Edutec
Journal of Education And Technology
2597-9221 (Online)
Volume 5 Number 3 March 2022

Application of Digital Electromyography Portable (DEP) In Arduino Uno Based Progressive Muscle Relaxation (PMR) Exercise in The Elderly

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Article History	Received : Jan 7th 2022 Revision : Feb 9th 2022 Publication : March 30th 2022

ABSTRACT

Progressive muscle relaxation exercise is an intervention carried out to train muscles to regularly move maximally. Technological developments in the 4.0 era made changes so that the elderly knew that the application of portable digital electromyography could be done at home. Muscular strength is the amount of force a muscle can produce with maximum effort. An electromyograph is used as an interrogator by measuring the sensory activity of the elderly muscles. Teacher performance in education is very important. There are several factors that influence teacher performance, namely factors from work motivation and work discipline. The purpose of this study was to determine the level of accuracy of the application of digital electromyography in the elderly. This research was conducted on 30 elderly who are in environment III, Medan Sunggal sub-district with a quasi-experimental research design with a pretest-postest design. The method used in this study is to use a questionnaire level of sophistication and weighting of technological components in the instrument. The analytical method used in this research is descriptive statistical analysis method. Based on data analysis in this study, the results showed that there were significant differences in the accuracy of the application of portable digital electromyography in the elderly with a value of r count = 0.453 r table = 0.44.

Keywords: Online Learning, Gamification, Moodle

INTRODUCTION

Key Words: Electromyography; Muscle Strength; Exercise; Educational Status; Muscles

INTRODUCTION

Elderly is a period when humans have reached maturity in size and function. In addition, the elderly are also a time when a person experiences setbacks over time. According to the Ministry of Health, the elderly are divided into three groups, namely the early elderly, the elderly, and the high-risk elderly. The Elderly is the final stage of the human life cycle, which is part of the life process that cannot be avoided and will be experienced by every individual (Dosen Pendidikan, 2020). According to WHO, the elderly population in Southeast Asia is 8% or around 142 million people. In 2050 it is estimated that the elderly population will increase 3 times from this year. While in Indonesia in 2020 it is estimated that the number of elderly people is around 80 million people (Ministry of Health of the Republic of Indonesia, 2016).

The elderly will experience an aging process starting to appear from the age of 45 years and problems will arise around the age of 60 years marked by a description of the decline in the elderly body function regarding strength/energy decreased by 88%, visual function decreased by 72%, body flexibility decreased 64%, memory decreased by 61%, hearing decreased by 67% and sexual function decreased by 86%. Decreased body function in the elderly will lead to problems with movement disorders and function of the elderly. The elderly experience decreased walking function, decreased balance function, decreased functional ability, and decreased independence in activities of daily living (Utomo, 2010). One therapy to relax the limbs is progressive muscle relaxation (PMR) exercise. Exercise can reduce pain due to muscle injury and relax the limbs from fatigue (Elfira et al., 2020). Progressive muscle relaxation exercises are also able to provide changes in cholesterol, uric acid, and blood sugar levels in the body by doing it every day (Elfira, 2020). Applications of progressive muscle relaxation exercises are able to reduce pain and relieve anxiety (Natosba et al., 2020).

In this technological era, there are so many tools or findings that make it easier for us to do something. One of the tools used to detect muscle is electromyography. Electromyography is a tool used to record changes in muscle tissue voltage to diagnose nerve and muscle disorders (Yin, 2010). Electromyography in muscles serves to detect the electrical potential generated by muscles during contraction and relaxation so that it can be used to control a system. The signal used in the elbow extension-flexion movement at an angle of 45, 90, and 135 degrees is carried out using a backpropagation algorithm artificial neural network that works in a trained manner with 60 inputs, 4 hidden neurons, and 2 outputs. When testing the learning signal, the accuracy value is 78.33% (Rokhana & Wardana, 2000). Electromyography signal analysis performed on tired muscles during driving found that the required frequency is 12,782 Hz for the fatigue phase (Mohd Azli et al., 2019). Electromyography (EMG) is a technique used to evaluate nerve and muscle function by recording the electrical activity produced by skeletal muscles. The evaluation aims to diagnose muscle and nerve disorders in the peripheral nervous system through the skin and into the muscle tissue that distinguishes between nerve roots and muscle diseases (glenagles.com, 2020). Assessment of lower limb muscle activity provides information on neuromuscular behavior before and after physical activity. Electromyography can identify changes in the motor skills of the elderly and help create preventive strategies for age-related changes in neuromuscular factors that can interfere with daily activities and increase the risk of falls in the elderly (Coscrato et al., 2013).

The physical portion of the motor neuron and muscle fiber system that is connected via the neuromuscular junction (or end plate) is called the IZ. The action potential travels in the opposite direction towards the termination of the tendon and generates a propagation potential over the skin. During dynamic contraction, the relative motion of the muscle to the skin (i.e. the electrode system) determines the strong signal changes when the IZ shifts under the electrode pair. Therefore, the electrode must be placed between the IZ and the tendon termination to ensure meaningful signal recording. Since, for now, high-density EMG recording techniques are available almost exclusively in research laboratories, practitioners can refer to papers and books for guidance on finding the best electrode placement in the most superficial muscles. The traditional bipolar configuration requires the electrodes to be placed parallel to the muscle fibers and such a position can be obtained carefully by examining the highest EMG signal amplitude. Otherwise, innovative electrode designs have been proposed; Bipolar concentric electrodes, for example, can be used without having to worry about the direction of the muscle fibers due to their intrinsic isotropy (Boccia et al., 2015).

METHOD

The type of research used is a quasi-experimental design with a pretest-posttest design with one type of treatment. This study uses an intervention that is progressive muscle training. This research was conducted in the sub-district of Medan Sunggal in the elderly with an age range above 45 years. This research was conducted from June to August 2021. This research method used a questionnaire and observation. Respondents in this study were 20 respondents with sample criteria namely; 1. Willing to be a respondent, 2. Over 45 years old, and 3. The respondent is in good health.

Table 1. The components in the process of applying DEP (portable digital electromyography) are;

No.	Komponen	Specification	Amount
1	Socket power AC	2 Pin 220VAC	1
2	Fuse & holder	1 A, 220 VAC	1
3	Saklar power	On Off & indikator 220VAC	1

4	Jack audio	3mm	1
5	Jack banana	Black, green, red, yellow	15
6	Potensiometer	20KΩ	1
7	Spacer	M3, 25mm	8
8	baut	M3, 10mm	8
9	Kapasitor	Mylar	5
		Elco	4
10	Resistor	¼ watt	17
11	Diode	1N4002	4
12	Arduino	Arduino UNO R3	1
13	Display	TFT 3.0	1

Table 1. The stages of DEP (Digital Electromyography Portable) processing follow the following workflow:

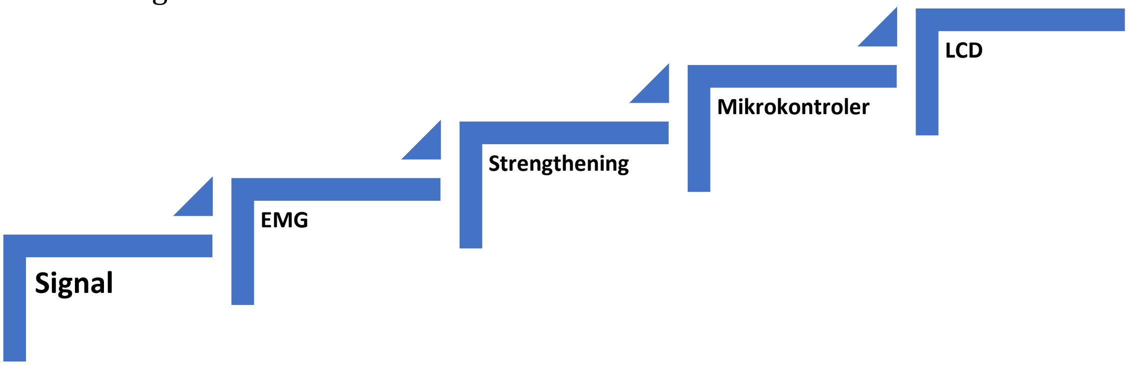


Figure 1. DEP workflow

This research is based on the development procedure by (Serhat Kurt, 2018) namely ADDIE (Analyze, Design, Develop, Implement, Evaluate). The stages that have been implemented include (1) analysis, (2) design, (3) development, (4) implementation, (5) evaluation. The following is an explanation of the research results at each stage.

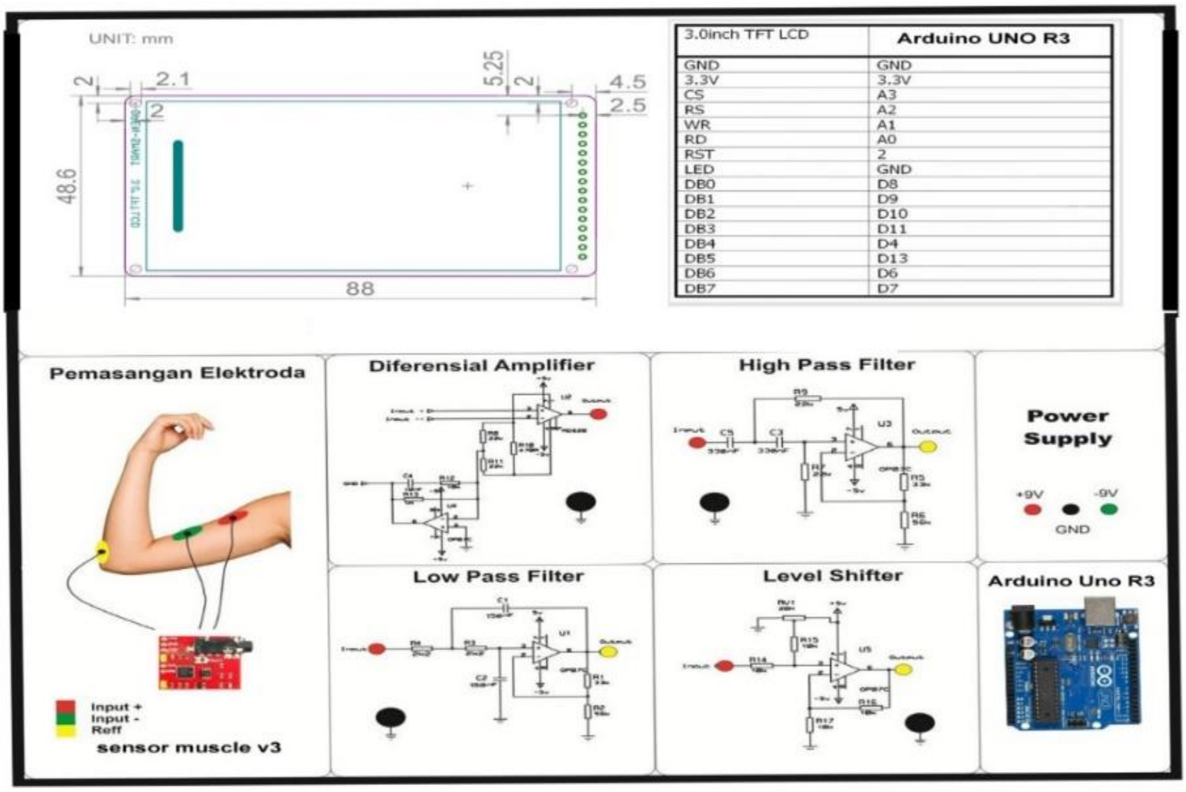


Figure 2. Design Overview of DEP components

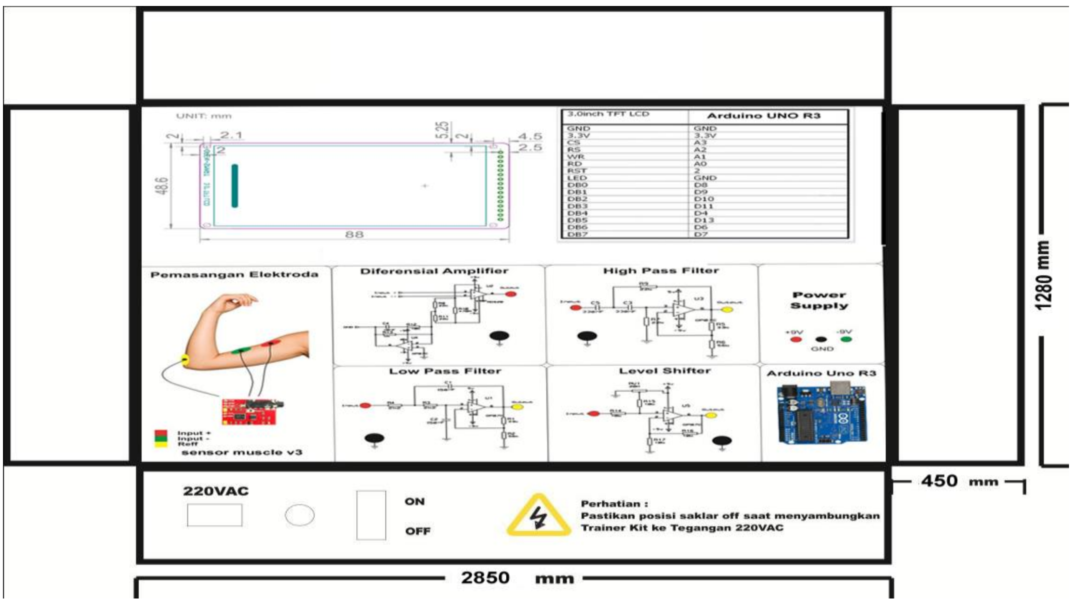


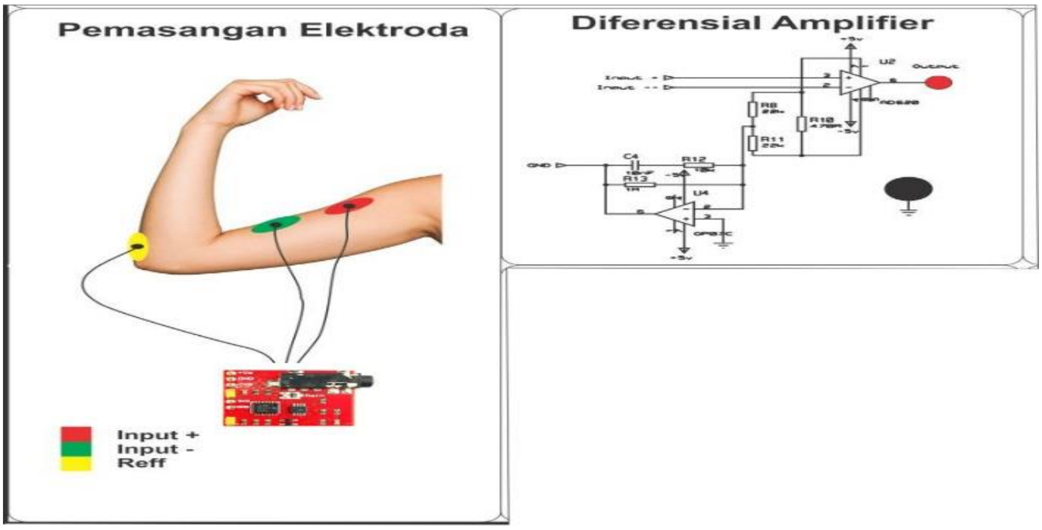
Figure 3. Overall design of DEP

The display design above is transformed into a frame design made with ice cream sticks. The frame design is made by pasting using UHU glue. The DEP (Digital Electromyography Portable) circuit consists of several circuits including a power supply, an AD620 amplifier circuit, a High Pass Filter circuit, a Low Pass Filter circuit, a level shifter circuit, and an Arduino Nano.

a. Power Supply Circuit. This circuit is made capable of producing a stable voltage of +9V and -9. The main voltage source comes from AC 220 electricity and then it is lowered by a CT transformer. To be able to produce +9V and -9V voltages, IC 7809 and IC 7090 are used. IC 7809 is used for +9V stable voltage while IC 7909 is used to stabilize -9V voltage. Here is a picture of the power supply circuit schematic. The power supply display on the DEP is a 2 mm banana jack with +9V and -9V output.

b. The Instrumentation Amplifier circuit uses the AD620 IC which is used for the voltage found in human muscles. Muscle tension in humans is measured by attaching electrodes to human skin. The AD620 amplifier circuit is added with a drift right leg using the OPO7 IC. The instrumentation amplifier circuit is given a +9V and -9V voltage coming from the power supply.

c. The High Pass Filter circuit is used to evaluate high and low frequencies, where the cut off frequency is 20 Hz using a gain of 1.6 times.



d. Low Pass Filter circuit is used to detect low and high frequencies.

e. The Level shifter circuit is used to increase the voltage level because the ADC on the Arduino is not able to read signals that have negative voltages.

f. Adruino Uno R3 uses Atmega 328, there are 30 I/O PINs. Pins on Arduino nano consist of 8 analog pins, 14 digital pins, pins for voltage input and reset pins.

g. Muscle V3

h. Open Smart TFT LCD 3.0

RESULT AND DISCUSSION

The results of this study were carried out by the Functionality Test of the Tool. The test is carried out with the work response on the electronic circuit. The following are the test results of each electronic circuit:

1. Power Supply

The power supply circuit consists of two parts, namely +9V and -9V for the voltage source for all circuits in the test. Measurements are made with a multimeter. Based on the test, it shows that the output of the power supply is +8.9 V and -9.2 V. Based on the measurement results, it can be concluded that the power supply is working well.

2. Instrumentation Amplifier

The magnitude of the gain in the AD620 amplification circuit is 108 times. The reinforcement data can be seen in Table.2.

Table 2. Reinforcement Test Results

No	Voltage Input (mV)	Output voltage Theoretically (mV)	Voltage output (mV)	Gain	Error
1	10	1080	980	98	9%
2	20	2160	2100	105	3%
3	30	3240	3200	106	2%

4	40	4320	4200	105	3%
		Average error			4%

The gain is obtained by giving the amount of Rg (resistor gain) which is connected to pins 1 and 8 AD620. Based on the amplifier circuit that has been made, Rg in the circuit is obtained by providing two 22KΩ 470Ω resistors, where the 22KΩ resistor is arranged in series and then in parallel with the 470Ω resistor. Thus, it is obtained that the gain is 108 times the result of theoretical calculations while in practice, the reinforcement does not have to be exactly 108 times.

3. High Pass Filter

Testing this circuit is done using AFG as input and to see the output using an oscilloscope. The input quantity given is the amplitude of 1 V and the frequency is changed. In the high pass filter circuit also uses IC OP07 which is given a resistor of 33kΩ and 56kΩ, so that the gain is 1.6 times. The following are the results of the high pass filter frequency response test in Table 3.

Table 3. Frequency Response of High Pass Filter

No.	Frequency (Hz)	Input voltage (V)	Output Voltage (V)	Av
1.	1	1	0	0
2	2	1	0	0
3	5	1	0	0
4	8	1	0.4	0.4
5	10	1	0.4	0.4
6	15	1	0.6	0.6
7	20	1	0.8	0.8
8	25	1	1	1
9	30	1	1.2	1.2
10	35	1	1.4	1.4
11	40	1	1.4	1.4
12	50	1	1.4	1.4
13	60	1	1.4	1.4
14	70	1	1.4	1.4

From these results it can be concluded that the high pass filter circuit can work well because it can pass the expected high frequency of 20Hz and above.

1. Low pass filter

The low pass filter circuit that was made based on the previous design has a cut off frequency of 500Hz. Table 11 is the frequency response of the Low pass filer circuit.

Table 4. Low Pass Filter Frequency Response

No.	Frequency (Hz)	Input voltage (V)	Output Voltage (V)	Av
1.	200	1	1.4	1.4
2	250	1	1.4	1.4
3	300	1	1.4	1.4
4	350	1	1.4	1.4
5	400	1	1.4	1.4
6	450	1	1.4	1.4
7	500	1	1	1
8	550	1	1	1
9	600	1	1	1
10	650	1	0.8	0.8
11	700	1	0.6	0.6
12	750	1	0.6	0.6
13	800	1	0.6	0.6
14	850	1	0.6	0.6

It can be concluded that the low pass filter circuit can work well because it can pass the expected low frequency of 500Hz and below.

2) Level shifter

The level shifter circuit is tested by providing a voltage input with AFG and the output of the level shifter circuit is displayed on the Arduino IDE serial. The variable resistor is arranged so that the output of the circuit increases or decreases until the entire signal has positive polarity. From observations it is found that the level shifter circuit can accommodate the need to increase the offset voltage of the EMG signal to all sunyla have positive polarity. This means that the level shifter is able to turn the pressure level into a positive overall.

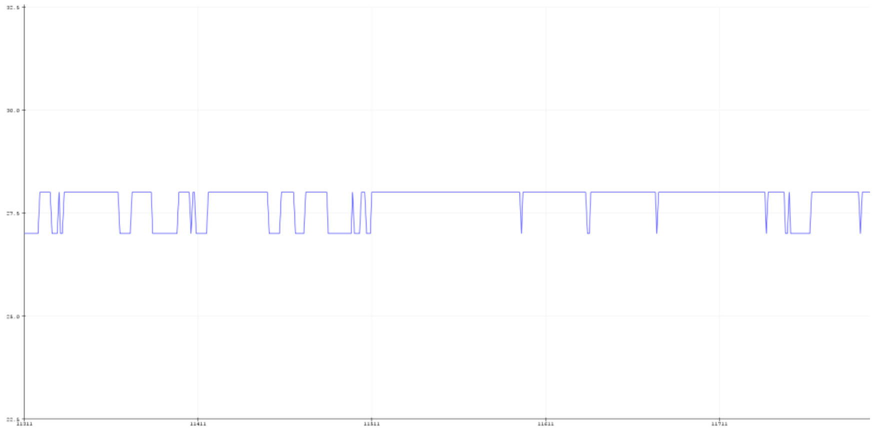


Figure 4. Level Shifter Test

Item	r count	r table	Description	Item	r count	r table	Description
1	0.453	0.444	valid	16	0.203	0.444	Not valid
2	0.599	0.444	valid	17	0.622	0.444	valid
3	0.506	0.444	valid	18	0.493	0.444	valid
4	0.585	0.444	valid	19	0.577	0.444	valid
5	0.547	0.444	valid	20	0.461	0.444	valid
6	0.496	0.444	valid	21	0.453	0.444	valid
7	0.530	0.444	valid	22	0.542	0.444	valid
8	0.697	0.444	valid	23	0.347	0.444	not valid
9	0.620	0.444	valid	24	0.621	0.444	valid
10	0.594	0.444	valid	25	0.446	0.444	valid
11	0.488	0.444	valid	26	0.668	0.444	valid
12	0.605	0.444	valid	27	0.516	0.444	valid
13	0.451	0.444	valid	28	0.612	0.444	valid
14	0.610	0.444	valid	29	0.290	0.444	not valid
15	0.444	0.444	valid				

Table 5. Results of the use of DEP in the elderly

Based on the value of the r product moment table with a total of n = 20 and a significance level of 5%, the r table is 0.444. The criteria for the instrument item validation test if the r count (rxy) is more than r table then the item is considered valid and vice versa if it is less than r table it is considered invalid. All the results of item calculations can be seen in Table 5.

CONCLUSION

The research study (Dos Reis et al., 2019) found that a total of 6697 titles and 92 expressed great variability in the methods applied to recording and processing/analyzing data. The most commonly used procedures for sEMG were identified. Methodological studies with objective comparisons are very important to improve standardization carried out in the elderly. While in this study the application of portable digital electromyography can be given to the elderly with a maximum of 500 Hz/1.4 volts. This research is suggested to be able to provide developments related to the detection of muscle strength that can be visualized by homecare by medical personnel.

CONFLICT OF INTEREST

No conflict of interest has been found between the authors.

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