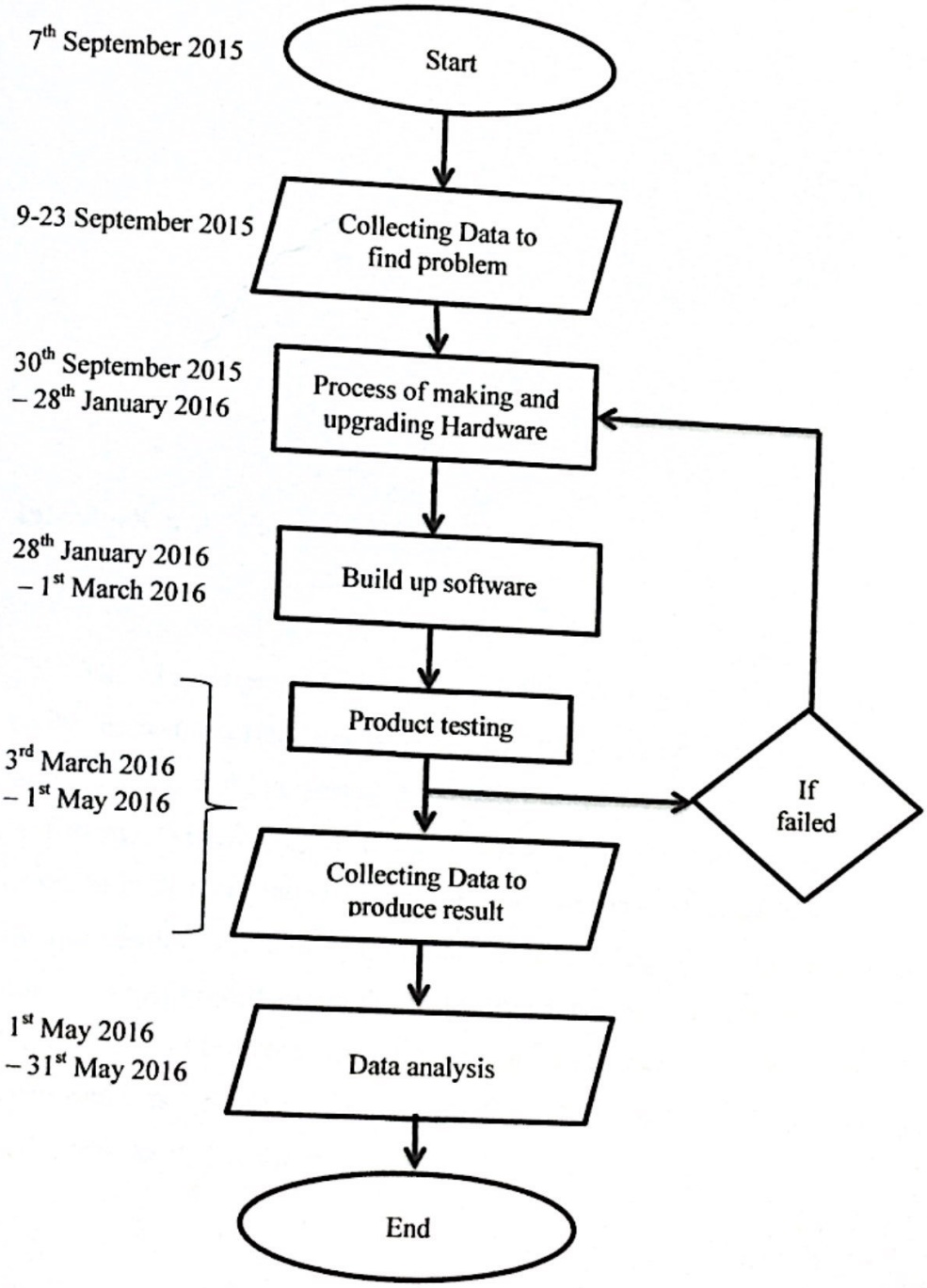

Figure 3.8 : Flowchart of methodology

Chapter 4

Result and Discussion

4.1 Introduction

This chapter presents the results of the study that were conducted based on the method described in Chapter 3. The data obtained throughout the study were analysed and interpreted. Summaries of results are generally presented in figures. Typical graphs and tables relating to the experiments will be provided in this chapter. This chapter describes the analysis of data followed by a discussion of the research findings. The findings relate to the research questions that guided the study. Data were analysed to identify and explore the relationship between severity of PD patients, level of speed, number of cycle and time of pedalling session by the purpose to help PD patient to get speed recover by pedalling.

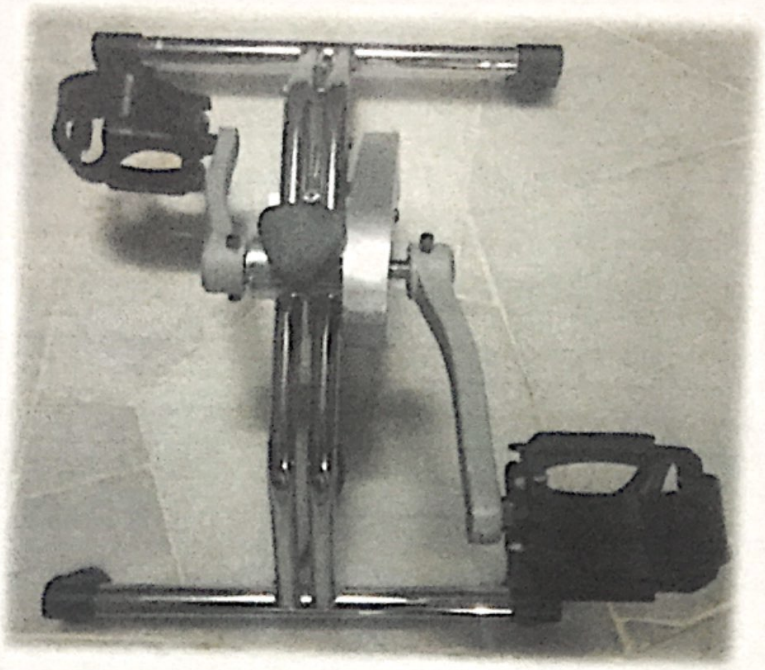

Figure 4.1 : Final output of pedal exerciser hardware

4.2 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 cycle is directly proportional to each other, which is the slower the speed, the lesser the number of cycle during pedalling session. It is measured in 1 minute time duration. 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.

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

Table 4.1: Relationship between speed and number of cycle per minute

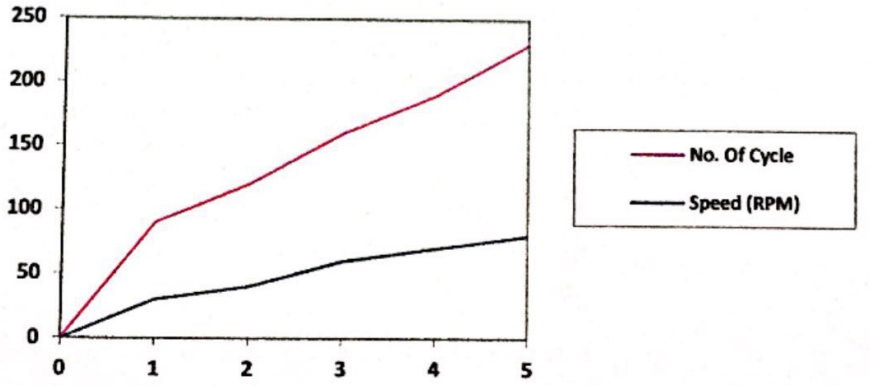

Figure 4.2 : Graph Relationship between speed and number of cycle for 60seconds

4.3 Evaluation test referring to comfortableness

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

Table 4.2 : Evaluation test on comfortableness

Notes:

1(a) I was found this DFPE is easy to use and friendly.

1(b) DFPE was modified from the original and has been added on with a motor to help DFPE in movement, the design is suitable and comfortable.

1© During exercise session, the position of DFPE is consistence while paddling.

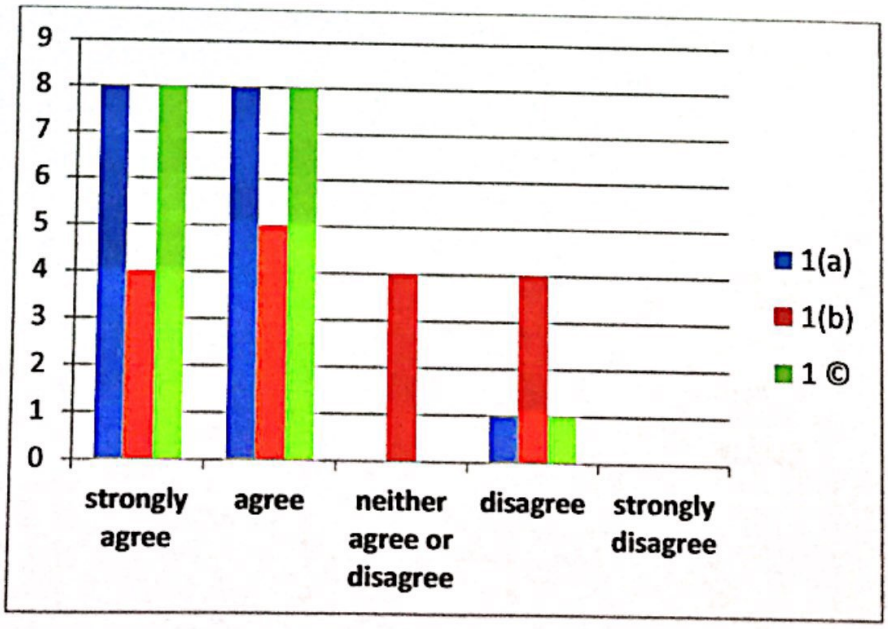

Figure 4.3 : Graph evaluation test on comfortableness

4.4 Evaluation test referring to speed usability

Speed	Strongly agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
2(a)	2	7	7	1	
2(b)	9	5	3		
2©	8	9			
2(d)	5	8	4		

Table 4.3 : Evaluation test on speed usability

Notes:

2(a) Speed in DFPE can be adjustable depends on the purposes and needs of patient, I have found that the speed level is suitable to be in DFPE.

2(b) Gear was used in DFPE to move it automatically comes with adjustable speed controller.

2© DFPE suitable for the purpose of exercise.

2(d) DFPE suitable for the purpose of Parkinson's Disease patient in increasing time of recovery.

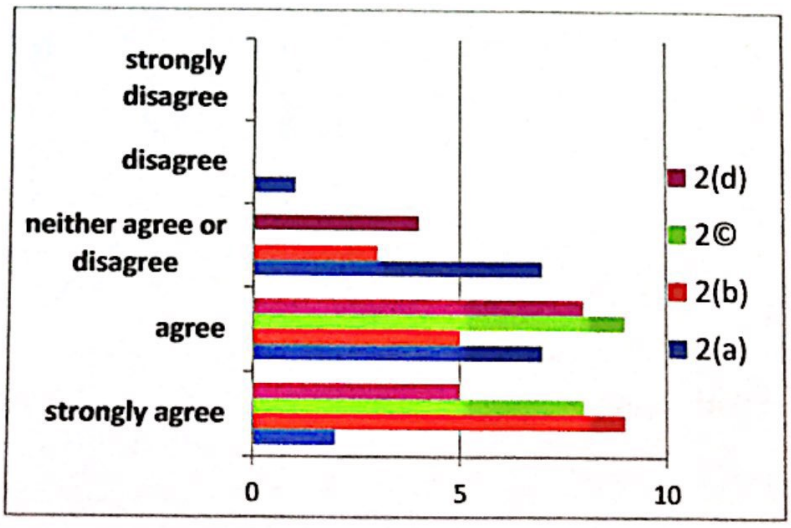

Figure 4.4 : Graph evaluation test on speed usability

4.5 Evaluation test referring to effectiveness of pedal exerciser

Effectiveness	Strongly agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
4(a)	6	9	2		
4(b)	5	4	6	2	
4©	7	8	2		
4(d)	6	8	3		

Table 4.4 : Evaluation test on effectiveness of pedal exerciser

Notes:

4(a) I think that I would like to use this product frequently.

4(b) I think that I would need support of a technical person to be able to use this product.

4© I found that some additional function in the product were well integrated.

4(d) I imagine that most people would learn to use this product very quickly.

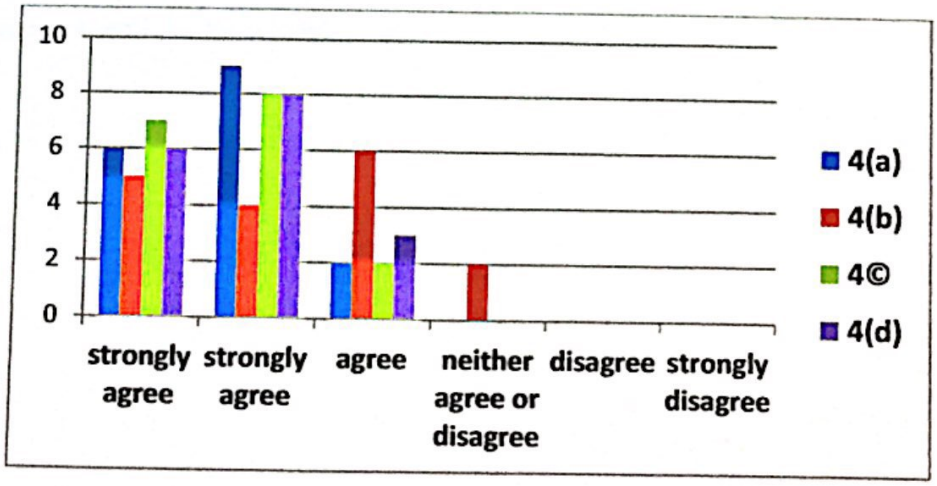

Figure 4.5: Graph evaluation test on effectiveness of pedal exerciser

4.6 Conclusion for evaluation test

Evaluation test was analysed in 3 terms which is comfortableness during pedalling, speed usability and effectiveness of pedal exerciser. The evaluation test was conducted to 17 subjects. As we can see in table 4.2, most of the subjects agree and some of them strongly agree about the comfortableness during their pedalling. In addition they are also found that pedal exerciser are friendly user which is it is easy to handle. Subjects are also agreed that the new rubbers of thermoplastic elastomers are useful on pedal exerciser because it is gripped well on the floor and slipping of pedal exerciser is less.

For the evaluation test on speed usability, most of the subjects agree that the speed is usable on the pedal exerciser, so that they can adjust according to their will. But, for the effectiveness of pedal exerciser on PD recovery, most of them answered either agree or disagree, because they do not sure about the fact. It is because not all of subject was exposed to medical field. Lastly, the analysis on table 4.5 shows that pedal exerciser was effective to the user. Most of them are strongly agreed to that and it is proved in the questionnaire and the bar chart.

Chapter 5

Conclusion and Recommendation

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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Development Of Speed In Pedal Exerciser For Parkinson's Disease Patient

Thank you for taking time to fill in this questionnaire, you will remain anonymous. The goal of this questionnaire is to get some data through the range of agree or disagree of information about Pedal Exerciser. Please indicate the extent to which you agree or disagree with the following statements by putting a √ in the appropriate box.

No	Statements/Question	Strongly Disagree	Disagree	Agree	Strongly Agree	Do Not Know
1	Pedal Exerciser regularly used either at home or in a rehabilitation unit.					
2	The frequency of using Pedal Exerciser is more than 3 times a week.					
3	Existing Pedal Exerciser comfortable to use during exercise.					
4	Existing Pedal Exerciser has problems and need to be improved.					
5	Existing Pedal Exerciser slipping during exercise session.					
6	The slipping issue of Existing Pedal Exerciser makes user uncomfortable.					
7	Existing Pedal Exerciser make noisy sound when users are pedaling.					
8	That noisy sound disturbing emotion and user's concentration during exercise.					
9	Pedal Exerciser can help a patient with Parkinson's Disease.					
10	Fast pedaling will help Parkinson's Disease Patient.					

Consent form

Title of study: Development Of Speed In Pedal Exerciser For Parkinson's Disease Patient

I understand about the information of this study and received explanation from the investigator about the purpose of the investigation, including benefits and risks.

I am _____, Identity Card number _____, phone number _____,
***Agree/Disagree** to participate in the studies as described above.

Signature,

_____
Date:

Borang kebenaran

Tajuk kajian: Pembangunan kelajuan Dalam Pedal Exerciser Bagi Pesakit Parkinson

Saya memahami mengenai maklumat kajian ini serta mendapat penjelasan lanjut daripada penyelidik mengenai tujuan penyelidikan termasuk faedah dan risikonya.

Saya _____, nombor Kad Pengenalan _____, nombor telefon _____,
***Bersetuju / Tidak Bersetuju** untuk menyertai kajian yang dinyatakan seperti diatas.

Tandatangan,

_____
Tarikh:

POLITEKNIK
Jabatan Pengajian Politeknik

Development Of Speed In Pedal Exerciser For Parkinson's Disease Patient

Thank you for taking time to fill in this questionnaire, you will remain anonymous. The goal of this questionnaire is to get some data through the range of instrument usability about Pedal Exerciser. Please indicate the extent to which you choose with the following statements by putting a √ in the appropriate box by following the range.

Age : 1-10 ☐ 41-50 ☐
11-20 ☐ 51-60 ☐
21-30 ☐ 61-70 ☐
31-40 ☐

Gender: F ☐ M ☐

Occupation: _____

Do you have any leg, ankle or tendon problem? _____

If you have leg, ankle or tendon problem, what is the cause? _____

How many times you do exercise in a week? _____

What kind of exercise that you do? _____

No	Item & Elements	Strongly agree	Agree	Neither agree or Disagree	Disagree	Strongly Disagree
1	**COMFORTABLENESS** a) I was found this DFPE is easy to use and friendly. b) DFPE was modified from the original and has been added on with a motor to help DFPE in movement, the design is suitable and comfortable. c) During exercise session, the position of DFPE is consistence while padding.	☐	☐	☐	☐	☐
2	**SPEED** a) Speed in DFPE can be adjustable depends on the purposes and needs of patients, I have found that the speed level is suitable to be in DFPE. b) Gear was used in DFPE to move it automatically comes with adjustable speed controller. c) DFPE suitable for the purpose of exercise d) DFPE suitable for the purpose of Parkinson's disease patient in increasing time of recovery.	☐	☐	☐	☐	☐
3	**FOOT PRINT BASE & PADDLING** a) I feel comfortable when I put my foot on the foot print base. b) I have a smooth paddling session. c) On the base for foot print placement, there are a rubber tied to make sure foot always stay in a right position during paddling. I feel comfortable with it.	☐	☐	☐	☐	☐
4	**EFFECTIVENESS** a) I think that I would like to use this product frequently. b) I think that I would need support of a technical person to be able to use this product. c) I found that some additional functions in the product were well integrated. d) I imagine that most people would learn to use this product very quickly.	☐	☐	☐	☐	☐

Other recommendation for the purpose to improve DFPE:

_____

_____

_____