Automatic Vibration Device for Stroke Patients

M.M.M. Aminuddin, N.H.H.M. Tarmizi

Abstract: Permanent paralysis due to stroke could be avoided if they do some exercises on the affected limbs to keep the flowing of the blood and soften the muscle. Every treatment or exercise needs to be done periodically and requires the help of a normal person such as nurses or physiologists. However, a caretaker may not be able to provide 100% of the assistance to those stroke patients. Therefore, an automatic device that can provide a periodic exercise could help stroke patients in their recovery process with minimal participation of caretaker. However, the available machine that can accommodate such services is bulky and costly. It exercises the whole body, and this is not beneficial if the stroke only effect to some part of the body. Hence, this study had shown that Theory of Inventive Problem Solving approach is able to reduce the size of the machine but gives significant impact on the specific limbs. The findings could be used as foundation for stroke rehabilitation development system.

***Index Terms*: TRIZ, stroke rehabilitation, vibration, permanent paralysis.**

I. INTRODUCTION

Stroke was reported to be one of the largest causes the long-term disability and death among young adults [1-2]. Besides suffer from spasticity and sensorimotor deficits, individuals with stroke also suffer from decrease of muscle activity and have distraction of blood circulation. Therefore, it reduced independence in every life [3-4]. To solve this issue, medical expert gives the solution which is stroke patient must do the rehabilitation process. Stroke rehabilitation is a process which patient with disabilities as effect of stroke manages to resume of daily living and reestablish their lifestyle through a learning process. This process also assists patients in gaining better understanding of their condition, help patient to adapt their disabilities and prevent other complications [5]. For Walker [6], stroke rehabilitation is intensive and repetitive movement training that will maximizes the functional and cognitive abilities of the patient. In stroke rehabilitation process, there are some technique that been used which is traditional training, mechanical technique and vibration technique.

For vibration technique, Whole Body Vibration (WBV) device are mostly used in stroke rehabilitation. Researchers found that WBV as a novel form of exercise that has beneficial effects on cardiovascular function include muscle activity and blood flow [7]. This technique currently used in hospital or rehab center and in order to complete the recovery process must have physical activity between physiologies and stroke patients. However, the physiologies may not be able to monitor their patient all the time and this make patients loss of interest to recover. Owing to the cost barrier like the increasing prices of rehabilitation exercise and costly of rehab device, also makes stroke patient be de-motivated to recover.

Therefore, the aim of this study is to design a rehabilitation device which able to assists the rehabilitation process of stroke patients with increases the muscle activity and blood flow on specific affected limb such as leg. This device will be automatic vibrated on certain time or user can set time based on desired time. This device can be considered an important tool in the field of post-stroke rehabilitation.

II. METHODOLOGY

A.Design Circuit

The design of this device is done by using Trimming approach. Trimming is one of the Theory of Inventive Problem Solving (TRIZ) tool. The available body vibration machine is dissected into components and it function as shown in Fig. 1.

This machine gives a full body vibration treatment. From the function model as shown in Fig.1, patient needs to lay down on the vibration platform and supported by the handlebar. When switch is ON, the vibration platform will vibrate. The elastic straps are an option where it can be used or not because that straps for arms exercise. The combination of motor, springs, washers and screws is to create the vibration manually.

B. Trimming

Trimming is a process to discard redundant function and components without eliminate the significant function. The function model in Fig.1 is trimmed to a new function model as shown in Fig. 2. By using the Arduino Uno as a controller, it will control the vibration motor, real time clock (DS1302) and Liquid Crystal Display I2C (LCDi2c). An Arduino development board which designed by Atmel. The microcontroller provides a flexible, easy-to-use hardware and software platform that widely used by students or designers. Arduino's software is free open source that can easily download from the internet. This inexpensive and less hassle microcontroller can be use in the development of automatic leg vibration device.

Revised Manuscript Received on July 9, 2019

M.M.M. Aminuddin, Centre for Telecommunication Research & Innovation (CeTRI), Fakulti Kejuruteraan Elektronik & Kejuruteraan Komputer (FKEKK), Universiti Teknikal Malaysia Melaka (UTeM), Malaysia.

N.H.H.M. Tarmizi, Centre for Telecommunication Research & Innovation (CeTRI), Fakulti Kejuruteraan Elektronik & Kejuruteraan Komputer (FKEKK), Universiti Teknikal Malaysia Melaka (UTeM), Malaysia.

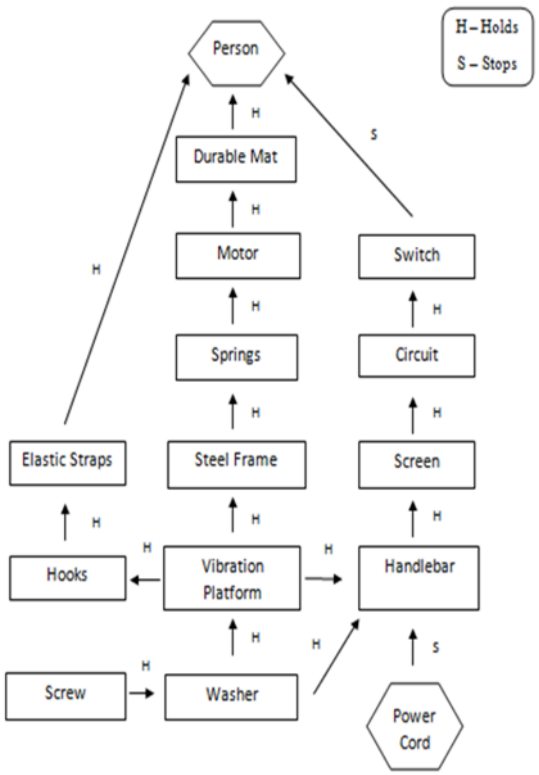

Figure 1: Function Model of available body vibration machine [7].

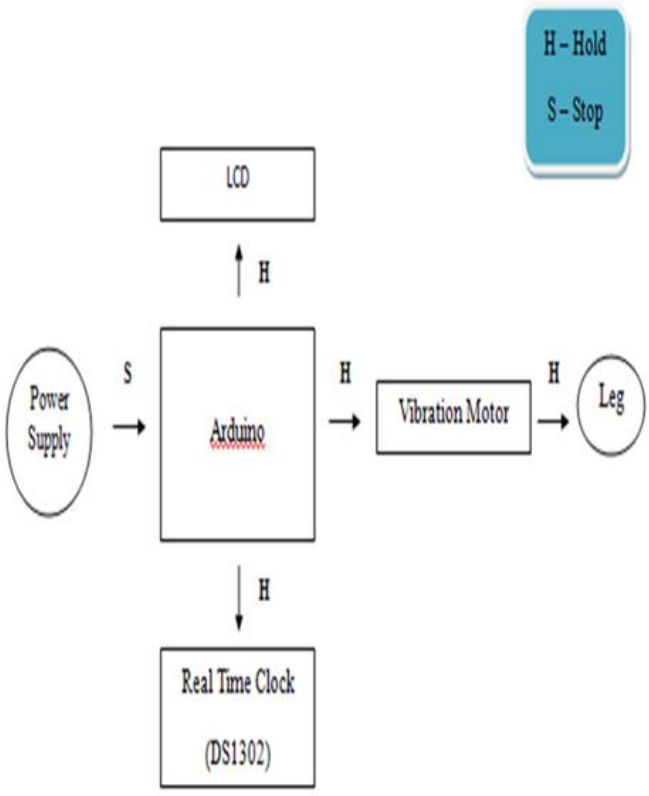

Figure 2: A trimmed version of function model.

Arduino Uno has 14 digital input/output pins (6 PWM outputs, 6 analog inputs), a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. This device onwards is called automatic vibration device (AVD).

Fig. 3 shows the function process of AVD. The device is always in standby mode. It has two modes: automatic mode and manual mode. For automatic mode, when the time setting (in coding) is set, then vibration motor will be turn ON and give vibration (50 Hz) on patient legs. Meanwhile for manual mode, the vibration motor will be function when user set their desired time.

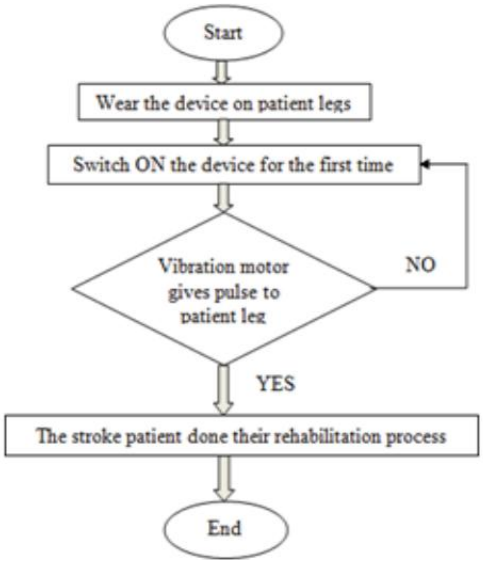

Figure 3: Process flow of AVD.

C. Experimental Paradigm

Ten healthy young adults (5 females and 5 males) with age range from 21 to 25 year were participating in the study. The subjects were randomly picked from the general population of the Universiti Teknikal Malaysia Melaka (UTEM) and from personal contacts. The subjects were fully informed verbally of the purposes and procedure of the study. Subjects who had previous health issues related to cardiovascular system were excluded from this experiment.

During experiment period, subjects were asked to maintain their regular diet and normal life-style patterns. Subjects were asked to refrain from caffeine-containing beverages (tea, coffee, coca cola) from at least the night before experiment is conducted. Subjects were also asked to refrain from participating in any heavy physical exercise to avoid interruption in muscle activity reading. During the test sessions, subjects were barefoot to avoid footwear attenuation of the vibration.

All testing procedures were performed in the room at Kolej Kediaman Satria UTEM (Lekir) and all testing conducted at similar times (14:00 - 17: 00) of the day to avoid any possible biased study result due to diurnal variation. In order to examine the effect of the device on muscular activities of participants, the electromyography (EMG) activities of left leg muscles participants were recorded by using ENG sensor. Participants were assigned to receive different duration of vibration in a passive frequency (10 Hz-55 Hz). During all sessions,

subjects were required to lie down in the supine position and the AVB were attached on subject's leg.

III. RESULTS

Fig.4 and Fig.5 show the average muscle activities responses of female and male students, respectively. Muscle activity that was measured using EMG sensor then produced raw data signals. VB is stand for vibration. Normal is the muscle at normal condition. Vibration was given for 3 minutes.

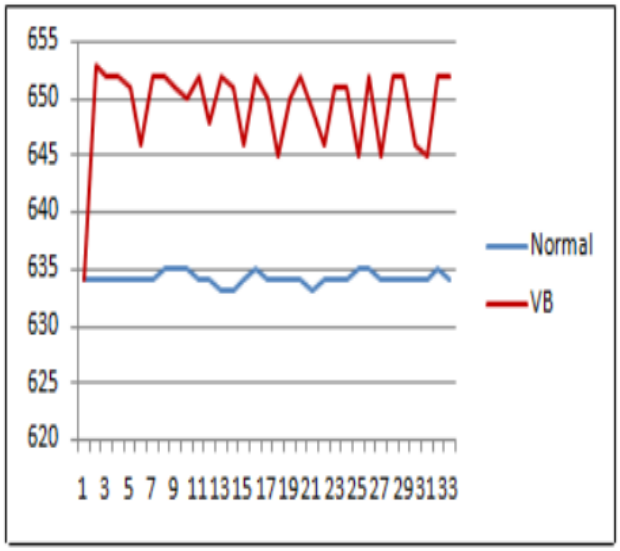

Figure 4: The average results of female participants of muscle activities of averaged EMG signals . VB is stand for vibration. Normal is the muscle at normal condition.

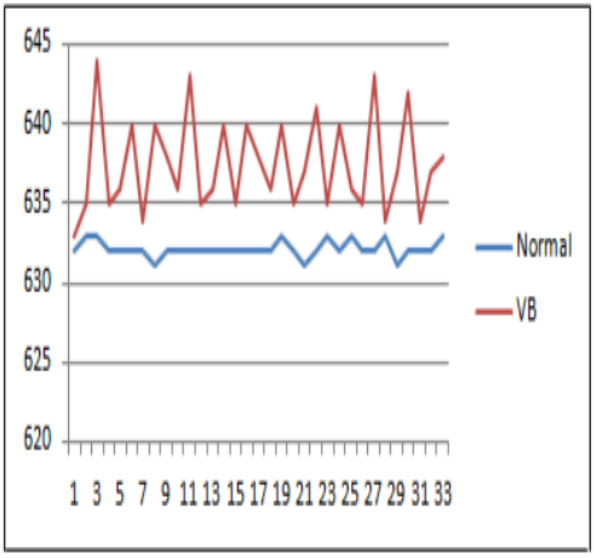

Figure 5: The average results of male participants of muscle activities of averaged EMG signals . VB is stand for vibration. Normal is the muscle at normal condition.

Fig.6 shows Systolic blood pressure (SYS) value before and after apply vibration onto 10 participants. SYS is obtained by using high blood pressure monitor. Subject 1 to 5 are female participants and 6 to 10 are male participants.

IV. DISCUSSION

Based on the presented results, there was a significant different in muscle condition and blood flows before and after the sensation of vibration from the AVD. From the Fig. 3 and Fig. 4, all participants showed an increase of muscle activities after the vibration. Interestingly, female participants showed

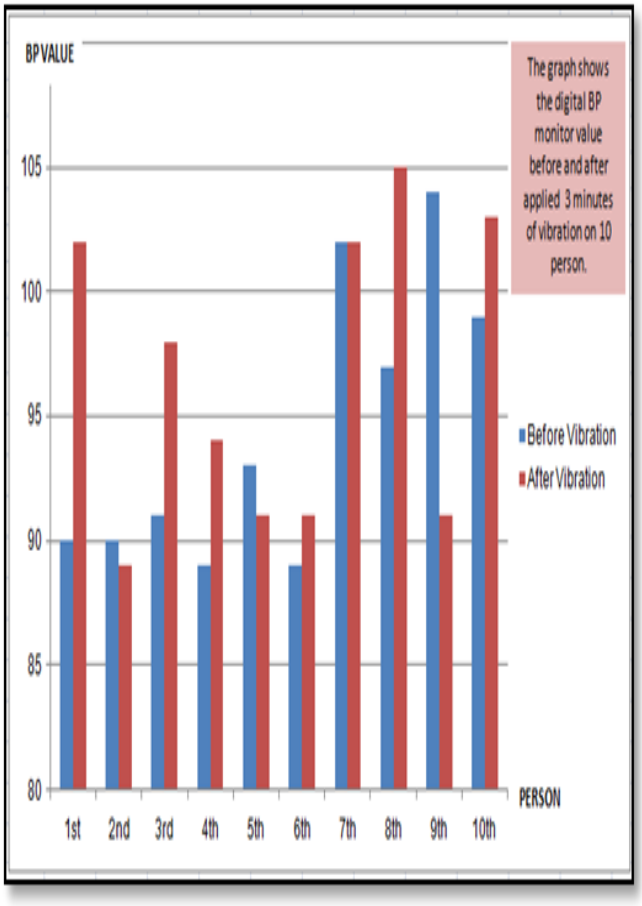

Figure 6: Systolic blood pressure (SYS) value of 10 participants when exposed to 3 minutes of vibration. Based on the bar chart graph, seven participant success increase their blood pressure while blood pressure for another three participants (2nd, 5th, 9th person) was decreased.

higher muscle activities than male participants. This could be caused by a female muscle is more soften than a male hence, a small vibration could give a higher impact on the muscle. Nevertheless, Mann-Whitney rank sum of significant test ($p<0.05$) shows that both genders elicited a significant change of muscle activities of before and after the sensation. This is aligned with the finding of Gholoum et al [7] and Huang et al [8].

From Fig. 6, there was a significant change of blood pressure condition before and after 3 minutes passive vibration from AVD. The calculated coefficient of variation was found that 70% of participants increase their blood pressure after applied vibration. Meanwhile, another 30% of participant decrease their blood pressure but still in normal range when applied vibration. This could probably these 3 participants were in nervous state but AVD had made them felt relax like having a massage.

Mann-Whitney rank sum of significant test ($p<0.05$) shows that the different of blood pressure of most participant were significant.

V.CONCLUSION

In conclusion, the AVD which was designed from the trimmed model of full body vibration machine by using TRIZ tool called Trimming has been successfully gives a significant effect to muscle and blood flow as full body vibration machine but it is more focus on specific part of body. constructed using TRIZ approach. The trimming process makes the AVD design become more simple, lightweight in size and much more affordable in price. Arduino make it user friendly which user can easily set the time of AVD to be functioned. The finding is promising, and the product has potential to for rehabilitation device market especially device for stroke patients. The result shows the improvement on participant leg muscle activity and blood pressure.

ACKNOWLEDGMENT

The authors are grateful for the support of Universiti Teknikal Malaysia Melaka.

REFERENCES

1. J. Adamson, A. Beswick, and S. Ebrahim, “Is stroke the most common cause of disability?” Journal of Stroke and Cerebrovascular Diseases, vol. 13, no. 4, pp. 171–177, 2004
2. C. Brog˚ardh and J. Lexell, “Effects of cardiorespiratory fitness and muscle-resistance training after stroke,” PM&R : The Journal of Injury, Function, and Rehabilitation, vol. 4, no. 11, pp. 901–907, 2012.
3. M. ˚ Astr¨om, K.Asplund, andT. ˚ Astr¨om, “Psychosocial function and life satisfaction after stroke,” Stroke, vol. 23, no. 4, pp. 527– 531, 1992
4. J. J. Eng and P.-F. Tang, “Gait training strategies to optimize walking ability in people with stroke: a synthesis of the evidence,” Expert Review of Neurotherapeutics, vol. 7, no. 10, pp. 1417–1436, 2007.
5. R. L. Sacco, S. E. Kasner, J. P. Broderick et al., “An updated definition of stroke for the 21st century: A statement for healthcare professionals from the American heart association/American stroke association,” Stroke, vol. 44, no. 7, pp. 2064–2089, 2013.
6. Walker, M. (2002): 'Stroke rehabilitation', Br. J. Cardiol., 9, pp. 23 30
7. Gholoum M. S. , Edmond T., Woods S., Ball D., Thin A. G. (October 2012). The Effect of Whole Body Vibration on Peripheral Cardiovascular Function. School of Life Sciences, Heriot Watt University, Edinburgh, UK.
8. Huang M., Pang M. (February 2019). Muscle Activity and Vibration Transmissibility During Whole Body Vibration in Chronic Stroke. Scandinavian Journal of Medicine and Science in Sports DOI: 10.1111/sms.13408

AUTHORS PROFILE

Mai Mariam Mohamed Aminuddin is a senior lecturer at Universiti Teknikal Malaysia Melaysia (UTeM) and has been worked as educator for more than 18 years. She obtained TRIZ Certificated Instructorship Level 1 from MyTRIZ in 2018. She also is a certified TRIZ Practitioner Level 3 awarded by the International TRIZ Association (MATRIZ) in 2017. Her area of expertise is artificial intelligence, biomedical engineering and TRIZ.

Noor Huda Hazirah Tarmizi graduated from Universiti Teknikal Malaysia Melaka in Electronic Engineering. This paper is her final year project and she was awarded bronze medal for this project in an innovation competition.