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AGE-RELATED MUSCLE FUNCTION IDENTIFICATION USING EMG AMPLITUDE ANALYSIS

MUHAMMAD SAUFI BIN SANUSI

Thesis submitted in fulfilment of the requirement
for the award of the degree of
B. Eng (Hons) Mechatronics Engineering

Faculty of Manufacturing Engineering

UNIVERSITI MALAYSIA PAHANG

JUNE 2016

SUPERVISOR DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Bachelor of Engineering in Mechatronics Engineering.

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I hereby declare that the work in this thesis is my own except for quotation and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted for award of other degree.

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ABSTRACT

The relationship between electromyography (EMG) and age group is to identify and analysis the electrical activity/signal on upper-limb muscle. Nine participants/subjects with their arm fixed at 90º angle and perform isometric contraction using the dynamometer. The EMG is one kind of biological signal that can be recorded by using signal sensors. A raw EMG signal is obtained from the experiment and then will be filtered to get accurate results. The Root-Mean-Square (RMS) and Mean-Absolute-Value (MAV) is then obtained by using the calculations from the raw data. The results shows the EMG activity for younger age group is more significant (higher activity) compare to the adult and older age group.

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LIST OF ABBREVIATIONS

EMG	Electromyography
sEMG	Surface electromyography
RMS	Root mean square
MAV	Mean absolute value
STD	Standard deviation
MVC	Maximum voluntary contraction
CoV	Coefficient of variance
VL	Vastus lateralis
VM	Vastus medialis
CV	Conduction velocity
MVE	Maximum voluntary exertions

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Upper limb is the parts of human body that extending from the deltoid region (part ofshoulder) until finger. The upper limb movements are important for the human basic activity such as lifting an objects, writing, cooking, driving and etc. As the day and week past away, every muscles will have a different electrical pulse produced. Electromyography (EMG) was needed to study every change.

Electromyography is an electro diagnostic technique to studying, evaluating, and recording of an electrical activity of a muscle. The main devices used to detect the electrical pulse were using an electrode. The electrodes detect the electrical signal that changes proportionally with time. The changes occurred because of the reduction of muscle fibres.

In this study, the parameter was the age of the subjects. It will be divided into three ages groups that including the younger, adults and older. From the groups we will analyze and evaluating the electrical signal according to each groups.

1.1.1 ELECTROMYOGRAPHY (EMG) SIGNAL

The electrical signal produced by the muscle is around -90Mv. Measured EMG potential range is between the ranges less than 50µV and up to 20 to 30Mv depending on the muscle condition during observation. The root-mean-square (RMS) is one of the most important as it gives a measure of the power of the EMG signal. The normal EMG frequencies in human bodies are between 5Hz to 450Hz and the mean-absolute values (MAV) are used for calculating the area under the graph of the EMG signal.

1.1.2 Upper Limb Muscle

The upper limb muscle or also known as upper extremity is a group of muscles that extending from deltoid muscle in the shoulder to the tip of the fingers. The structure of the upper limb part consists of shoulder girdle, shoulder joint, arm, forearm, wrist, and hand. In this research, the muscles that will be choose is biceps brachii that located in the arm and brachioradialis muscle that located in the forearm region.

1.1.3 Contractions

There are many types of muscles contractions in human body to do the daily activities such as isometric, isokinetic, concentric, and eccentric contractions. Isometric contraction is the types of contraction that will be choose in this study. This movement would cause biceps brachii and brachioradialis (forearm) to having a contraction without moving any parts of the arm.

1.2 PROBLEM STATEMENT

The electrical activity on the upper limb muscle changes proportional with the time (increasing of human ages). For example, the electrical signal of 18 years old boy was different from 30 years old men. By recording, measuring, analyzing, and evaluation of the EMG-age related muscle function identification, it is possible to study and understand the electrical activity of an upper limb muscle.

1.3 OBJECTIVES

- To study the changes of electrical activities of a upper limb muscle using surface EMG-age relationship.
- To understand the comparison of Root-Mean-Square and Mean-Absolute-Value between muscles and age group.
- To record the results of the EMG based on the age of the subject.
- To analyze the EMG signal with different age group using amplitude analysis

1.4 SCOPES

1.4.1 Robotics

Electromyography (EMG) is very useful for the designing and fabricating of a mechanical/ mechatronic/bionic arm, legs and etc. To fabricate this robotic part, studies about how human hands response to stimulate is essential to makesure the mechanical arm work properly.

1.4.2 Medical

EMG mainly used for the diagnostic tool for identifying neuromuscular diseases. Some EMG method can be used to detect spinal nerve injury because this injury does not cause neck or mid-back pain that cannot be detected by using surface EMG.

1.4.3 Rehabilitation

EMG is used in rehabilitation / neuro-rehabilitation as medium for the researchers and engineers to develop a new technology to assist patients that have musculoskeletal problems or nervous system injury.

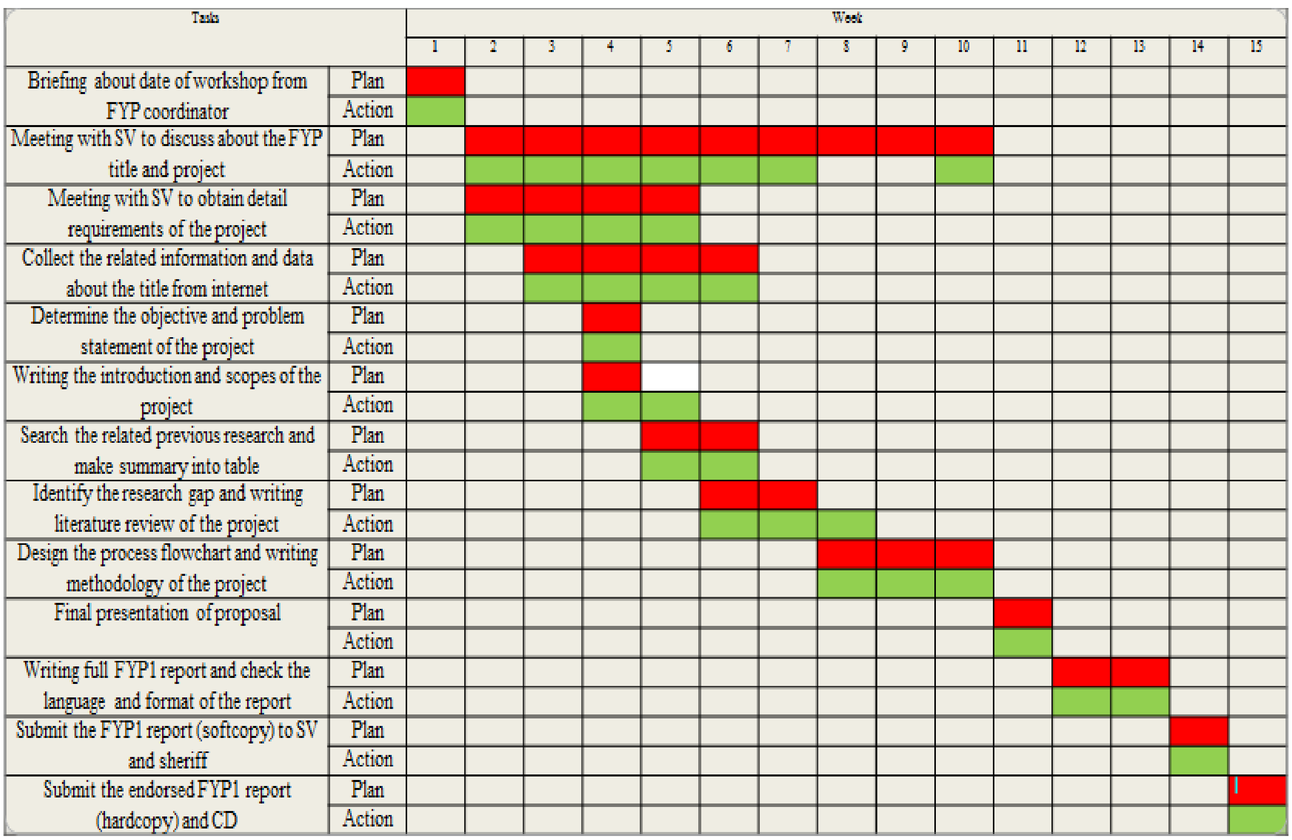
1.4.4 Sport Science

Electromyography (EMG) is used in morphological analysis of the motor unit. It is important to synchronize the systems that supply kinematic data with electromyography to determine the period when different muscles join the muscle movement. Surface electromyography (sEMG) is an important tool of biomechanical analysis and has increasing importance in sports. This study helps to improve activity and prevents the risk of injury.

1.5 BUDGET PLAN

The whole study will be conducted in the iMam’s lab at faculty of manufacturing engineering (UMP Pekan). There is no need for any raw materials use in this experiment but there is some devices that will be use. Some of the devices are hand dynamometer, EMG sensors, and surface electrode. All the devices will be provided by the supervisor. The software that will be use is Microsoft Excel 2010. This software is use forrecording, filtering, sorting, calculating, and analyzing the data obtains from the experiment.

1.6 GANTT CHART



1.7 CONCLUSION

The electromyography (EMG) signal will be observed and analyzed by a numbers of individual who have been separated into three categories: youth, adult and elder. The muscles that will be chosen in this research is biceps brachii and brachioradialis (forearm muscle) because most patients have troubles in this section. The important parameters will be use in this study is root-mean-square (RMS), mean, standard deviation (STD), coefficient of variance (CoV), and mean-absolute value (MAV).

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The main purpose of this chapter is to study and review the existing literature to find out more information about the surface electromyography (EMG) for determining and analyzing the signal on the upper-limb muscle such as biceps brachii, triceps brachii, and dorsal interosseous muscle. There a lot of article found on Google Scholar but only five articles that have been shortlisted in the table below. This table is grouped according to title, subject, type of EMG, objective and methodology.

2.2 Table 2.1 literature review on EMG-age relationship compare to subject, type of EMG, type of muscle, objective and methodology.

No	Title	Subject	Type of EMG	Muscle	Objective	Methodology
1	Age-related differences in corticospinal control during functional isometric contractions in left and right hands	10 young (5M,5F) range 19-31 years, 10 old (5M,5F) range 60-79 years.	Surface EMG	Dorsal interosseous muscle	To examine age-related differences in electromyography (EMG) responses to transcranial magnetic stimulation (TMS) during functional isometric contractions in left and right hands.	Subjects seat comfortably on experimental chair. Their elbow flexed at ~90 degree and their shoulder at ~45 degree.
2	Differences in age-related fiber atrophy between vastii muscles of active subjects: a multichannel surface EMG study	12 young (12 M) range 18-23 years, 12 older (12M) range 65-69 years.	Surface EMG	Vastus lateralis (VL), vastus medialis obliquus (VM)	To determine if vastus lateralis (VL) and vastus medialis obliquus (VM) muscles are equally affected by age-related fiber atrophy	Performed isometric knee extension at 30%, 50% and 70% of axial voluntary contraction
3	Age-related increase in electromyography burst activity in males and females.	16 younger, range <26 years, 15 older,	Surface EMG	Biceps brachii (BB), triceps brachii (TB), vastus lateralis (VL), biceps	To determine whether bursts in EMG recorded over 8 hour diffred between	Long term EMG recoded using surface electrodes. Data

		range >70 years		femoris (BF)	young male and female.	inspection confirmed using RMS
4	Age-related differences do affect postural kinematics and joint kinetics during repetitive lifting	14 young, range 20-31 years, 14 older, range 43-54 years	Surface EMG	Erector spinae muscle	To investigated differences between kinematics and kinetics of repetitive lifting of different ages	EMG amplitude was calculate using RMS pre and after lifting. Kinematic and kinetic data smoothed using Butterworth low-pass filter
5	Age and sex differences in steadiness of elbow flexor muscles with imposed cognitive demand	36 young (18M,18F) range 18-25 years, 30 older (13M, 17F) range 60-72 years	Bipolar surface EMG	brachioradialis, triceps brachii	To determine age related differences in steadiness of isometric contractions	Non-dominant arm tested to minimize variability. Contraction performed without performing the cognitive task

2.3 METHOD OF SEARCH CRITERIA

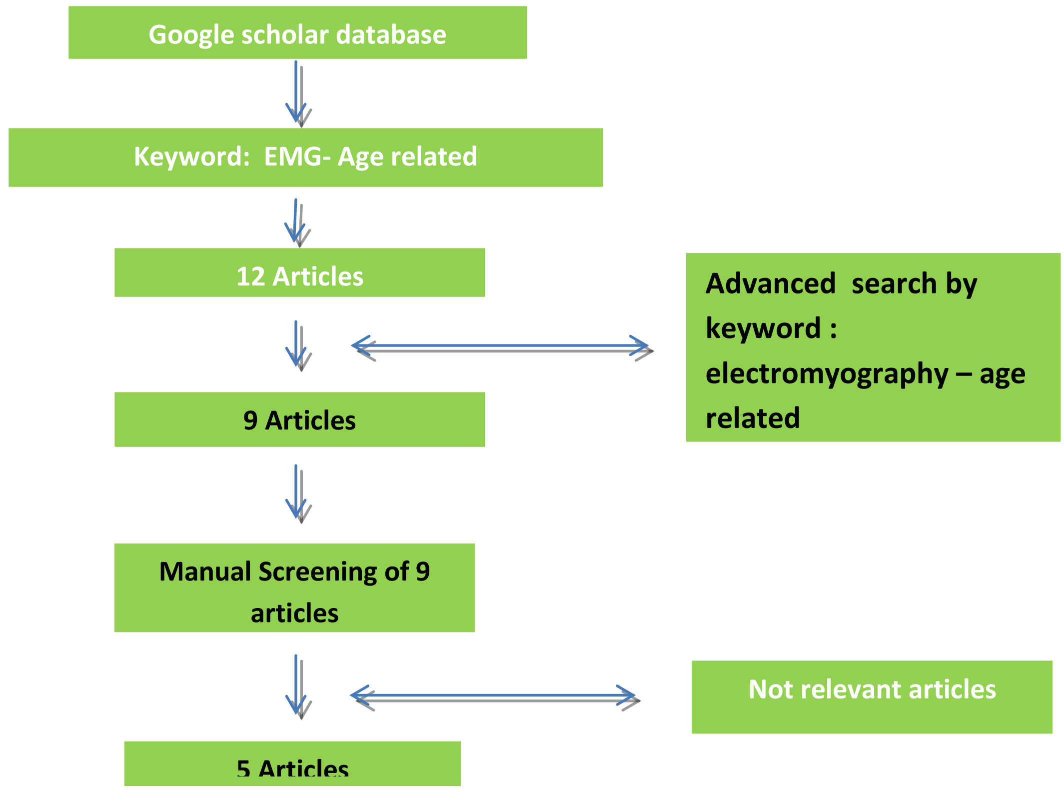


Figure 2.1: Flow chart of methodology

2.4 LITERATURE REVIEW RESULTS

From figure 2.1, it is found 12 articles from the Google Scholar website using the keyword 'EMG-age related '. By using advanced search using the keyword "electromyography-age related", it was found 9 articles. 5 article out from 9 article were shortlisted due to some of the major point is almost or near the same with the EMG-age related muscle function. Below are the short summaries of the 5 articles.

2.4.1 Age-related differences in corticospinal control during functional isometric contractions in left and right hand

First publish in October 2005. Based on the article, the subject used twenty volunteers divided into ten young and ten old which included five male and five female in every class. The young group was age between nineteen to thirty-one years old and the older group range between sixty to seventy-nine years old. During the experiment, the Surface Electromyography (EMG) was used to examine the age-related differences in electromyographic (EMG) responses to transcranial magnetic stimulation (TMS) during functional isometric contractions in left and right hands. The research was expected to see a reduced muscle evoked potentials (MEP) amplitudes and shorter EMG silent periods in the dominant hand of right-handed older subjects. The subjects shoulder was abducted in ~45º angle and the elbow is flexed at 90º angle. The analysis shows that the age differences in MEP area were associated with response in the left hand where the area was 30% more lowly for the old subjects compared to the young subjects. In this experiment, the signal was amplified and band-pass filtered is used with value from 13 – 1000Hz.

2.4.2 Differences in age-related fiber atrophy between vastii muscles of active subjects: a multichannel surface EMG study

Publish in June 2015; the purpose of this study is to determine if vastus lateralis (VL) and vastus medialis obliquus (VM) muscles are equally affected by age-related fiber atrophy. Atrophy is a degeneration process of removal waste product from the muscle fiber to prevent defective nutrition or nerve damage. The subjects include twelve young man age between eighteen to twenty-three years old and twelve older man age between sixty-five to sixty-nine years old. They have to perform isometric knee extensions for 30%, 50%, and 70% of maximal voluntary contraction. Electromyography (EMG) signal were recorded using eight electrodes. The results show that the conduction velocity (CV) has a different behavior for the two muscles that they are greater for the young man compared to the elder.

2.4.3 Age-related increase in electromyography burst activity in males and females.

Publish in 2013, this experiment is to determine whether bursts in EMG recorded over 8 hour differed between younger and older, male and female. The subjects are sixteen younger individuals (eight male and eight female) age less than twenty-six years old. The older individuals consist of eight male and seven female ages more than seventy years old. They were asked to participated 8 hour recording day and must visit the laboratory twice during the 8 hour. For the first time the maximal electromyography (EMG) is recorded and the subjects were asked to do their normal daily routine. After 8 hours, the subjects came to the laboratory and the maximum voluntary exertions (MVE) were doing and the EMG signal was recorded. The entire signal was amplified 1000 times and band-pass filtered was used between 20 – 450Hz. The results were the age-related increase in burst percentage by 5% to 9% being active for the younger muscles compared to 16% to 27% for the older muscles.

2.4.4 Age-related differences do affect postural kinematics and joint kinetics during repetitive lifting.

This article was published on 2014; the main purpose is to investigate differences between kinematics and kinetics of repetitive lifting of different ages. Twenty-eight men participated to become the subjects for this experiment. That was including fourteen younger male age between twenty to thirty-one years old and fourteen elder male with age between forty-three to fifty-four years old. During the experiment, the subjects were asked to lift a 13kg box for a frequency 10 lifting per minute. The muscles activity was recorded using surface electromyography (sEMG) and the signal was amplified 500 times and band-pass filtered at 10 – 450Hz. The impedance of the skin must be less than 10kΩ. The results were the younger subjects took a longer interval compare to the older one because the younger participants initially extended their lumbar spine at a lower mean peak angular velocity than the older group.

2.4.5 Age and sex differences in steadiness of elbow flexor muscles with imposed cognitive demand.

Publish on January 2015, the experiment is done to determine age related differences in steadiness of isometric contractions when high cognitive demand were imposed with ranges of forces with the elbow flexor muscle and sex differences in steadiness among the older subjects during low cognitive demand were imposed. The subjects consist of thirty-six young people divided into eighteen male and eighteen female subjects with age between eighteen to twenty-five years old. Another group was thirty older people consist of thirteen male subjects and seventeen female subjects range between sixty to eighty-two years old. Each subject must performed cognitive task at rest pre contractions and also during sub maximal contraction. The bipolar surface electrode was placed at biceps brachii, brachioradialis and triceps brachii muscles for recording the EMG signal. The signal was amplified 100 times and band-pass filtered from 13 – 1000Hz. From the results, it is clear that the young adults have higher levels of physical activity compare to the older adults. The biceps brachii EMG activity for the older adults is greater relative to control than the younger adults during the high cognitive demands were imposed during sub maximal contractions.

2.5 RESEARCH GAP

After review all the article, there was a research gap finding of the literature:

	Articles	**Current Study**
Type of muscles	There is no research are using biceps and brachioradialis (forearm) simultaneously	Biceps and brachioradialis (forearm) muscle will be choose
Procedure of experiment	There is no research in the literatures in which the subjects used hand dynamometer with isometric contraction	The subjects will be asked to press a hand dynamometer with isometric contraction.

2.6 CONCLUSION

Base on the review of the five articles, it was found that all of the research does not have a detail frequency and amplitude analysis. It also found that most of the research is using biceps brachii and triceps brachii as their main muscles instead of other upper limb muscle. All the research are using band-pass filtered range from 10 Hz to 1000 Hz and amplifying the EMG signal up to 1000 times.

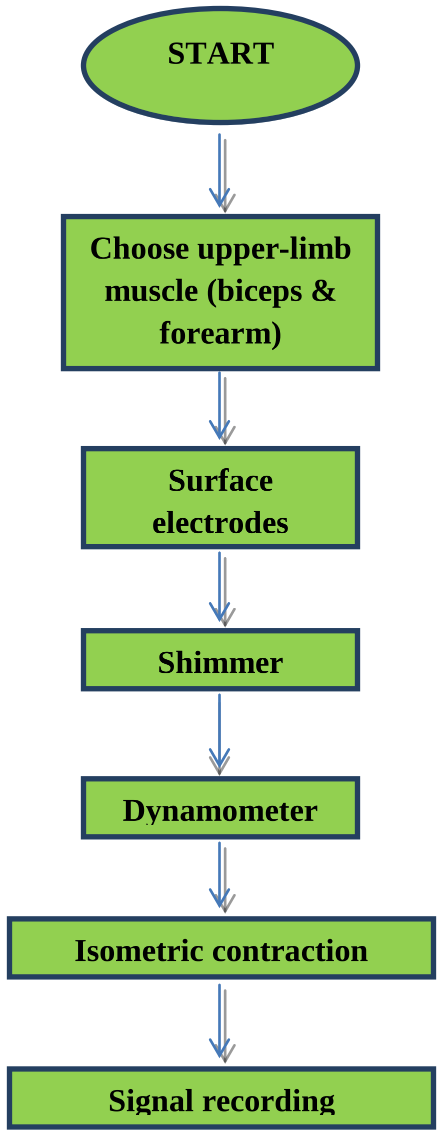
CHAPTER 3

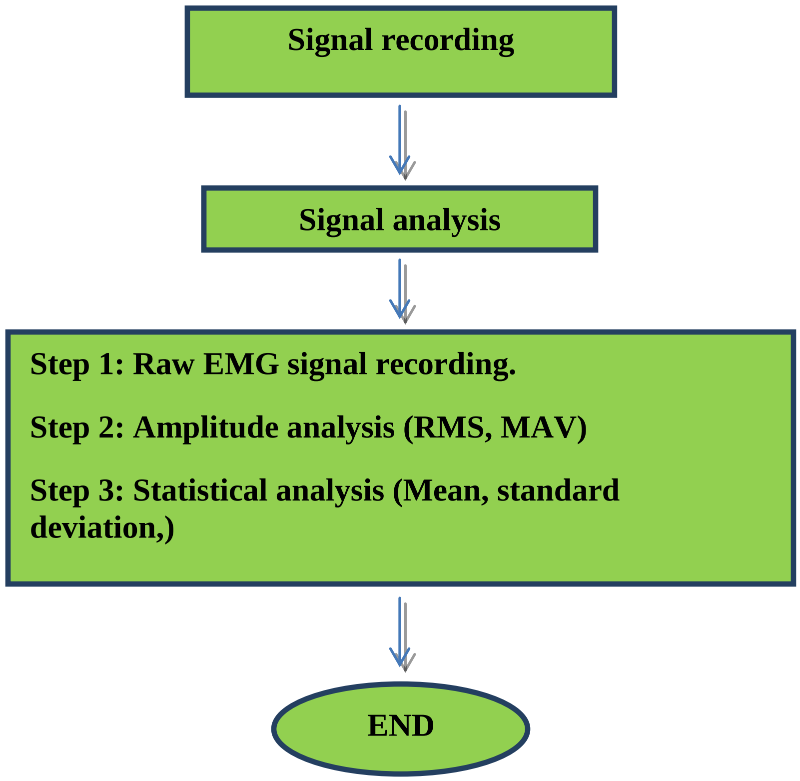
METHODOLOGY

3.1 INTRODUCTION

This chapter focuses about the measurement and analyzing process for electromyography (EMG) signal data collection for the upper-limb muscle with three different age group using isometric contractions. All the procedures and equipment use in this experiment will be listed plus the explanation about how the experiment work and how to collect the EMG signal data will be discuss in this chapter.

3.2 PROCESS FLOW CHART





3.3 SUBJECT

Subjects will consist of nine participants that will be divided into three age groups mainly young, adult, and older. Each group will consist of three participants. All the subjects does not have any musculoskeletal problems or nervous system diseases. The gender of the subjects is neglected.

	Young	**Adult**	**Older**
Number of subjects	3	3	3
Age range	20 - 29	30 - 39	40 - 49

Table 3.3.1: Subjects

3.4 DEVICES & TOOLS

3.4.1 Shimmer Sensor

EMG Sensor was used to measure the electrical signals obtained during muscle contractions. These devices also can be used to take the data of surface EMG signal recording and electrical potential waveform. This device use with the surface electrodes. All the electric and electronics devices such as cell phones and even watch should be put away from this device to avoid error in data recording.

Figure 3.1: Shimmer EMG sensor

3.4.2 Surface Electrodes

The main device that will be use in this experiment. It will be use together with the EMG sensor and it consists of many shapes and sizes. The ideal size of the surface electrode is 10 mm in diameter because a bigger electrode increases the detection amplitude and decreasing high frequency interference. The recommended inter-electrode distance is 20 mm from another because a shorter distance can cause unstable reading of the EMG signal.

Figure 3.2: Surface electrode

3.4.3 Hand Dynamometer / Dumbbells

Hand dynamometer is used to measure grip strength, pinch strength, force, and to perform muscle fatigue studies. This device is use as a load during the isometric contraction. The hand dynamometer also can replace with a dumbbells to act as the load carried.

Figure 3.3: Hand dynamometer

3.4.4 Alcohol swab

Alcohol swab is use for the cleaning of the skin surface. A clean skin surface is vital because any debris such as dust and sand can cause interference during data recording and inaccurate signal reading.

Figure 3.4: Alcohol swab

3.5 SOFTWARE

Figure 3.5: Microsoft Excel 2010

Microsoft Excel 2010 software will be use to record, filtering, sorting, calculating, and analyzing all the data obtain from the experiment using frequency and amplitude analysis.

3.6 EXPERIMENT

The first one the subject will be test one person per test only. The participant will be place on a chair in comfortable position. The alcohol swab will be put at the surface of the skin before placing the surface electrodes. The electrodes are connected to the EMG sensor and the raw EMG signal can be obtain during the participant doing the isometric contraction. The test will be conduct three times to take the average reading and to obtain more accurate reading.

3.7 AMPLITUDE ANALYSIS

i) Root-Mean Square (RMS)

The RMS of the EMG signal can be obtain using this formula:

$$RMS = \left(\frac{1}{S}\sum_{1}^{S} f^2(s)\right)^{\frac{1}{2}}$$

Where S = window length

f(s) = data within the window

ii) Mean Absolute Value (MAV)

The MAV is an average distance between EMG value and mean:

$$\text{MAV} = \frac{1}{N}\sum_{i=1}^{N}|x_i - \tilde{x}|$$

Where $\tilde{x}$ = Mean

N = number of data point

3.8 STATISTICAL ANALYSIS

i) Mean

$$\overline{X} = \frac{\sum X}{N}$$

ii) Standard Deviation

$$\sigma = \sqrt{\frac{\Sigma f(x - \overline{x})^2}{\Sigma f}}$$

iii) Coefficient of Variation / Variance

$$\textbf{CoV} = \frac{\sigma}{\mu}$$

3.9 CONCLUSION

This experiment was conduct with nine participants as the subjects from UMP students and staff. All participants are requiring carrying the load (dynamometer / dumbbell) according to each age group. Then raw EMG signal was record and analyze using several methods such as RMS and MAV.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter is mainly for the results from the experiment conducted. The tabulation of data consisted of Root-Mean-Square (RMS), Mean-Absolute-Value (MAV), mean, standard deviation, and coefficient of variance (CoV) based on the age group (young, adult, older). The comparison was done by comparing age group, type of muscles, and etc.

The surface Electromyography (sEMG) data collection from 9 subjects in the EMG amplitude experiment had been done before proceed to data analysis phase. The statistical analysis which included mean, standard deviation, and coefficient of variation will be calculated for RMS and MAV.

4.2 RESULTS

The Root-Mean-Square (RMS) value of each subject was calculated by using sEMG (surface EMG) raw data taken from experiment. Each trial of RMS value was calculated according to every age group for biceps and forearm respectively. The sEMG raw data are recorded from the electrical signals generated by subject's muscles thereby the unit of both RMS and MAV value is in millivolts (mV). The RMS value of 1st trial is calculated from the sEMG raw data of subjects perform isometric contractions for 100% maximal voluntary contraction (MVC) by gripping the hand dynamometer. Although MVC is not needed for this experiment, the subject has to perform 2nd and 3rd trial for 70% and 50% of MVC to get an average data.

The Mean-Absolute-Value (MAV) of each subject was calculated also by using sEMG raw data taken from experiment. The way of recorded sEMG raw data for MAV is same with the RMS value thereby the unit of MAV is also millivolts (mV). The MAV of 1st trial, 2nd trial and 3rd trial for each age group subject is calculated by the same method as RMS value by according to 100%, 70% and 50% maximal voluntary contraction (MVC) respectively.

4.3 AMPLITUDE ANALYSIS

The amplitude analysis is about getting the Root-Mean-Square (RMS) and Mean-Absolute-Value (MAV) from the raw data (sEMG) and use the data for the next phase which is statistical analysis

4.3.1 Age Group: Young (20 – 29 years old)

Table 4.1: Root mean square - RMS (Biceps)

	Trial 1	Trial 2	Trial 3
Young 1	2.080	2.067	2.060
Young 2	2.080	2.068	2.061
Young 3	2.067	2.060	2.059

Table 4.2: Root mean square (Forearm)

	Trial 1	Trial 2	Trial 3
Young 1	2.067	2.064	2.062
Young 2	2.186	2.094	2.072
Young 3	2.132	2.090	2.067

Table 4.3: Mean absolute value - MAV (Biceps)

	Trial 1	Trial 2	Trial 3
Young 1	0.054	0.059	0.061
Young 2	0.085	0.073	0.055
Young 3	0.038	0.033	0.017

Table 4.4: Mean absolute value - MAV (Forearm)

	Trial 1	Trial 2	Trial 3
Young 1	0.156	0.158	0.160
Young 2	0.166	0.127	0.092
Young 3	0.140	0.112	0.072

From table 4.1 and 4.2, the value of RMS in both biceps and forearm muscle decreased as the number of trial increased. However, for the MAV in table 4.3 and 4.4 shows some of the subject has increasing value of MAV with most subjects has decreasing value per each trial.

The RMS and MAV value for adult age group is shown in table 5 until 8 below.

4.3.2 Age Group: Adult (30 – 39 years old)

Table 4.5: Root mean square - RMS (Biceps)

	Trial 1	Trial 2	Trial 3
Adult 1	2.075	2.065	2.058
Adult 2	2.071	2.060	2.061
Adult 3	2.073	2.068	2.059

Table 4.6: Root mean square - RMS (Forearm)

	Trial 1	Trial 2	Trial 3
Adult 1	2.160	2.137	2.093
Adult 2	2.143	2.102	2.087
Adult 3	2.115	2.094	2.060

Table 4.7: Mean absolute value – MAV (Biceps)

	Trial 1	Trial 2	Trial 3
Adult 1	0.077	0.061	0.045
Adult 2	0.069	0.055	0.027
Adult 3	0.069	0.043	0.029

Table 4.8: Mean absolute value – MAV (Forearm)

	Trial 1	Trial 2	Trial 3
Adult 1	0.134	0.102	0.080
Adult 2	0.115	0.093	0.067
Adult 3	0.099	0.071	0.069

From table 4.5 –4.8, all the value of RMS and MAV for both biceps and forearm muscle decreased as the number of trial increased.

The RMS and MAV value for old age group is shown in table 9 until 12 below.

4.3.3 Age Group: Older (40 – 49 years old)

Table 4.9: Root mean square – RMS (Biceps)

	Trial 1	Trial 2	Trial 3
Old 1	2.059	2.056	2.056
Old 2	2.051	2.047	2.046
Old 3	2.050	2.050	2.046

Table 4.10: Root mean square – RMS (Forearm)

	Trial 1	Trial 2	Trial 3
Old 1	2.057	2.057	2.055
Old 2	2.049	2.048	2.047
Old 3	2.048	2.048	2.043

Table 4.11: Mean absolute value – MAV (Biceps)

	Trial 1	Trial 2	Trial 3
Old 1	0.057	0.055	0.056
Old 2	0.055	0.054	0.054
Old 3	0.049	0.049	0.045

Table 4.12: Mean absolute value – MAV (Forearm)

	Trial 1	Trial 2	Trial 3
Old 1	0.056	0.056	0.054
Old 2	0.048	0.047	0.039
Old 3	0.044	0.042	0.037

From table 4.9 – 4.12, all the value of RMS and MAV for both biceps and forearm muscle decreased as the number of trial increased.

4.4 STATISTICAL ANALYSIS

The RMS value of each subject needs to further explore by statistical analysis in order to find out the significant differences and comparing between young, adult, and old age group. The criteria of measurements for statistical analysis in this study included mean, standard deviation (STD) and coefficient of variance (CoV) by applying their respective formula to the calculations.

The MAV of each subject also needs to further explore by statistical analysis in order to find out the significant differences between each age group. The criteria of measurements for statistical analysis are the same for the RMS value which included mean, standard deviation (STD) and coefficient of variation (CoV) by applying their respective formula to the calculations.

The value of mean, STD, and CoV from the RMS trials is shown in table 4.13 and 4.14 below.

Table 4.13: Biceps

Biceps	Mean	STD	CoV
Young 1	2.064	0.0018	0.086
Young 2	2.117	0.0430	2.020
Young 3	2.096	0.0233	1.112
Adult 1	2.066	0.0060	0.292
Adult 2	2.064	0.0043	0.208
Adult 3	2.067	0.0043	0.208
Old 1	2.057	0.0023	0.114
Old 2	2.048	0.0034	0.169
Old 3	2.049	0.0027	0.1302

Table 4.14: Forearm

Forearm	Mean	STD	CoV
Young 1	2.069	0.0072	0.347
Young 2	2.070	0.0068	0.328
Young 3	2.062	0.0031	0.149
Adult 1	2.130	0.0404	1.897
Adult 2	2.111	0.0374	1.773
Adult 3	2.089	0.0331	1.587
Old 1	2.056	0.0013	0.064
Old 2	2.048	0.0012	0.059
Old 3	2.046	0.0033	0.163

For the value of mean, STD, and CoV for the biceps, young age group is relatively higher than adult and old age group except for young 1 that has lower value of mean (2.064), STD (0,0018), and CoV (0.086) compare to the other subjects in adult and old age group. For the forearm, the entire subject from adult age group has higher value of mean, STD, and CoV compare to the young and old age group.

The value of mean, STD, and CoV from the MAV trials is shown in table 4.15 and 4.16 below.

Table 4.15: Biceps

Biceps	Mean	STD	CoV
Young 1	0.058	0.0026	4.396
Young 2	0.071	0.0107	15.038
Young 3	0.029	0.0077	26.443
Adult 1	0.061	0.0196	32.124
Adult 2	0.050	0.0253	50.357
Adult 3	0.047	0.0257	54.743
Old 1	0.056	0.0014	2.525
Old 2	0.054	0.0008	1.439
Old 3	0.048	0.0027	5.594

Table 4.16: Forearm

Forearm	Mean	STD	CoV
Young 1	0.158	0.0025	1.550
Young 2	0.128	0.0456	35.543
Young 3	0.108	0.0411	38.042
Adult 1	0.105	0.0334	32.247
Adult 2	0.092	0.0292	31.814
Adult 3	0.080	0.0225	28.225
Old 1	0.055	0.0013	2.410
Old 2	0.045	0.0057	12.785
Old 3	0.041	0.0042	10.348

For the value of mean (biceps), all the age group has almost nearest value between each age group within the range of 0.029 – 0.071 with the lowest value is subject young 3 with 0.029.For STD, adult age group has the highest value of STD (0.0196 - 0.0257) with young age group in the second highest value. For the CoV, the adult also has the highest value compare to the young and older age group.

For the value of mean (forearm), young age group has the highest value of mean (0.108 – 0.158) compare to the other age group. For the STD and CoV, young age group also has the highest value except for subject young 1 (0.0025 and 1.550 respectively)

4.5 GRAPH

4.5.1 Biceps (Root Mean Square)

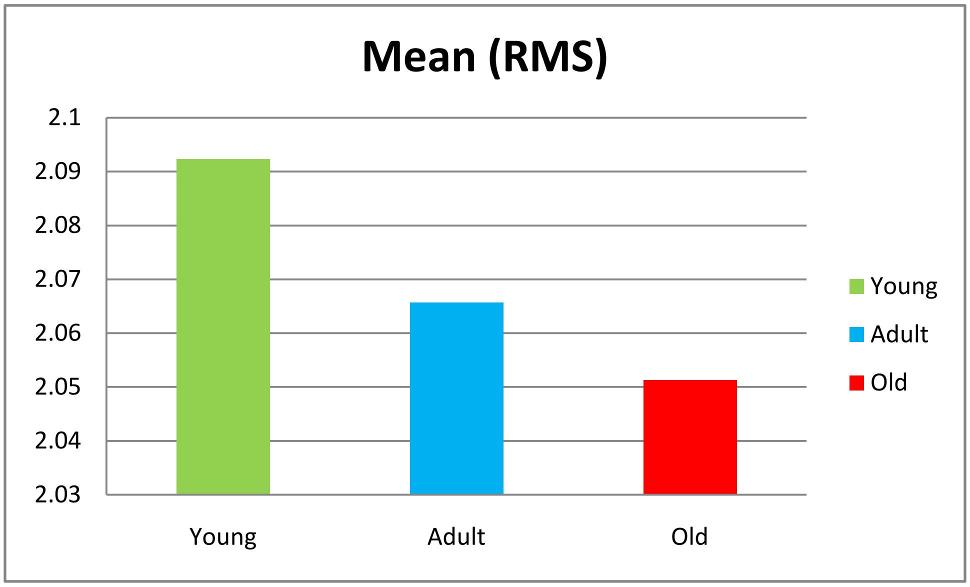


Figure 4.1: Graph of mean versus age group

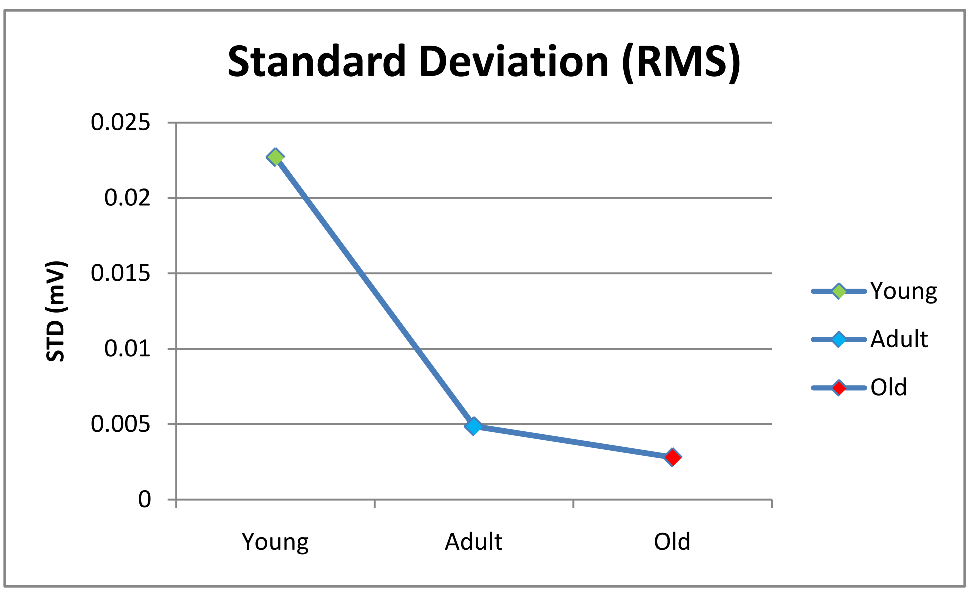


Figure 4.2: Graph of standard deviation versus age group

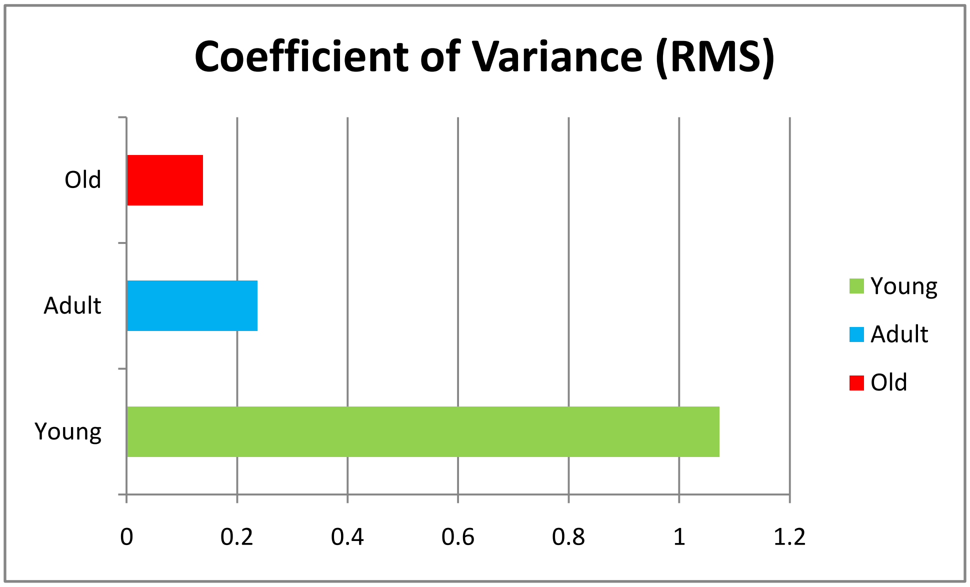


Figure 4.3: Graph of coefficient of variance versus age group

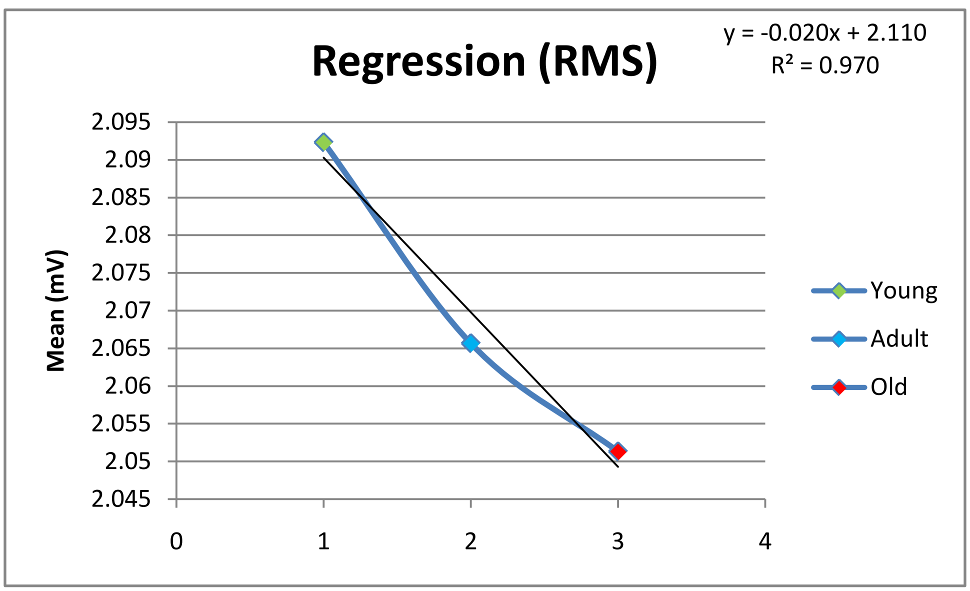


Figure 4.4: Graph of mean (regression) versus age group

4.5.2 Biceps (Mean Absolute Value)

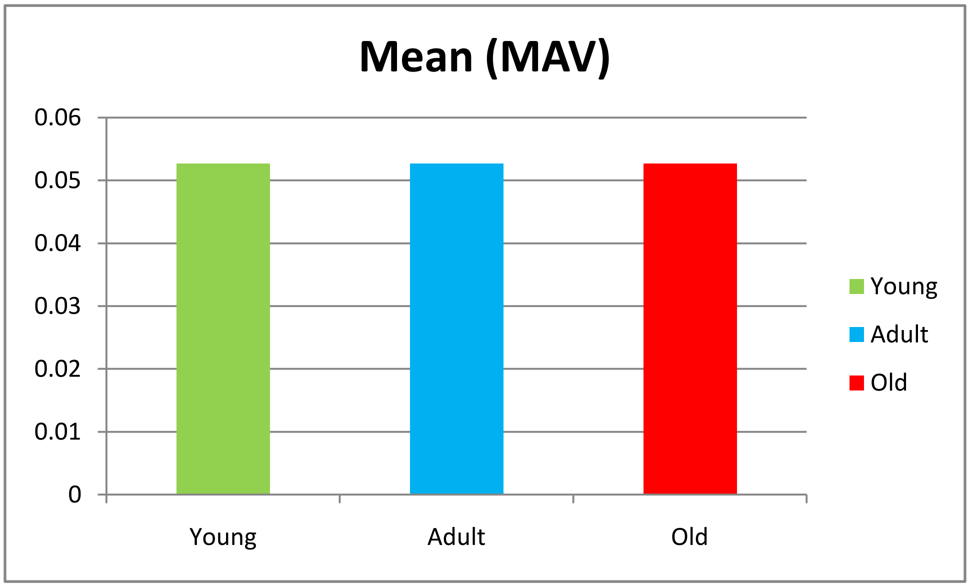


Figure 4.5: Graph of mean versus age group

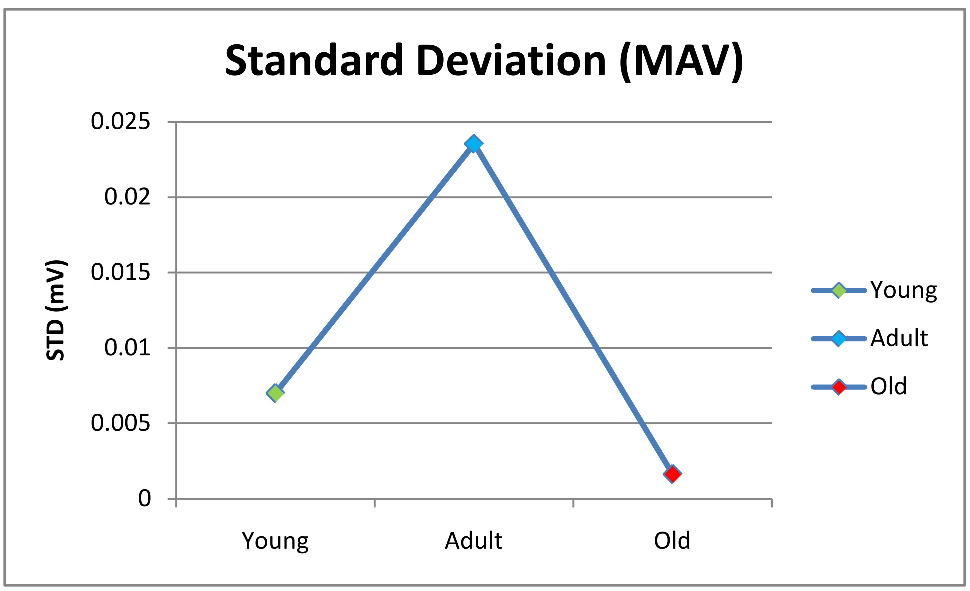


Figure 4.6: Graph of standard deviation versus age group

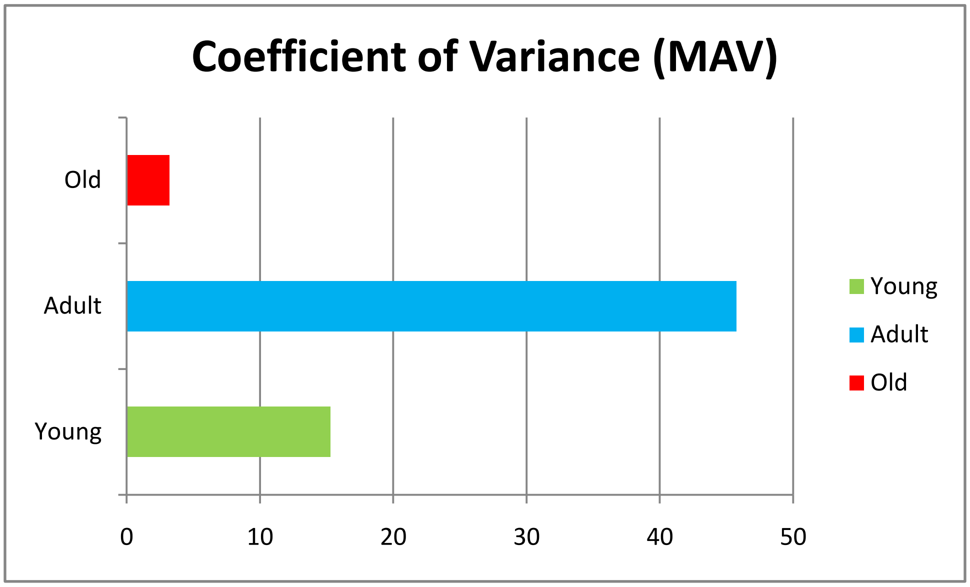


Figure 4.7: Graph of coefficient of variance versus age group

4.5.3 Forearm (Root Mean Square)

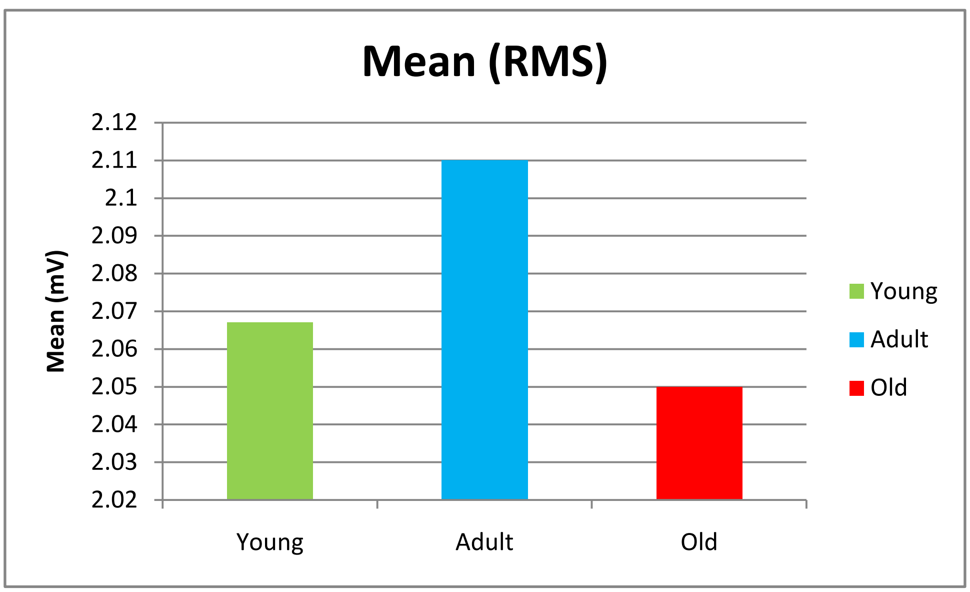


Figure 4.8: Graph of mean versus age group

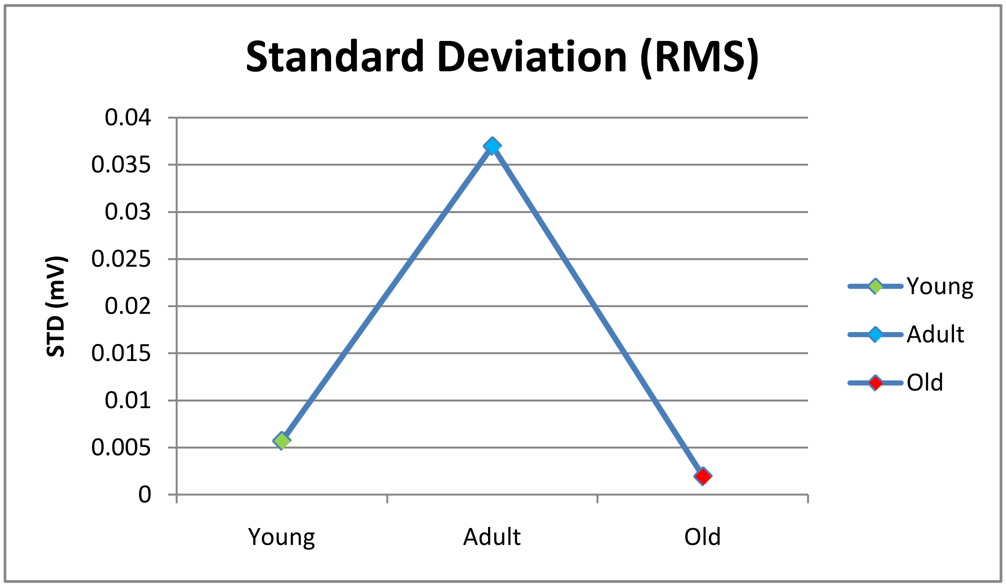


Figure 4.9: Graph of standard deviation versus age group

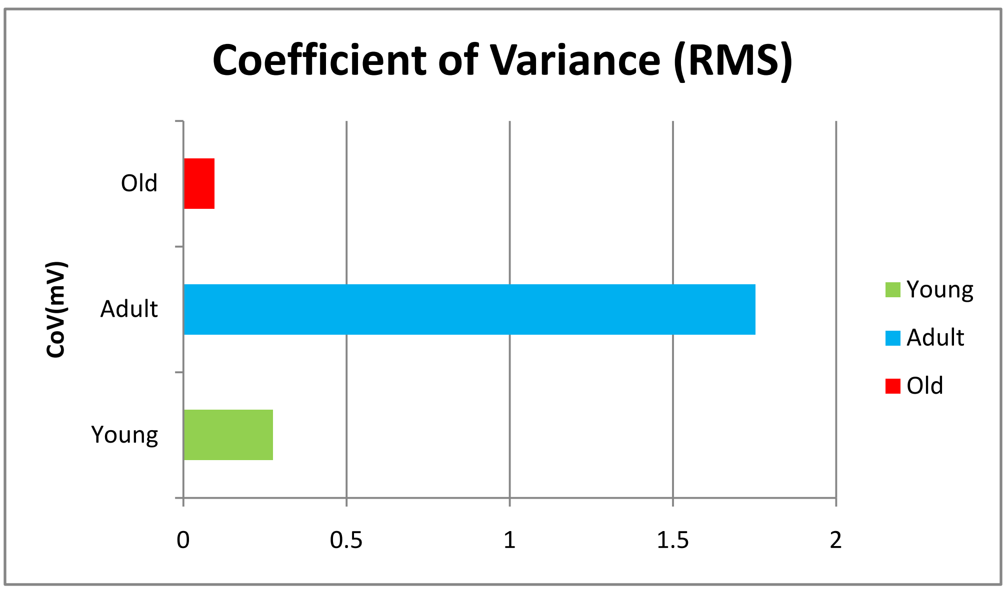


Figure 4.10: Graph of coefficient of variance versus age group

4.5.4 Forearm (Mean-Absolute-Value)

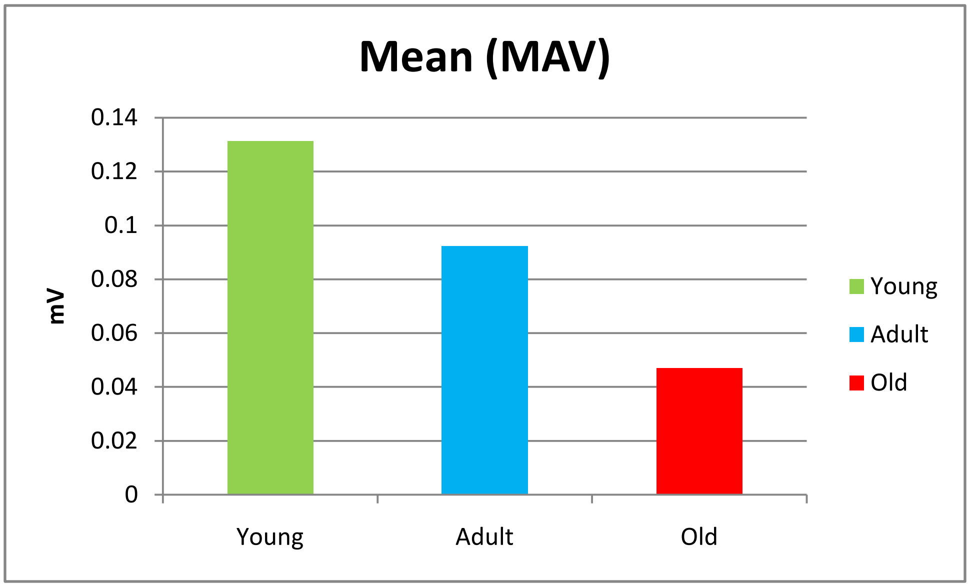


Figure 4.11: Graph of mean versus age group

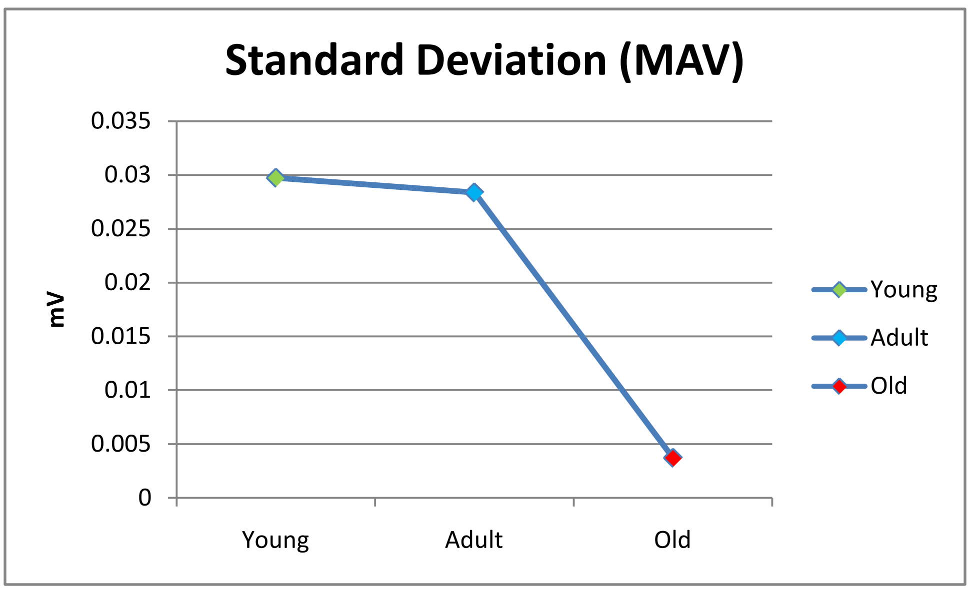


Figure 4.12: Graph of standard deviation versus age group

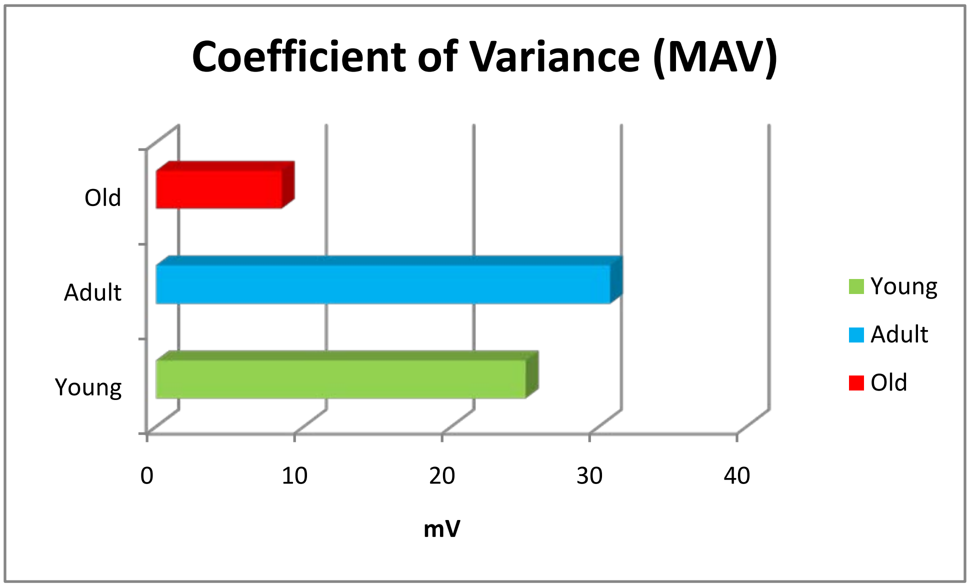


Figure 4.13: Graph of coefficient of variance versus age group

4.6 COMPARISON

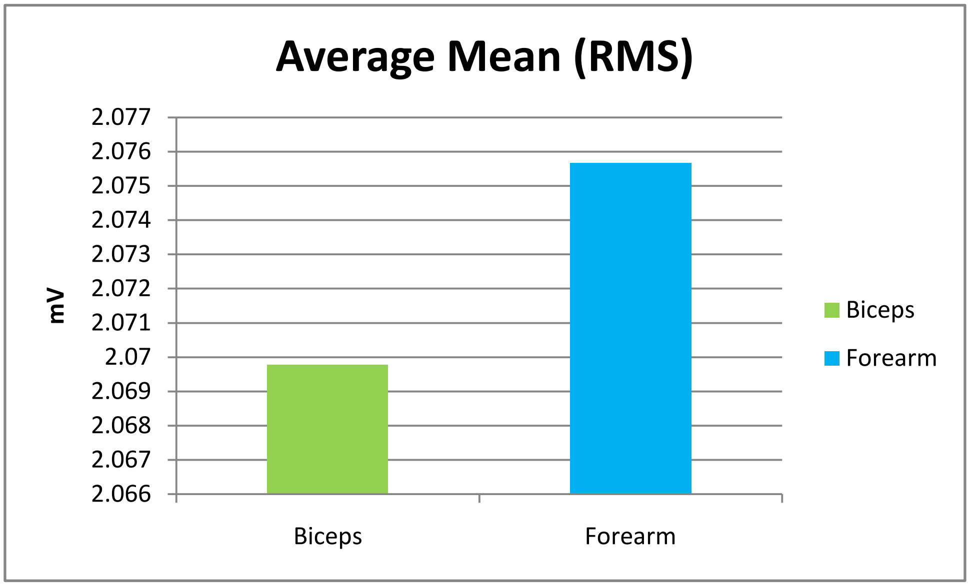


Figure 4.14: Graph of comparison between muscles.

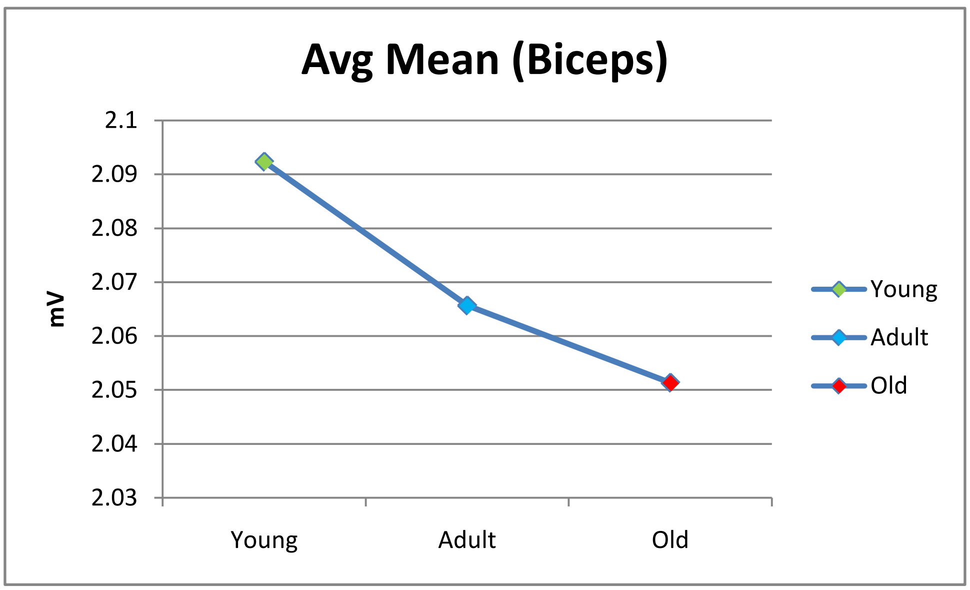


Figure 4.15: Graph of comparison between age group

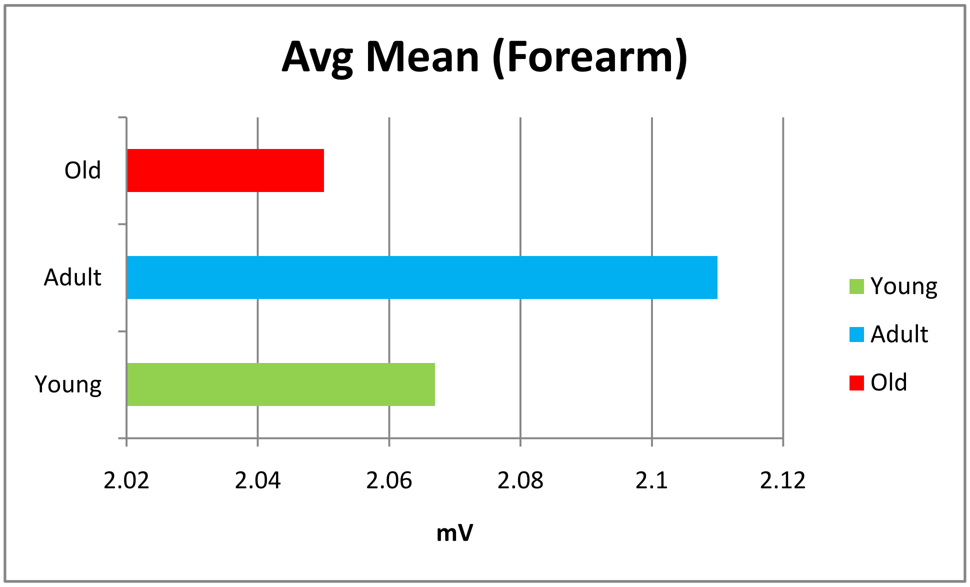


Figure 4.16: Graph of comparison between age group (forearm)

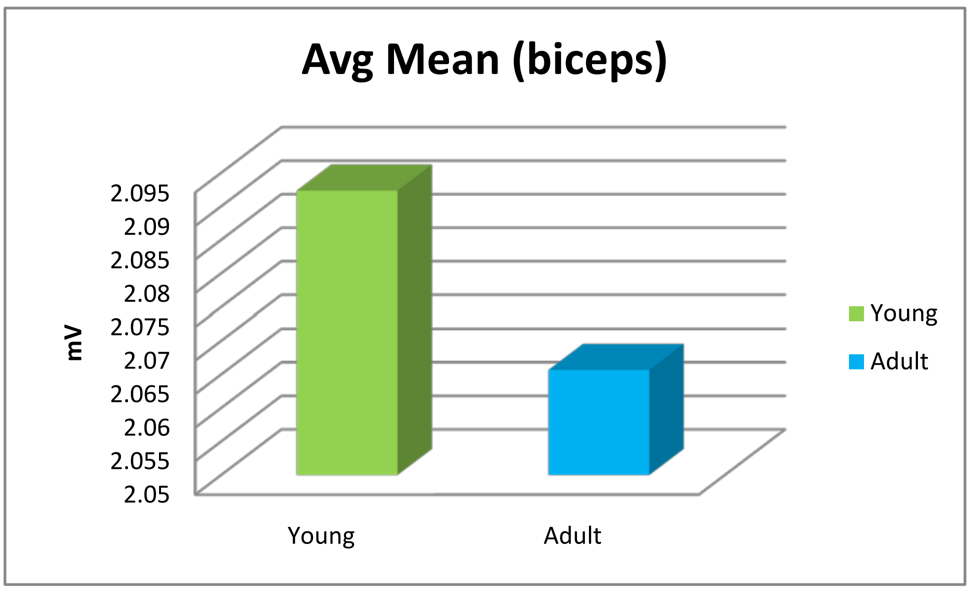


Figure 4.17: Graph of comparison between young and adult (biceps)

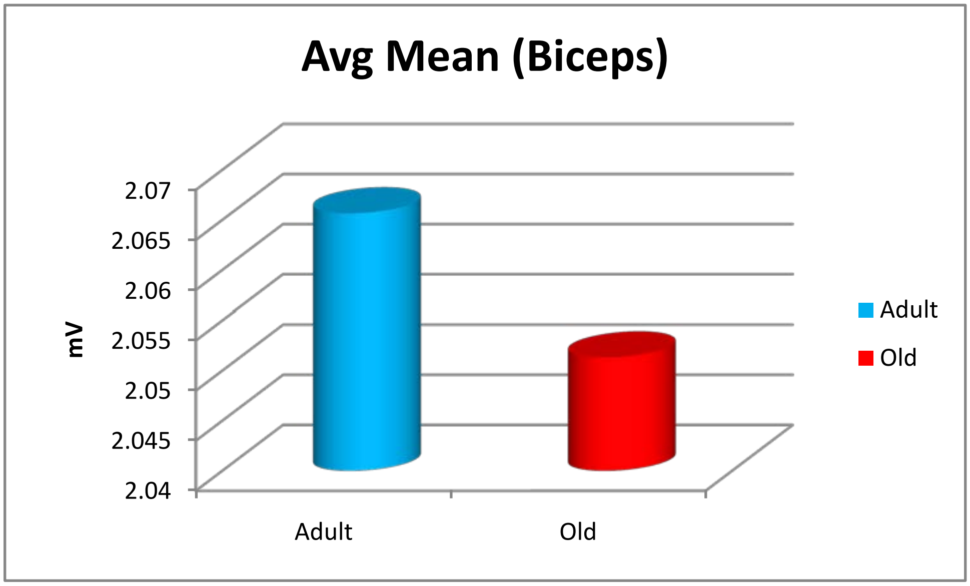


Figure 4.18: Graph of comparison between adult and old (biceps)

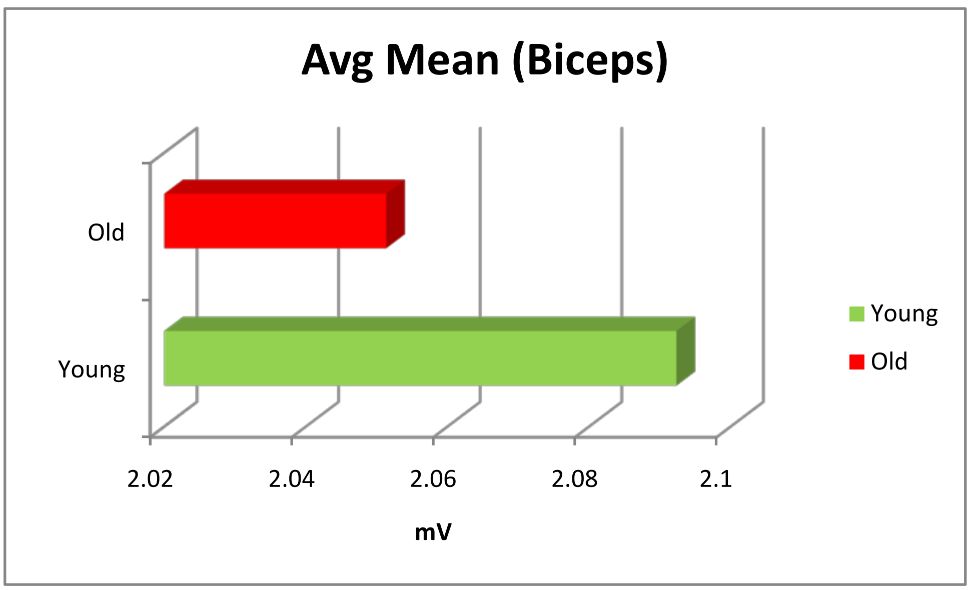


Figure 4.19: Graph of comparison between young and old (biceps)

4.7 DISCUSSION

From the above analysis results, the EMG signals generated from the forearm muscle (figure 4.14) is higher than signals generated by the biceps brachii muscle for all three age groups. The reason is because the muscle activity in forearm muscle is more active than that in biceps muscle during isometric contractions. The biceps can increased the EMG signal generated if the experiment are using other types of contractions such as concentric or isokinetic. When comparing the muscle activity of forearm muscle between age group (figure 4.16), the EMG results show that the forearm muscle from adults are higher than the younger and older subjects. This result proves that the metabolic properties of the adult forearm muscle are greater than younger and older forearm muscle.

For the biceps (figure 4.15), the graph shows that the electrical activities are higher for the younger with adult is the second most highest. This is opposite to the adult which has more EMG signals generated at the forearm muscle. A younger person has higher fatigue resistance ability in their biceps brachii muscle compare to adults and older persons therefore the EMG recorded for the biceps for young age group is relatively has higher coefficient of determination in RMS and MAV value compare to the other age group.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 INTRODUCTION

This chapter discuss about the overall results and the objective of the experiment. The objective stated for this experiment is achieved.

5.2 CONCLUSION

From the previous experiments/researches, it is stated that most of the experiment is using triceps brachii, vastus lateralis, and brachioradialis to conduct the research about EMG signal according to the age group. It also has different methods and parameters used to study the EMG but in this experiment, it uses biceps brachii and forearm (brachioradialis) as the main muscle to study. Different method used in this experiment is by using a hand dynamometer to replace the need for load/dumbbell and also by using Shimmer sensor instead of using EKG sensor for detection and recording the signal.

From the graph obtained from the data, it is clear that the Root-Mean-Square (RMS) for the younger age group is slightly higher than adult and old age group for the biceps brachii muscle. However, for the Mean-Absolute-Value (MAV) is same for all three age group but different in standard deviation and correlation of variance.

For the forearm muscle, adult has more EMG activity (RMS) compare to the young and old age group but higher MAV for the younger follow by adult and old.

For the comparison of muscles, forearm is more significant or higher EMG activity than the biceps. This is because isometric movement mainly causes more contraction at the forearm rather than the biceps. Comparing the age group and muscles, young has higher RMS at the biceps but adult at the forearm.

5.3 RECOMMENDATION

There are many improvements need to be done for the future experiment. The first one is the improvement for the angle of the elbow during data recording. Different angle of elbow (more or less than 90º) can cause error in the reading and would affect the results.

The second recommendation is the use of other software such as MATLAB or other software instead relying only in Microsoft Excel. For example, the guided user interface (GUI) can be developed using the MATLAB. The GUI will act as the main interface for the researchers to obtain the data without need to do many complex calculations. They just have to key in the data and the results will appear faster compare to the manual calculations.

The third one is the method of compressing the hand dynamometer. During the experiment, subjects had to press the hand dynamometer manually and no maximum voluntary contraction (MVC) was recorded and the reading of the dynamometer changes dramatically with every subject’s movement. The use of digital dynamometer can increase the accuracy of the MVC although it was not use in this experiment.

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This thesis is prepared based on the following references

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Thiago Yukio Fukuda, Jorge Oliveira Echeimberg. (2010)”*Root Mean Square Value of the EMG Signal in the Isometric Torque*”:Vol 10, no 1.

APPENDIX

Table of RMS, MAV, mean, standard deviation, and coefficient of variance in Microsoft Excel

YOUNG — from RMS

forearm	Y1	Y2	Y3
t1	2.067	2.186	2.132
t2	2.064	2.094	2.09
t3	2.062	2.072	2.067

Column1	mean	STD	Cov
Y1	2.064333	0.00178	0.086203
Y2	2.117333	0.042763	2.019659
Y3	2.096333	0.023306	1.111748

biceps	Y1	Y2	Y3
t1	2.08	2.08	2.067
t2	2.067	2.068	2.06
t3	2.06	2.061	2.059

Column1	mean	std	cov
Y1	2.069	0.007176	0.346851
Y2	2.069667	0.006795	0.328295
Y3	2.062	0.003082	0.149477

from MAV

biceps	Y1	Y2	Y3
t1	0.054	0.085	0.038
t2	0.059	0.073	0.033
t3	0.061	0.055	0.017

Column1	mean	std	cov
Y1	0.058	0.00255	4.395706
Y2	0.071	0.010677	15.03814
Y3	0.029333	0.007757	26.44336

forearm	Y1	Y2	Y3
t1	0.156	0.166	0.14
t2	0.158	0.127	0.112
t3	0.16	0.092	0.072

Column1	mean	std	cov
Y1	0.158	0.002449	1.55031
Y2	0.128333	0.045614	35.54316
Y3	0.108	0.041085	38.04192

ADULT — from RMS

biceps	A1	A2	A3
t1	2.075	2.071	2.073
t2	2.065	2.06	2.068
t3	2.058	2.061	2.059

Column1	mean	std	cov
A1	2.066	0.006042	0.292426
A2	2.064	0.004301	0.20839
A3	2.066667	0.005017	0.242741

forearm	A1	A2	A3
t1	2.16	2.143	2.115
t2	2.137	2.102	2.094
t3	2.093	2.087	2.06

Column1	mean	std	cov
A1	2.13	0.040417	1.897492
A2	2.110667	0.037425	1.773124
A3	2.089667	0.033175	1.587596

from MAV

biceps	A1	A2	A3
t1	0.077	0.069	0.069
t2	0.061	0.055	0.043
t3	0.045	0.027	0.029

Column1	mean	std	cov
A1	0.061	0.019596	32.12446
A2	0.050333	0.025346	50.35726
A3	0.047	0.025729	54.74332

forearm	A1	A2	A3
t1	0.134	0.115	0.099
t2	0.102	0.093	0.071
t3	0.08	0.067	0.069

Column1	mean	std	cov
A1	0.105333	0.033967	32.24744
A2	0.091667	0.029162	31.81351
A3	0.079667	0.02249	28.2295

OLD

from RMS

biceps	O1	O2	O3
t1	2.059	2.051	2.05
t2	2.056	2.047	2.05
t3	2.056	2.046	2.046

Column1	mean	std	cov
O1	2.057	0.002345	0.114011
O2	2.048	0.003464	0.169146
O3	2.048667	0.002667	0.130166

forearm	O1	O2	O3
t1	2.057	2.049	2.048
t2	2.057	2.048	2.048
t3	2.055	2.047	2.043

Column1	mean	std	cov
O1	2.056333	0.001333	0.06484
O2	2.048	0.001225	0.059802
O3	2.046333	0.003333	0.162893

from MAV

biceps	O1	O2	O3
t1	0.057	0.055	0.049
t2	0.055	0.054	0.049
t3	0.056	0.054	0.045

Column1	mean	std	cov
O1	0.056	0.001414	2.525381
O2	0.054333	0.000782	1.438778
O3	0.047667	0.002667	5.594406

forearm	O1	O2	O3
t1	0.056	0.048	0.044
t2	0.056	0.047	0.042
t3	0.054	0.039	0.037

Column1	mean	std	cov
O1	0.055333	0.001333	2.409639
O2	0.044667	0.005711	12.78496
O3	0.041	0.004243	10.3479