CHAPTER 12

An Innovation of Pedal Exerciser

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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 pedalling to pedalling 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 rubber ferrule of pedal exerciser rubber feet so that it can grip well and non-slip during pedalling session. In addition, this innovation is become 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. Pedal exerciser can be used in various levels of ages of human. As a result, we will find out the relationship between Parkinson's disease patient and the use of pedal exercise either it is helpful or not besides of the data analysis about a comfortable feeling of patient while using pedal exerciser.

Keywords: pedal exerciser, non-slip, rubber ferrule, Parkinson's therapy.

Introduction

Pedal exercisers are used by types of person, such as Parkinson' patient, stroke patient, patient that have been accident and need legs or arms exercise and patient with artificial legs and arms. Parkinson's disease patient use pedal exerciser to help them in fast healing process. Normally in rehabilitation, patients are using simple tools to treat ankle injuries However, as the technologies growing rapidly, rehabilitation device also flow by following the technologies. This can be prove by introducing several automated devices that can help to increase the effectiveness of ankle rehabilitation treatment such as pedal exerciser(Nazrin et al., 2015). 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 the interview to the physiotherapy, nurse and technical person, and also from the research, there are some problem statements that have found and need to improve in existing pedal exerciser. Common problems with pedal exerciser are slipping of floor while pedalling. For this thesis, Parkinson Disease is the disease 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("Parkinson's Forced Exercise Study Using Theracycle | Theracycle," 2012). Each and every day, people with Parkinson Disease awaken, trapped in their bodies. Their limbs are stiff, their hands shake, and their legs won't follow their brain(Lieberman, 2002). The worst trembling will make them feel so uncomfortable.

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(Chairman, Symposium, & Society, 2004). 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(Lim, Ng, Tzen, Yap, & Ho, 2015). There are 2 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.Parkinson's disease is a chronic neurodegenerative condition that leads to progressive disability (Poewe and Mahlknecht 2009), reduced health-related quality of life, and high healthcare costs (Weintraub et al 2008, Kaltenboeck et al 2011). It is expected that more than 8 million people worldwide may develop Parkinson's disease in the coming decades (Dorsey et al 2007)(Rana, MD, FRCPC, & Hon, 2013). Parkinson's disease causes tremor and reduces mobility and functional performance. People with

Parkinson's disease 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.

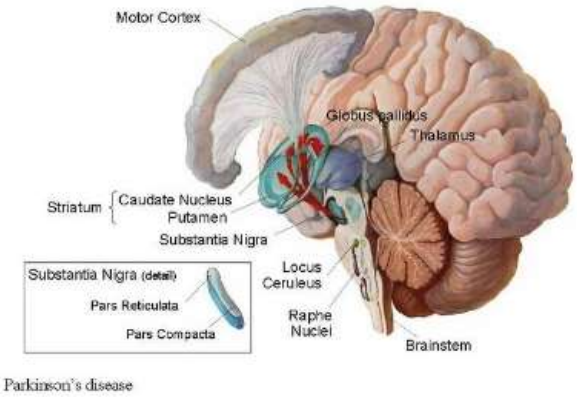

Fig. 1 Brain regions affected by Parkinson's disease

Tremor in Parkinson Disease

Parkinson disease causes certain brain cells to die. These are the cells that help control movement and coordination. The disease leads to shaking (tremor) and trouble walking and moving. Nerve cells use a brain chemical called dopamine to help control muscle movement. With Parkinson disease, the brain cells that make dopamine slowly die. Without dopamine, the cells that control movement cannot send messages to the muscle. This makes it hard to control the muscles. Slowly, over time, the damage gets worse. No one knows what causes these brain cells to waste away.Tremor problem experienced by Parkinson's disease patient will cause incidence of fall, with rate near to 70% patients in initials stages of the Boher classification(Suarez, 2011). Below is the Fig. shows brain between individual with Parkinson's disease and without Parkinson's disease.

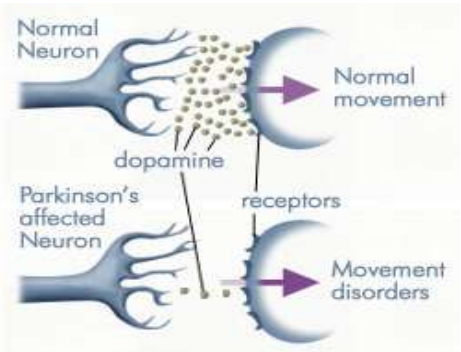

Fig. 2 Dopamine levels in a normal and a Parkinson's affected neuron

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(Rapin & Tambosco, 2014). It shows that higher speed during cycling may help Parkinson's disease patient in healing process. Forced 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 mile group bicycle trip across lowa("Parkinson's Forced Exercise Study Using Theracycle | Theracycle," 2012). Normally, the woman with Parkinson's disease would pedal at a speed of 50-60 repetitions per minute (RPM), but during this this trip she was forced to pedal at a 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 pedalled throughout the day, the woman noticed her tremor went away while she was pedalling on the tandem bicycle. The healing progress can be measure by using Electromyography (EMG) technique. EMG is an easy to use technique and has been commonly used in a measurement and vast range of research on muscle physiology(Kamaruddin, Khalid, & Shaameri, 2015). In the 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.

Methodology

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. 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 without having to get on a bike.

Fig 3. Pedal exerciser

This is a helpful way to achieve exercise 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(Freire-korn & Mshsa, 2012). As said

in the beginning of this study, the problem of pedal exerciser are slipping on the floor. So that, the problem statement can be solve by replacing the material of feet rubber on te pedal exerciser. The material is from thermoset rubber to thermoplastic elastomer.

Thermoplastic elastomers (TPEs) 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. TPEs 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.(Hufenbach et al., 2013) 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. TPEs are the most commonly used polymer in gripping plastics like those that are commonly found in exercise equipment. Thermoplastic elastomers dominate products all around us. 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(Prisacariu et al., 2011). The development of new material of rubber will provide comfortableness to the patient during exercise session.

Discussion

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.

Table 1
Table of 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

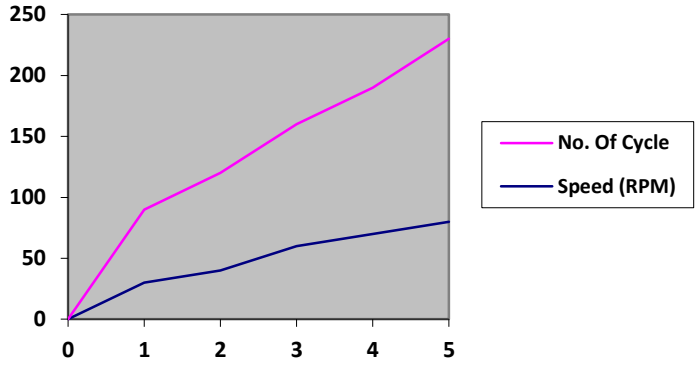

Fig. 4 Graph show relationship between speed and number of cycle for 60seconds

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.

References

Chairman, O., Symposium, I., & Society, M. D. (2004). Moving Along, *6*(1), 1–16.

Freire-korn, S., & Mshsa, S. F.-K. (2012). *Terror Highway 193: A Guide for the Suddenly Disabled*. iUniverse. Retrieved from https://books.google.com/books?id=8OHjJIGyrDsC&pgis=1

Hufenbach, W., Langkamp, A., Gude, M., Ebert, C., Hornig, A., Nitschke, S., & Böhm, H. (2013). Characterisation of strain rate dependent material properties of textile reinforced thermoplastics for crash and impact analysis. *Procedia Materials Science*, *2*, 204–211. http://doi.org/10.1016/j.mspro.2013.02.025

Kamaruddin, N. A., Khalid, P. I., & Shaameri, A. Z. (2015). Jurnal Teknologi Full paper The Use of Surface Electromyography in Muscle Fatigue Assessments – A, *6*, 1–5.

Lieberman, A. N. (2002). *Shaking Up Parkinson Disease: Fighting Like a Tiger, Thinking Like a Fox : a Book for the Puzzled, the Hopeful, the Willing, and the Prepared*. Jones & Bartlett Learning. Retrieved from https://books.google.com/books?id=gFnfXWkaT8AC&pgis=1

Lim, C. M., Ng, H., Tzen, T., Yap, V., & Ho, C. C. (2015). Jurnal Teknologi WITH P ARKINSON ' S D ISEASE, *18*, 79–85.

Nazrin, M., Shahrol, S., Basah, S. N., Khairunzam, W., Ahmad, W., & Bakar, S. A. (2015). Jurnal Teknologi, *12*, 45–52.

Parkinson's Forced Exercise Study Using Theracycle | Theracycle. (2012). Retrieved from http://www.theracycle.com/articles/parkinsons-bike-study.aspx#

Prisacariu, C., Scortanu, E., Airinei, A., Agapie, B., Iurzhenko, M., & Mamunya, Y. P. (2011). New Developments in Thermoplastic Polyurethanes of Variable Crystallinity : Sensitivity of Cyclic Stress-Strain Response to Chemical Structure. *Procedia Engineering*, *10*, 446–454. http://doi.org/10.1016/j.proeng.2011.04.076

Rana, A. Q., MD, FRCPC, & Hon, F.-U. K. (2013). *Natural Therapies for Parkinson's Disease* (Vol. 4). FriesenPress. Retrieved from https://books.google.com/books?id=AWv3AQAAQBAJ&pgis=1

Rapin, A., & Tambosco, L. (2014). Effort training in Parkinson ' s disease : A systematic review, *57*, 79–104. http://doi.org/10.1016/j.rehab.2014.01.003

Suarez, A. (2011). Balance in Parkinson ' s disease patients changing the visual input. *Brazilian Journal of Otorhinolaryngology*, *77*(5), 651–655. http://doi.org/10.1590/S1808-86942011000500019