Evolution in Electrical and Electronic Engineering Vol. 2 No. 1 (2021) 221-227

EEEE

Homepage: http://penerbit.uthm.edu.my/periodicals/index.php/eeee
e-ISSN : 2756-8458

Development of Home-Based Physiotherapy Device For Monitoring of Muscle Treatment

Nazmi Abdullah[1], **Wan Mahani Hafizah Wan Mahmud**[1,2*]

[1]Faculty of Electrical and Electronics Engineering,
Universiti Tun Hussein Onn Malaysia, Batu Pahat, 86400, MALAYSIA

[2]Advanced Medical Imaging and Optics (AdMedic) Focus Group,
Faculty of Electrical and Electronic Engineering,
Universiti Tun Hussein Onn Malaysia, Batu Pahat, 86400, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/rpmme.2021.02.01.025
Received 18 February 2021; Accepted 09 May 2021; Available online 30 April 2021

Abstract: Most studies of muscle treatment are hospital-based. However, to build a better environment in medical purpose, the convenient technologies are very useful. Due to the pandemic Covid-19 , the arrangement of face-to-face consultation with physiotherapist will increase the health risk. In order to reduce these complications, a telemedicine concept and compact assistive device is designed. The muscle treatment monitoring device is developed as monitoring tools for the patient daily use. The aim of this project is to determine whether muscle treatment monitoring device performed on patient would be effective at improving the muscle condition. For this purpose, the contraction and movement result was recorded in a voltage format. The larger muscle movement will provide a larger voltage and vice versa. The data set include 5 students from UTHM. The results show a high correlation between movement and voltage. To conclude, the development of this home based muscle monitoring device has proven to be reliable and could be used as an alternative physiotherapy process at home.

Keywords: Physiotherapy, Wireless, Flexion, Extension

1. Introduction

Physiotherapy is one of the best methods to help a patient who has a disability due to certain cases. It will help them to improve their abilities at the highest level of function. The physiotherapy also supports the patient to stay healthy and getting better in daily life. In general, physiotherapy provides an individual to be more independent to undergo routine activities everyday and also enables to do anything like a normal person if it is possible to restore optimal health [1-3].

There are many areas covered in physiotherapy programs especially in physical care, physical therapy and also muscle treatment. In order of that, the activity of the patient will be monitored by a physiotherapist every day to see the improvement of the patient's condition. Thus, the condition of every single activity should be monitored continuously [10-12].

**Corresponding author: wanmahani@uthm.edu.my*

From this, a wireless monitoring device needs to be developed as a medium to observe the condition of the patient. It is helpful for patients and nurses to monitor the level of recovery muscle. The movement of muscle has a different strength and it is related to the ability to move and lift objects. Therefore, the wireless monitoring device for muscle treatment can be used by a doctor and physiotherapist to monitor the patient globally.

2. Materials and Methods

In order to complete the project, the ADDIE method is used as a guideline system for solving problems. According to the result obtained, the device has positive responses during the evaluation.

2.1 Analysis Stage

The main problem of this project is muscle treatment can only be diagnosed at the physiotherapy center. However, this device might be helpful for a user to get information about muscle movement at their home. It is wearable and user friendly. Table 1 shows the needs and solution when implementing the project.

Table 1: The Needs and Solution of Project Implementation

Needs	Solution
How to measure the muscle movement	Myoware Muscle sensor
How to obtain the result of the measurement	Blynk Application
How to process the data in wireless	Node MCU ESP8266

2.2 Design Stage

Muscle treatment monitoring device uses the concept where the number of muscle movements determines whether the muscle is in good condition or in bad conditions [4-6]. Figure 1 shows the 3D connection of the device developed consists of the muscle sensor, and node MCU which is powered by the 9V battery. The device use electromyography as the muscle sensor. The sensor value will then send the signal to the node MCU at pin A0. The node MCU is powered up by the 9V battery. Since node MCU has ESP8266 which is a Wi-Fi module, it enable the device to send the data collected to the World Wide Web and IoT platform.

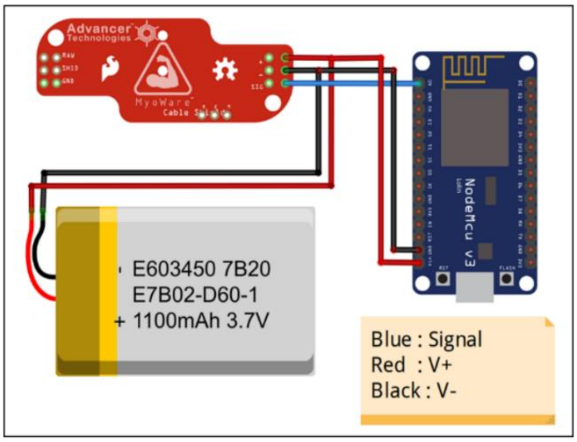

Figure 1: 3D Connection of the Project

2.3 Developmental Stage

The Internet of Things (IoT) is a system that is related to computing devices that have the ability to transfer data over a network without implementing human-to-human interaction [7-9]. With the growth of IoT applications in the Fourth Industrial Revolution (IR4.0), IoT devices are produced in various fields including the health sector. Table 2 lists the components involved including their function, respectively. Figure 2 shows the block diagram of the developed device. The Myoware Muscle Sensor will act as an input, the node MCU as a microcontroller and the Blynk apps and serial monitor will act as an output.

Table 2: Device Components and Functions

Component	Quantity	Function
Node MCU	1	Receive the signal from the myoware sensor and transmit to Blynk application.
Myoware Sensor	1	Amplify and convert data from analog to digital value of muscle movement before transmit to microprocessor
Electrode Pad	3	The electrode pad function as intermediary between object and sensor where it access the velocity by recording the activity of muscle.

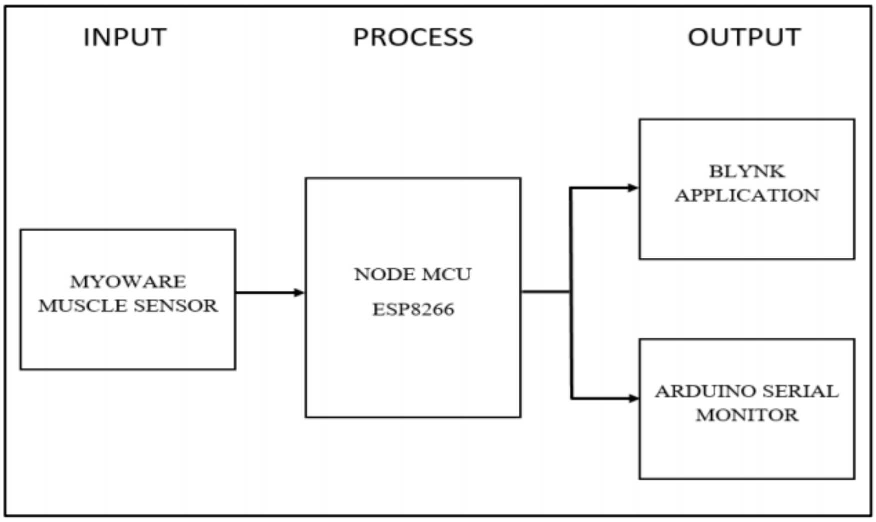

Figure 2: Block Diagram of the device

2.4 Implementation Stage

The installation to the subject is required to perform the early stage of data. During the test, the position of electrode is important to get the ideal result. The possible position of electrode pad is refer based on the middle of the bicep muscle. The muscle point should be accurate otherwise the large amount of unwanted signal (noise) are produced. The stable position of subject is require in other to avoid any movement.

2.5 Evaluation Stage

The device performance and how the data accurate is tested based on the various subject like arm skin and leg muscle. This data are produced to improve the data quality and accuracy. Further result of device are generate at the result phase. The flowchart in Figure 3 describes the steps of system operation, from the beginning of operation (turn on the mobile phone), through the use of sensor (placing the electrode) and last point of operation end (data transfer). If device are not connecting with the Blynk

Application, user have to make sure the reliability of the network connection. Else, user need to check the authentication token in Arduino software. Then, the skin surface will be cleaned and the electrode pads will be attached at the ideal position. After that, observation is made and the data is transferred into Blynk Application.

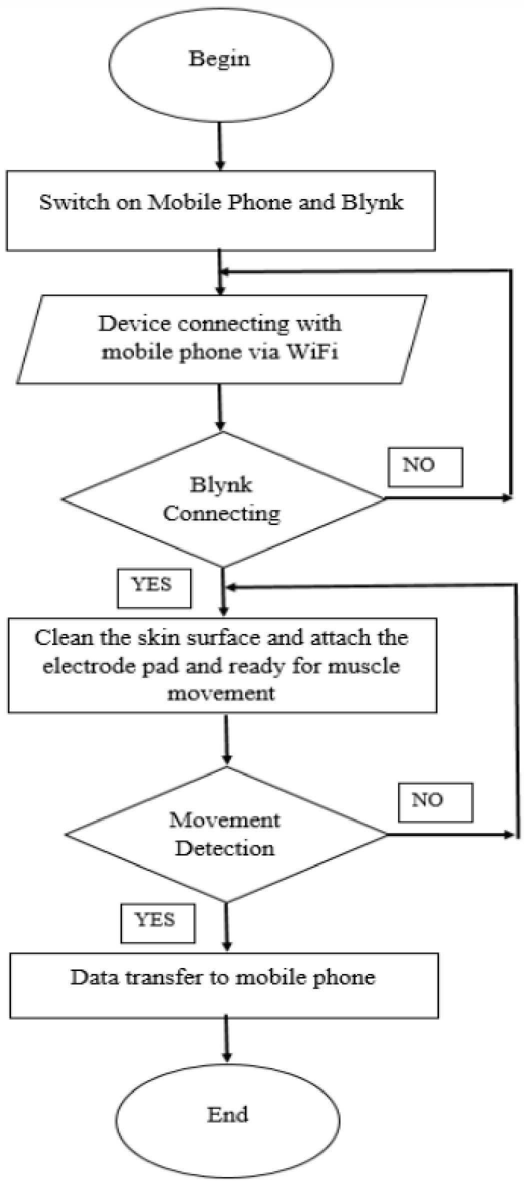

Figure 3: Flowchart of the project

3. Results and Discussion

The prototype of Muscle Movement Monitoring Device was created with portable and passive wearable. Almost 90% are wireless monitor from smartphone. Another 10% is basic electronic components. The system design are completely implemented by IoT. The result are created based on the real subject (human body).

3.1 Results

Figure 4 and 5 show the example of graph voltage against time of the bicep and forearm muscle, respectively. Both were compared between flexion and extension. Based on the Figure 4, the flexion obtained approximately at 35mV and it was the maximum value by random test. The extension has below than 10mV. Figure 5 which is for forearm muscle has approximately to 20mV. The peak value is for flexion and the rest state is an extension value. However, the results shown that there was differences between extension and flexion. Therefore, several data has been collected to generate the average and tolerance of the muscle movement.

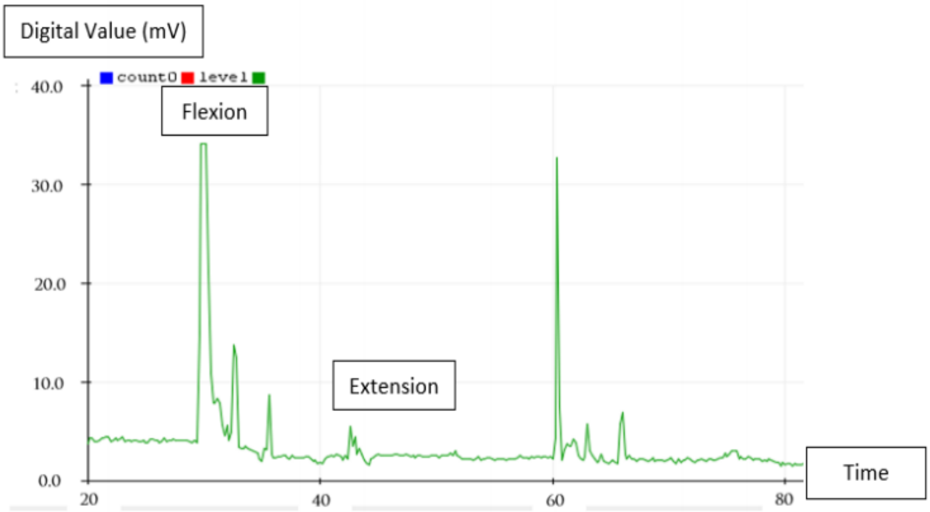

Figure 4: Serial Plot of Flexion and Extension (Bicep Muscle)

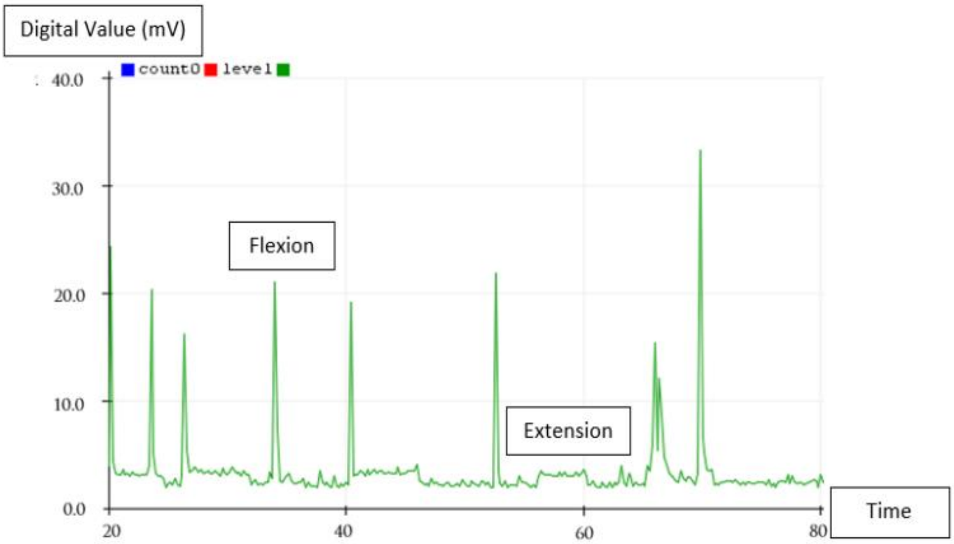

Figure 5: Serial Plot of Flexion and Extension (Forearm Muscle)

Table 3 shows a summary of the results. The data produced by the Myoware sensor which is applicable for muscle at the human body. The very first experiment are used at the bicep and forearm in the human body. It is an analysis and demonstration to see the effect between the sensor and the human body against the voltage. Muscle for both bicep and forearm control movement of flexion and extension. The bicep muscle worked to allow the hand to bend and straighten. The bending process is called flexion and the straightening process is called extension. Thus the same action occurs at the forearm. From the result obtained, it can relate with the theoretical of flexion and extension movement which is during forearm muscle relax the hand is in extension while when the forearm contracted the hand is in flexion. The result proves where process extension produced low voltage and during the flexion, there is a high value of voltage.

Table 3: Result Summary for Extension and Flexion of Biceps and Forearm Muscle

	Average Value Biceps Muscle (mV)		Average Value Forearm Muscle (mV)	
Subject	Flexion	Extension	Flexion	Extension
A	27	9	22.7	8
B	21.7	7	16	4
C	24	8.3	19.3	7.6
D	23.3	8.3	19.3	8
E	29	11	28.3	9.7
The mean for average value.	25	8.72	21.12	7.46
Standard deviation for the average value	3	1.5	4.7	2.1

3.2 Discussions

The aim of this study was to determine whether muscle treatment monitoring device performed on patient would be effective at improving the muscle condition. The 5 sample of data collected were based on the healthy person with different characteristic like muscle, weight, and height. Based on the data summary in Table 3, there were a numbers of mean and standard deviation calculated based on the excel software. The standard deviation were used to measure the threshold and tolerance for the calibration purpose. The mean value for bicep flexion was 25 mV and bicep extension was 8.72 mV. Therefore the threshold and tolerance for the flexion and extension of bicep muscle were 3 mV and 1.5 mV each. The same procedure and calculation performed on the forearm muscle. Thus, the mean value for forearm flexion was 21.12 mV and bicep extension was 7.46 mV. Therefore the threshold and tolerance for the flexion and extension of bicep muscle were 4.7 mV and 2.1 mV each. All the tolerance would be calibrated in Arduino software.

4. Conclusion

In conclusion, the muscle treatment monitoring device was developed as monitoring tools for the patient daily use. Hence, research into designing a muscle treatment monitoring device that can be conveniently controlled and the data which can automatically viewed by the Internet of Things (IoT) is a great value. The device was lightweight and highly sensitive, thus preferred as a home monitoring device. It provides quality and timely health assistance for both physiotherapist and patient. The device are able to be monitored by using smartphone and automatic measure by muscle sensor. The muscle treatment monitoring device design met the project’s expectations set at the beginning.

Acknowledgement

The authors would like to thank the Ministry of Higher Education Malaysia for supporting this research under Fundamental Research Grant Scheme Vot No. FRGS/1/2019/TK04/UTHM/03/10 and partially sponsored by Universiti Tun Hussein Onn Malaysia.

References

[1] F.V. Brozovich, C.J. Nicholson, C.V. Degen, Yuan Z. Gao, M. Aggarwal, and K.G. Morgan. "Mechanisms of Vascular Smooth Muscle Contraction and the Basis for Pharmacologic Treatment of Smooth Muscle Disorders", Pharmacol Rev 68, pp.476–532, 2016.

[2] J Wan, Z. Qin, P. Wang, Y. Sun and X. Liu. "Muscle fatigue: general understanding and treatment. Experimental & Molecular Medicine" 6 October 2017.

[3] M. S. Rashid, Z. Zaman, H. Mahmud, and M. K. Hasan, "Emotion Recognition with Forearmbased Electromyography," 2019.Author 1 et al., Evolution in Electrical and Electronic Engineering Vol. 0 No. 0 (2021) p. 1-9.

[4] J. O. Raj., et al. "Correlation of Forearm Circumference and Hand Length with Grip Strength in Healthy Young Adults". Acta Scientific Orthopaedics 2.10 (2019): pp. 10-15.

[5] P. Baschung Pfister, E. D. de Bruin, I. Sterkele, B. Maurer, R. A. de Bie, R. H. Knols, "Manual muscle testing and hand-held dynamometry in people with inflammatory myopathy: An intraand interrater reliability and validity study" PLoS ONE 13 (3): e0194531, 2018.

[6] Cahyadi, Basri & Ibrahim, Zunaidi & Abu bakar, Shahriman & Khairunizam, Wan & Majid, S.H. & Mohamad Razlan, Zuradzman & Muhammad, M. & M. Nor, Rudzuan & Mustafa, Wan. (2018). "Upper Limb Muscle Strength Analysis For Movement Sequence Based on Maximum Voluntary Contraction Using EMG Signal" 1-5. 10.1109/ICASSDA.2018.8477638.

[7] Swamy G., Kodali R. K., and Lakshmi B. "An Implementation of IoT for Healthcare", IEEE Recent Advances in Intelligent Computational Systems (RAICS) 10-12 December 2015.

[8] L. Tarricone, L. Mainetti, L. Catarinucci, Danilo de Donno, M. L. Stefanizzi, L. Patrono, and L. Palano, "An IoT-Aware Architecture for Smart Healthcare Systems", IEEE Internet Of Things Journal, December 2015; Vol. 2, No. 6.

[9] Z. Achmed and G. Miguel, "Assimilating Wireless Sensing Nets with Cloud& Computing," Sixth Innt. Confe. Mobi. Ad-hocc Sense. Netks, pp. 263–266, Oct. 2010.

[10] S. F. Del Toro, S. Santos-Cuadros, E. Olmeda, C. Álvarez-Caldas, V. Díaz, and J. L. S. Román, "Is the use of a low-cost Semg sensor valid to measure muscle fatigue?," Sensors (Switzerland), Vol. 19, no. 14, pp. 1–19, 2019.

[11] J. W. Brandsma, T. A. Schreuders, J. A. Birke, A. Piefer, and R. Oostendorp, "Manual muscle strength testing: intraobserver and interobserver reliabilities for the intrinsic muscles of the hand.," J. Hand Ther., vol. 8, no. 3, pp. 185–90.

[12] A. Khanna and S. A. Muthukumaraswamy, "Cost-effective system for the classification of muscular intent using surface electromyography and artificial neural networks," Proc. Int. Conf. Electron. Commun. Aerosp. Technol. ICECA 2017, vol. 2017-Janua, no. November, pp. 366–371, 2017.