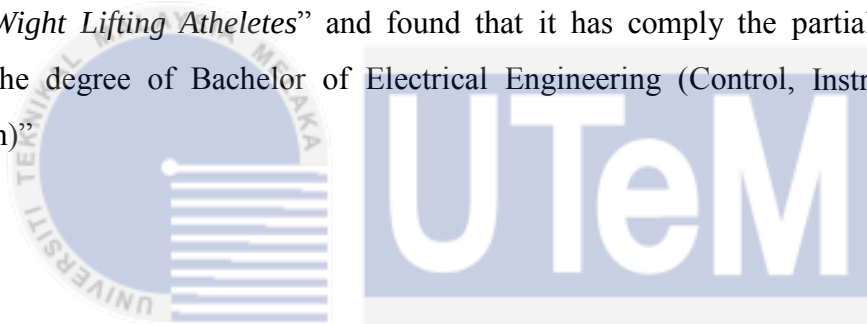


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Date

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**POWER SPECTRAL ANALYSIS OF SURFACE EMG OF SURFACE EMG FOR
WEIGHT LIFTING ATHELETES**

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I declare that this report entitle “*Power Spectral Analysis of Surface EMG for Wight Lifting Athletes*” is the result of my own research except as cited in references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.



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ABSTRACT

The study of feature Power Spectral Analysis of Surface Electromyography, (sEMG) for weight lifting athletes was done to help further research and medical purpose for human body. This study will focus on weight lifting athletes body part called muscle biceps brachii and arms. This study will relate the relationship between Power Spectral Analysis, (PSA) and EMG signal formed by human arms. The study first objective is to record the Motor Unit Action Potential, (MUAP) from the sEMG by using developed acquisition system. Then the study continue to analyze and validate the recorded sEMG signal using PSA technique. The scopes of this study are 3 different weight of dumbbell, with healthy test subject with no sickness. No sickness mean healthy person with no biceps brachii problem that can alter the test result. Then, the test subject will do biceps curl exercise. This exercise will be recorded using sEMG for 10 second. The sEMG uses are in the Figure 1.1, with compilation hardware of Arduino Mega, EKG/EMG Shield as sensor, and Passive Electrodes. The overall of this study is to implement the understanding of recorded EMG signal into usable signal using PSA, for further study. By the end of this study, a comprehensive report about PSA analysis and discussion made based on the results obtained from the test subject and experiment conduct.

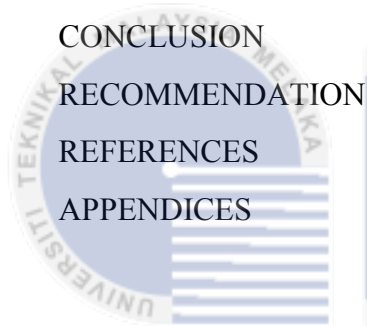
ABSTRAK

Kajian Analisa Kuasa Spektral menggunakan Elektromyografi, (sEMG) untuk atlet angkat berat telah dilakukan untuk tujuan untuk membantu penyelidikan lanjut dan tujuan perubatan untuk badan manusia. Kajian ini akan memberi tumpuan kepada atlet angkat berat bahagian badan dipanggil otot bicep brachii dan tangan. Kajian ini akan berkaitan hubungan antara Kuasa spektral Analisis, (PSA) dan isyarat EMG yang dibentuk oleh tangan manusia. Objektif pertama kajian adalah untuk merekodkan Potensi Unit Motor Aksi, (MUAP) dari sEMG dengan menggunakan sistem perolehan maju. Kemudian kajian terus menganalisis dan mengesahkan isyarat sEMG yang dirakam menggunakan teknik PSA. Skop kajian ini adalah 3 jenis pemberat yang berbeza, dengan keadaan sihat pada subjek ujian tanpa penyakit. Tiada penyakit bermakna orang yang sihat tanpa sebarang masalah brachii bicep yang boleh mengubah keputusan ujian. Maka, subjek ujian akan melakukan senaman bicep curl. Latihan ini akan dirakam menggunakan sEMG selama 10 saat. Penggunaan sEMG berada dalam Rajah 1.1, dengan perkakasan penyusunan Arduino Mega, EMG/EKG Shield sebagai sensor, dan Pasif Elektrod. Keseluruhan kajian ini adalah untuk melaksanakan pemahaman mencatatkan isyarat EMG kepada isyarat yang boleh digunakan menggunakan PSA, untuk kajian lanjut. Pada akhir kajian ini, satu laporan komprehensif tentang analisis PSA dan perbincangan dibuat berdasarkan keputusan yang diperolehi daripada subjek ujian dan proses eksperimen.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	ACKNOWLEDGEMENT	i
	ABSTRACT	ii
	ABSTRAK	iii
	TABLE OF CONTENTS	iv
	LIST OF TABLES	vi
	LIST OF FIGURES	vii
	LIST OF ABBREVIATIONS	ix
	LIST OF APPENDICES	x
1	INTRODUCTION	1
	1.1 RESEARCH BACKGROUND	1
	1.2 PROBLEM STATEMENT	2
	1.3 OBJECTIVES	2
	1.4 SCOPE OF WORK	3
2	LITERATURE REVIEW	5
	2.1 THEORY AND BASIC PRINCIPLES	5
	2.2 REVIEW OF PREVIOUS RELATED WORKS	12
	2.3 SUMMARY AND DISCUSSION OF THE REVIEW	15
3	RESEARCH METHODOLOGY	16
	3.1 EXPERIMENT SPECIFICATION	16

	3.2 EXPERIMENTAL SETUP	18
	3.3 EXPERIMENTAL PROCEDURE	22
	3.4 DATA COLLECTION AND FEATURE EXTRACTION OF ELECTROMYOGRAPHY (EMG) SIGNAL	24
	3.5 EVALUATION OF FEATURES EXTRATION DATA	25
	3.6 REALIABILITY OF THE DATA	26
4	RESULT AND DISCUSSIONS	27
	4.1 NOISE ANALYSIS	27
	4.2 EMG SIGNAL COLLECTED AND POWER SPECTRAL ANALYSIS	28
5	CONCLUSIONS AND RECOMMENDATION	33
	CONCLUSION	33
	RECOMMENDATION	34
	REFERENCES	35
	APPENDICES	38



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LIST OF TABLES

TABLE	TITLE	PAGE
1.1	Example Data Table for EMG Recording for Test Subject	3
1.2	Specification of the Test Subject	4
2.1	Recommendation of Electrode Usage	15



LIST OF FIGURES

FIGURE	TITLE	PAGE
1.1	The sEMG device	2
2.1	MUAPs extract from sEMG	7
2.2	Motor Unit	7
2.3	The Depolarization and Repolarization of Motor Unit (MU)	8
2.4	The Action Potential	9
2.5	The depolarization zone on muscle fiber membranes.	9
2.6	The model of a wandering electrical dipole on muscle fiber membranes	10
2.7	Generation of the triphasic MUAP	11
2.8	Motor Unit Recruitment and Firing Frequency	11
2.9	Factor effecting the EMG signal	11
3.1	Matlab Simulink Block Diagram Configuration of Arduino with EKG/EMG Shield.	18
3.2	Nikon Kohden wet gel disposable electrode	19
3.3	BD Alcohol Swab	20
3.4	Electrode Location	21
3.5	Flowchart of Experimetal Procedure	22
3.6	Exercise Procedure. (A) Arm Rest (B) Bicep Curl	23

4.1	Data for 2.5 KG (a) Statistic EMG Signal (b) PSD Graph (c) Statistic PSD	30
4.2	Data for 5.0 KG (a) Statistic EMG Signal (b) PSD Graph (c) Statistic PSD	31
4.3	Data for 10.0 KG (a) Statistic EMG Signal (b) PSD Graph (c) Statistic PSD	32
4.4	Mean of Power Spectral of 2.5KG, 5.0KG and 10.0KG	33



LIST OF ABBREVIATIONS

Abbreviation	Meaning
sEMG	Surface Electromyography
EMG	Electromyography
PSA	Power System Analysis
MU	Motor Unit
MUAP	Motor Unit Action Potential
EKG/EMG Shield	Electrocardiography Electromyography Shield
RMS	Root Mean Square
dB	Decibel
mV	millivolt
Na ⁺	Sodium Ion
K ⁺	Potassium Ion
Hz	Hertz
FFT	Fast Fourier Transform
PSD	Power Spectral Density

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	EKG/EMG Shield	38
B	Electrocardiography Electromyography Shield connector	38
C	Arduino Mega 2560 Function	39
D	Technical specifications for Arduino Mega 2560	39
E	Function of each part on Arduino Mega 2560	40
F	Passive Electrodes For Electrocardiography Electromyography	40
G	EMG signal	41
H	Power Spectral	44
I	Project Gantt Chart	47

CHAPTER 1

INTRODUCTION

Chapter 1, will give a brief explanation of the 'Power Spectral Analysis of Surface EMG for Weight Lifting Athletes'. Also the research background and motivation of the research will be discuss. Then all problem statement and scope will be determine by the end of this Chapter 1.

1.1 Research background

The Electromyography or EMG is a technique for evaluating and recording the electrical activity produced by skeletal muscles. EMG can be record by various method from low tech and low cost, to a high end tech but high cost method. Basically EMG is perform using an instrument or device call electromyography to produce a record called an electromyogram. An electromyography will detect the electrical potential generated by muscle cells when these cells are electrically or neurologically activated. The signals can be analyzed to detect medical abnormalities, activation level, or recruitment order to analyze the biomechanics of human movement.

For Power Spectral analysis of Surface EMG for weight lifting athletes cases, the focus will be on using the Surface EMG (sEMG) method. There are different methods like intramuscular that uses electrode needle that dangerous and pain. This why sEMG is completely safe in this cases. The hardware of sEMG device used shown in Figure 1.1.



Figure 1.1: The sEMG device

1.2 Problem Statement

The EMG signals are used in many clinical and biomedical applications. EMG is used as a diagnostics tool for identifying neuromuscular diseases, assessing low-back pain, kinesiology, and disorders of motor control. EMG signals are also used as a control signal for prosthetic devices such as prosthetic hands, arms, and lower limbs. Thus analyzing the EMG signal is the next step in solving this problem.

1.3 Objectives

The main objectives of this research are:

1. To record the MUAP from sEMG by using developed acquisition system.
2. To analyze and validate the EMG signals using Power Spectral Analysis.

1.4 Scope of work

This study scope will be a guideline towards achieving the objectives. The scopes of this study are the muscles that will be used in this study is biceps brachii. The exercise that will be done in this research is by using biceps curl method. The sEMG that will be used is Olimex Ekg/Emg Shield with Arduino Mega 2560 and also Passive Electrode will be used in this study. The Arduino Mega 2560 will be used as the microcontroller that acts as a data acquisition. The feature extraction that will be used is in the time domain which is mean, root mean square (RMS), standard deviation and variance. The analyze part of feature extraction electromyography (EMG) is using power spectral analysis using Matlab. There are 3 different weight with 5 tries. Table 1.1. There will be 5 person acted as test subject to help generated EMG signal from their hand into the sEMG device. The data collected from these test subject are by doing 10 second arm at rest and 10 second biceps curl. Also the test subject are healthy and no health issues especially nerves issues. Table 1.2.

Table 1.1: Example Data Table for EMG Recording for Test Subject

Trial\Weight	Duration (20 second)		
	2.5 KG	5 KG	10 KG
1			
2			
3			
4			
5			

Table 1.2: Specification of the Test Subject

Specification	Age	Height	Weight	Trial Weight	Health Condition
5 Male	20-25	160 cm to 190 cm	50 Kg to 80 Kg	2.5 Kg, 5 Kg, 10 Kg	Normal



CHAPTER 2

LITERATURE REVIEW

Chapter 2 will give a brief explanation of the theory and the history of EMG. Further basic principles, review of previous related works, summary and discussion of the review will be discuss. The knowledge of using sEMG and Power Spectral Analysis concept also will be describes.

2.1 Theory and basic principles

EMG is an experimental technique concerned with the improvement, recording and examination of myoelectrical sign or EMG sign create by the physical varieties in the condition of muscle fiber layers. This sign can be utilized as an assessment apparatus for applied research, physiotherapy, rehabilitation, and sports training. It is similar to what are the muscle doing in certain point with specific situations [1, 2].

Common advantages of EMG will be EMG permits to specifically "look" into the muscle, permits estimation of muscle execution, helps in choice making both before/after surgery, reports treatment and preparing administrations, helps patients to "find" and train their muscles, permits examination to enhance sports exercises and identifies muscle reaction in ergonomic studies.

2.1.1 Weightlifting, Power Spectral Analysis, Motor Unit Action Potential (MUAP).

Weightlifting is a focused quality based game, where competitors switch from the barbell position from the floor to the overhead position when endeavoring a greatest weight single lift. This movement includes entire body muscle power.

The Power Spectral analysis, for example, frequency range and median frequency and made correlations between information got from the influenced and contra-lateral sides of the subjects [3]. Power spectral analysis of surface EMG signals has been utilized to identify possible alterations in the firing frequency as well as action potential shapes. Most EMG enhancers utilize a high pass channel (frequently set at 20-450 Hz) such that the firing frequency range is typically lower than the bandwidth of the filter and thereby limits the ability to identify firing frequencies. Studies have demonstrated that the median frequency of the power spectrum is corresponded to activity potential shape, specifically name the action potential duration. [4]

The Motor Unit Action Potential (MUAP), is an essential idea in electromyography is the alleged motor unit (MU), which represent the anatomical and utilitarian component of the neuromuscular framework. The MU is shaped by the alpha spinal motor neuron and its innervated set of muscular cells [5]. The electrical changes created by action of the MU can be obtained and increased by cathodes spotted in muscle mass and these progressions can be recorded and altered utilizing EMG devices. A MUAP waveform can be described by various parameters identified with specific parts of the structure and physiology of the MU [6]. Figure 2.1.

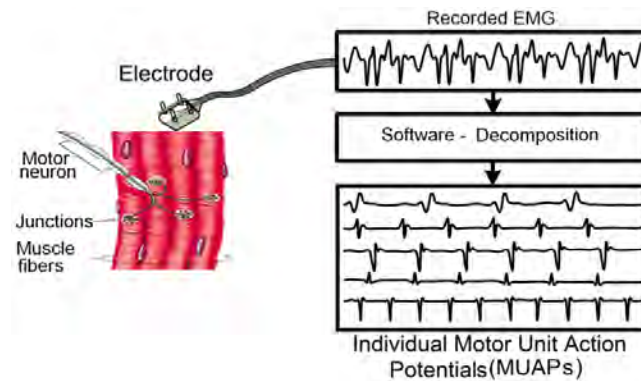


Figure 2.1: MUAPs extract from sEMG

2.1.2 The Motor Unit, (MU).

The Motor Unit consist of Alpha Motoneuron, Axon, Muscle Fibers, Motor Endplates, and Muscle fibers. Figure 2.2.

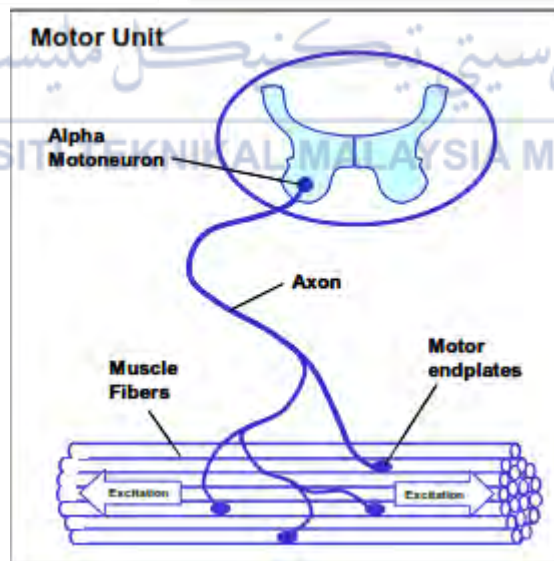


Figure 2.2: Motor Unit

2.1.2 Excitability of Muscle Membranes.

The nerve system will excite a control over muscle membranes. The ion pump in muscle cell create a balance between the internal and external of the muscle membrane. The muscle membrane have 3 stage called the Resting Potential, Depolarization process, and Repolarization. Figure 2.3. [7,8] Resting Potential is where the muscle is not moving, Depolarization is where the muscle moving forward, and Repolarization is where the muscle moving backward [9]. The Na^+ ion charges play an important part in this process.

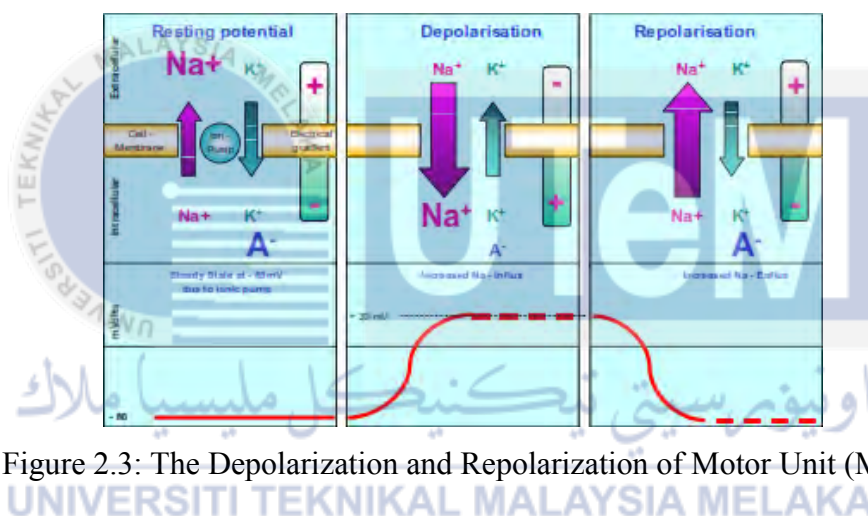


Figure 2.3: The Depolarization and Repolarization of Motor Unit (MU).

2.1.3 The Action Potential.

The Action Potential also known as Motor Unit Action Potential (MUAP), explain the Depolarization of muscle membrane which is counter by Repolarization immediately after that. Figure 2.4. This process produce about -80mV to +30mV of MUAP [10, 11].

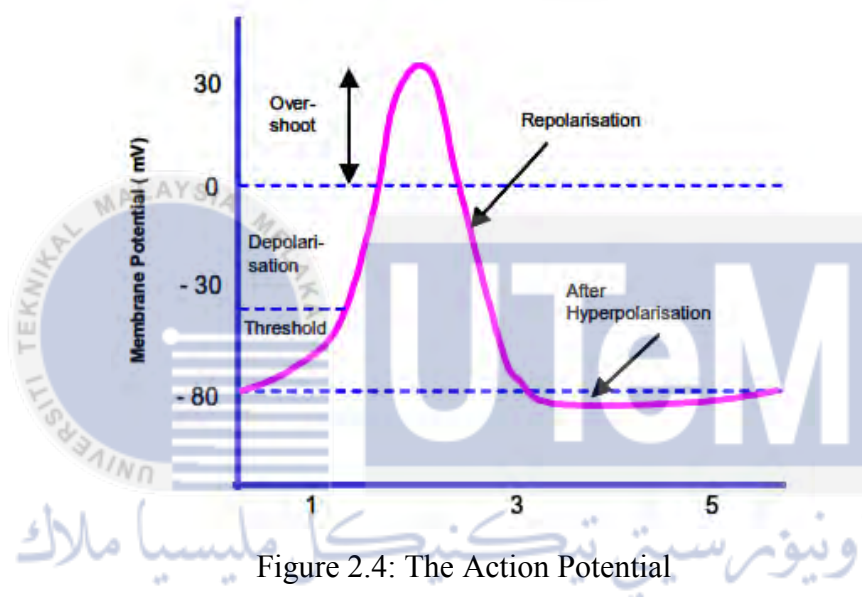


Figure 2.4: The Action Potential

The EMG signal from the Depolarization and Repolarization process will be collect by the sEMG device. Figure 2.5.

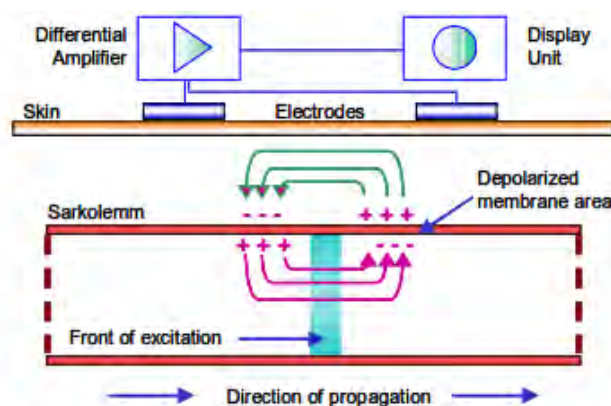


Figure 2.5: The depolarization zone on muscle fiber membranes.

2.1.4 Signal Propagation and Detection

The Depolarization and Repolarization process of the muscle membrane produce MUAP, that will be detect by the electrode and amplify by the sEMG device. This will give EMG signal depend on the specific requirement that will affect the EMG signal. Figure 2.9.

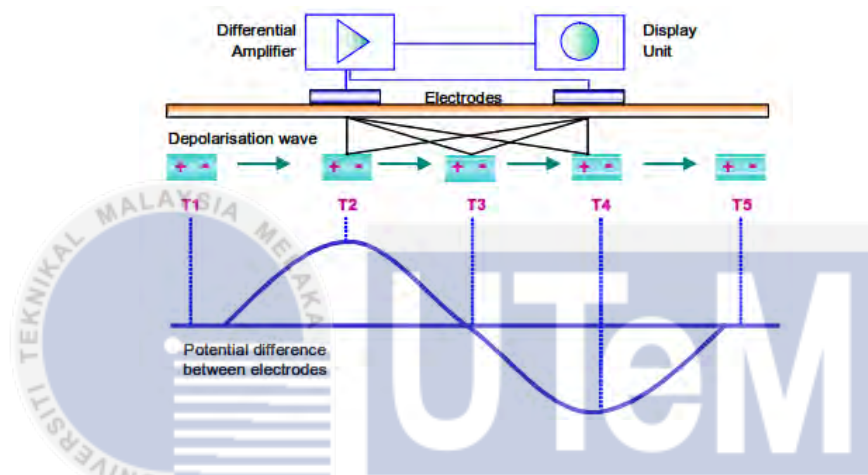


Figure 2.6: The model of a wandering electrical dipole on muscle fiber membranes

Figure 2.6 show at time point T1 the MUAP is created and ventures towards the electrode. An expanding potential contrast is measured between the electrodes which is at position T2. In the event that the dipole achieves an equivalent distance between the terminals electrodes and passes the zero line and gets to be most elevated at position T4, which implies the nearest to electrode 2. This model clarifies why the monopolar MUAP give out bipolar MUAP inside the differential amplification process [12, 13]. Commonly, all muscle membrane created triphasic MUAP, which depend on the location of electrode. The MUAP of all dynamic Motor Unit (MU), discernible under the electrode site are electrically superposed, and the bipolar signal with symmetric dispersion of positive and negative amplitudes. Figure 2.7. The most important factor affecting the MUAP is the recruitment of MUAP by all muscle within electrode area and their firing frequency [14]. For easy understanding, the EMG signal reflects the recruitment and firing characteristic of the identified motor units inside the muscle. Figure 2.8.

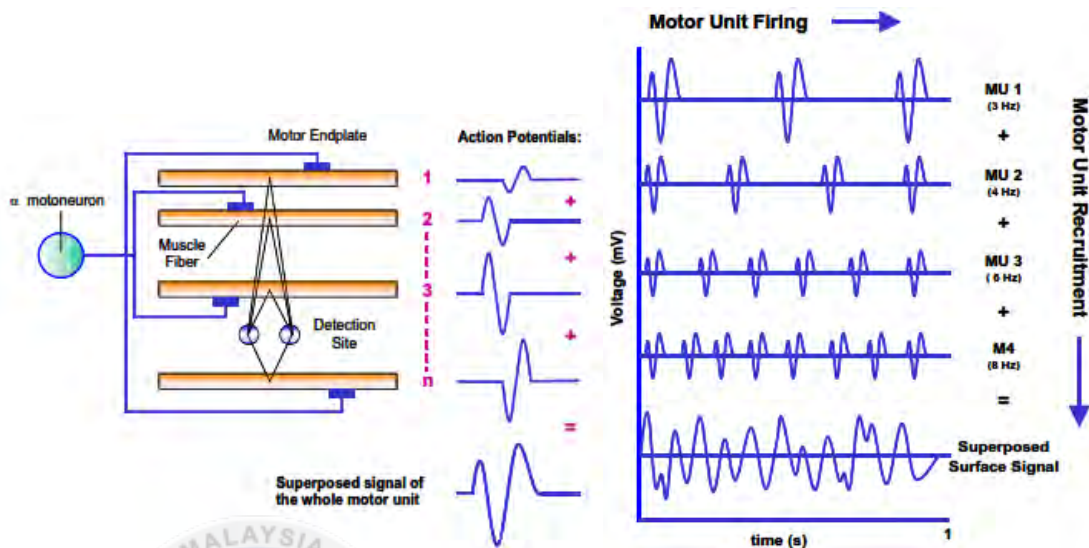


Figure 2.7: Generation of the triphasic MUAP

Figure 2.8: Motor Unit Recruitment and Firing Frequency

2.1.5 Factor Effecting the EMG signal.

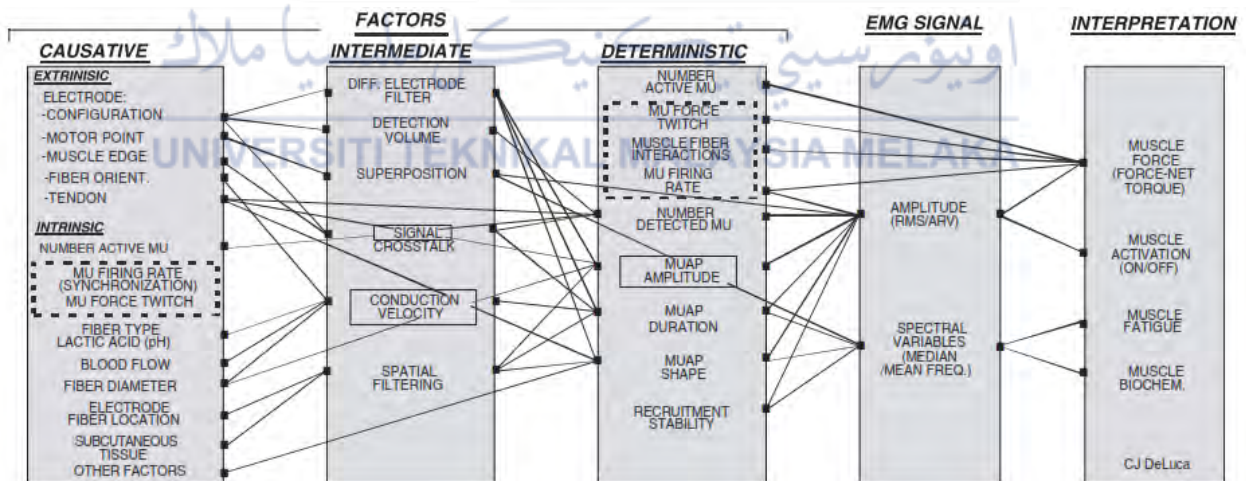


Figure 2.9: Factor effecting the EMG signal by C.J De Luca

2.2 Review of previous related works

Electromyography had its most punctual establishes in the exclusively polished by the Greeks of utilizing electric eels to "stun" illness out of the body. The source of the stun that went with this most punctual location and application of the EMG sign was not acknowledged until 1666 when an Italian, Francesco Redi, understood that it started from muscle tissue [15]. This relationship was later demonstrated by Luigi Galvani in 1791 who staunchly guarded the idea. Amid the following six decades, a couple of examiners fiddled with this newfound marvel, however it stayed for Dubois Reymond in 1849 to demonstrate that the EMG sign could be located from human muscle amid a deliberate compression. This significant disclosure stayed undiscovered for eight decades anticipating the improvement of mechanical actualizes to adventure it prospects. This interim delivered new instruments, for example, the cathode beam tube, vacuum tube speakers, metal terminals and the progressive needle terminal which gave intends to advantageously locating the EMG signal [16]. This basic actualize presented by Andrian and Bronk in 1929 let go the creative energy of numerous clinical scientists who held onto electromyography as a crucial asset for analytic techniques. As vital among these was the commitment of Buchthal and his partners.

Guided by the work of Inman et al., in the mid-1940s to the mid-1950s few examinations uncovered a monotonic relationship between the sufficiency of the EMG sign and the energy and speed of a muscle compression [17]. This huge finding had a significant effect, for example, it significantly advanced the utilization of EMG studies concerned with muscle capacity, engine control, and kinesiology. Kinesiological examinations got yet an alternate catalyst in right on time 1960s with the presentation of wire terminals. The properties of the wire anode were perseveringly used by Basmajian and his partners amid the following two decades.

In the early 1960s, an alternate emotional advancement happened in the EMG field, which is myoelectric control of controlled prostheses [18]. Amid this period engineers from a few nations created remotely fueled upper appendage prostheses that were made conceivable by

the scaling down of gadgets parts and the advancement of lighter, more minimized batteries that could be conveyed by amputees. Foremost among the advancements of remotely controlled prostheses was the work of the Yugoslavian engineer Tomovic and the Russian engineer Kobrinski, who in the late 1950s and early 1960s gave the first illustrations of such devices [19].

In the accompanying decade, a formal hypothetical premise for EMG started to develop. Up to this point, all information in the field had advanced from observational and frequently recounted perceptions. De Luca portrayed a numerical model that clarified numerous properties of the time domain parameters of the EMG sign, and Lindstrom, depicted a scientific model that clarified numerous properties of the frequency domain parameters of the EMG signal. With the presentation of diagnostic and simulation technique, new methodologies to the preparing of the EMG signal come. One of it was the Graupe and Cline, who utilized the autoregressive moving normal strategy for extraction data from the EMG signal [20].

The late 1970s and early 1980 saw the utilization of modern machine calculations and correspondence hypothesis to deteriorate the EMG signal into the individual electrical exercises of the muscle fiber. Today, the deterioration methodology guarantees to reform clinical EMG and to give an influential device to researching the definite control plans utilized by the sensory system to create muscle withdrawals. In the same vein, the utilization of a flimsy tungsten wire cathode for distinguishing the MUAP, from single filaments was mainstream for clinical application [21]. Different strategies utilizing the sEMG signal, for example, the utilization of average and mean frequencies of the EMG signal to portray the utilitarian condition of a muscle and the utilization of the conduction speed of the EMG sign to give data on the morphology of the muscle filaments started to begin.

The 1990s saw the powerful application of current sign transforming methods for the examination and utilization of the EMG signal, for example, the utilization of time and frequency investigation of the sEMG signal for measuring the relative commitment of low back muscles amid the vicinity and non-attendance of low back torment, the utilization of efficient

estimations of the muscle fiber conduction speed for measuring the seriousness of the Duchenne Dystrophy, the investigation of MUAP, deferral for placing the birthplace, the completion and the innervations zone of muscle filaments, and the application of time-recurrence examination of the EMG sign to the field of laryngology.

New engineering and advancement continue until the utilization of substantial scale multichannel recognition of EMG signals for placing wellsprings of muscle fiber anomaly, application of neural systems to give more noteworthy degrees of opportunity to the control of myoelectric prostheses, and for the examination of EMG sensors information for evaluating the engine exercises and execution of sound subjects and stroke patients. For the freshest improvement for EMG is the developing utilization of modern Artificial Intelligence strategies for the decaying the EMG signal. for locating sources of muscle fiber abnormality, application of neural networks to provide greater degrees of freedom for the control of myoelectric prostheses, and for the analysis of EMG sensors data for assessing the motor activities and performance of sound subjects and stroke patients. For the newest development for EMG is the emerging use of sophisticated Artificial Intelligence techniques for the decomposing the EMG signal [22].

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2.3 Summary and discussion of the review

Electromyography (EMG) is a practicable method to be implanted in getting the EMG signal from weightlifting athletes. EMG technique can be applied to many and different fields, as long it involve motor unit from muscle and nerve to be collect, and to be analyze later.

To obtain EMG signal from biceps brachii, electrodes are attached to skin near the biceps brachii skin region. The processes of obtaining the EMG signal including amplify and filter the signal for clear understanding of what are the muscle doing and what the signal produces. This will later help in analyzing the recorded data to be uses for further research or medical purpose.

Also the noise that produce by the hardware and skin contact can be decrease by the filter. For this research, sEMG method will be used compared to the other method such as needle electrodes and wire electrode.

Table 2.1: Recommendation of Electrode Usage.

Surface Electrodes (sEMG)	Needle Electrode	Wire Electrodes
Time force relationship of EMG signals	MUAP characteristics.	Kinesiological studies of deep muscles.
Kinesiological studies of surface muscles.	Control properties of motor units (firing rate, recruitment, etc.).	Neurophysiological studies of deep muscles.
Neurophysiological studies of surface muscles	Exploratory clinical electromyography.	Limited studies of motor unit properties.
Psychophysiological studies.		Comfortable recording procedure from deep muscle.
Interfacing an individual with external electromechanical devices.		

The EMG signal will later be read by the sEMG and transfer to Matlab by using specific Arduino Mega and Olimex Ekg/Emg Shield as main sensor. In Matlab, the EMG signal will be analyze. This step is to acquire signal information such as the maximum and minimum amplitude, peak-to-peak amplitude, mean amplitude, median amplitude and root mean square (RMS) value.

CHAPTER 3

METHODOLOGY

In this Chapter 3, will explain in detail the overall process in order to archive the objective described in Chapter 1. All these details methodology are important to complete the experiment and are in perfect order step by step.

3.1 Experiment Specification.

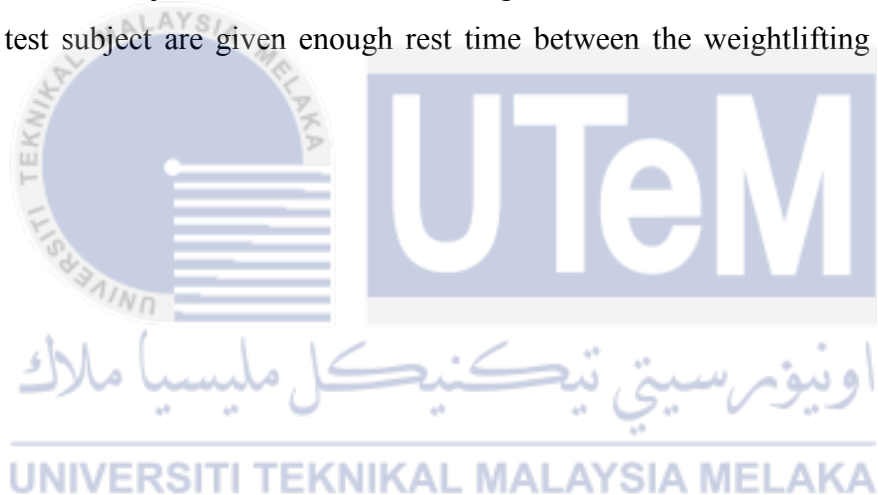
The experiment specification was to ensure will conduct according the scope stated in the Chapter 1. This experiment specification are divide into test subject, experimental procedure, experimental setup.

3.1.1 Test Subject.

There were 5 person as test subject which where data was collected from are all healthy and arm no sickness. The specification are already discuss in Chapter 1, Table 1.2. Also any person with too many fat are exclude from the experiment which may lead to undesired noise in the EMG signal. Also any hair in the point where electrodes was placed are removed. Any injury test subject also excluded.

3.1.2 Experimental Procedure.

The experimental procedure guideline are important to ensure the data collect are correct and valid throughout the EMG data collection process. This help the EMG data collection from varies far from each other and collected undesired noise and other muscle signal as the scope of experiment is only to collect biceps EMG signal. The weight lifting exercise are only the biceps curl. The weight lifting were conduct within 20 seconds time which 10 seconds arm rest and 10 seconds. The 5 test subject will lift 3 different weight which is 2.5 KG, 5 KG and 10KG with 5 trials. The test subject are given enough rest time between the weightlifting to prevent any injuries.



3.2 Experimental Setup

3.2.1 Data Acquisition Setup

The data acquisition setup used in this experiment are Arduino Mega 2560, EKG/EMG Shield, and Matlab in computer. This data acquisition setup was important to ensure EMG signal are detected and recorded. The interfacing between both Arduino (Hardware) and Matlab (Software) are most important to displaying EMG signal and saving it into computer file to be able to analyze. Figure 3.1 show the configuration in Matlab Simulink of Arduino input and Scope output to collect EMG signal. The sampling rate was for the Analog Input was set to 0.001s. Although the Matlab has an issues that computer time and real time are slightly differ from each other. This is overcome by using stopwatch.

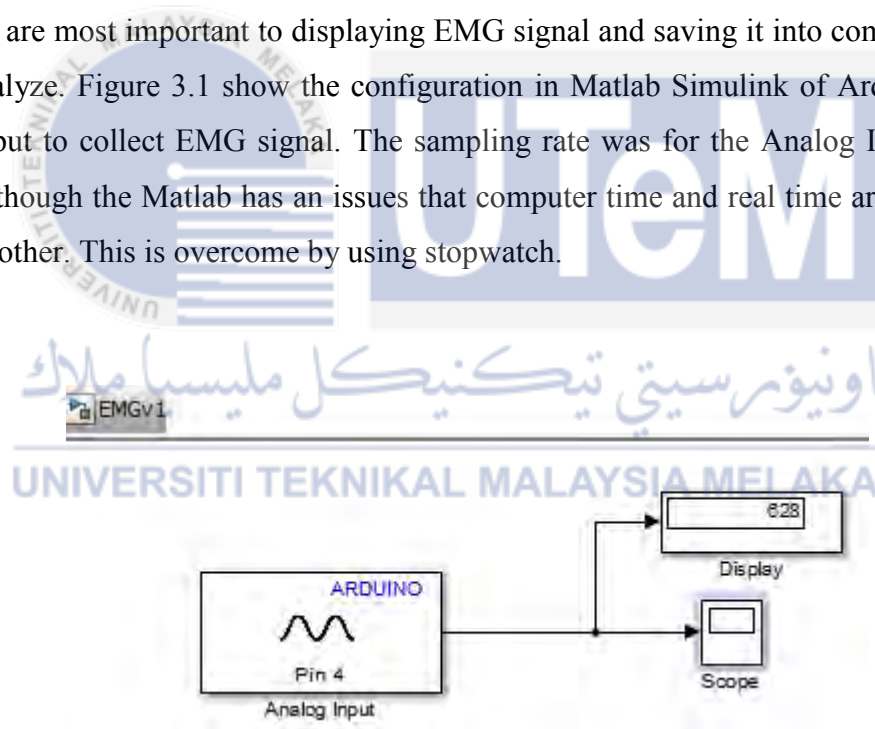


Figure 3.1: Matlab Simulink Block Diagram Configuration of Arduino with EKG/EMG Shield.

3.2.2 Electrodes Selection

There are two type of sEMG electrodes that are dry passive electrode and Nikon Kohden wet gel disposable electrode. Both electrode are good but Nikon Kohden wet gel disposable electrode are chosen because it is disposable, and give more accurate EMG signal. The passive electrode may degenerated, therefore Nikon Kohden wet gel disposable electrode are chosen. Figure 3.2 show the Nikon Kohden wet gel disposable electrode.



Figure 3.2: Nikon Kohden wet gel disposable electrode

3.2.3 Alcohol Swab

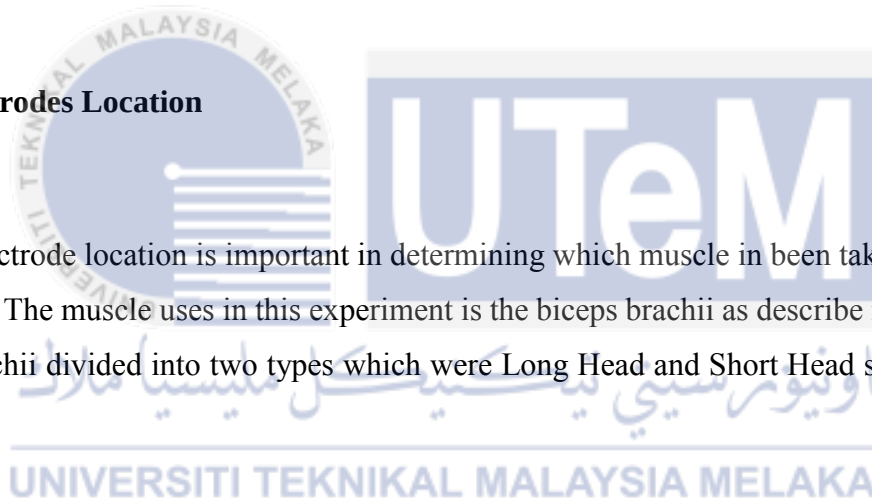
In order to remove unwanted impedance produce by dead skin, sweat and dirt, alcohol is used. There are several ways to remove this impedance that are using special cleaning paste, pure alcohol and sandpaper. This will help increase in skin conductivity and thus give fine EMG signal. For this experiment BD Alcohol Swab are used. Figure 3.3.

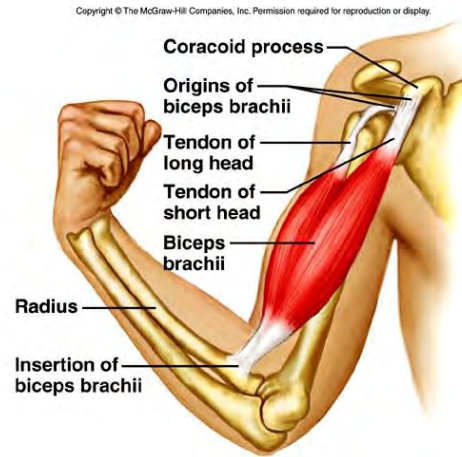


Figure 3.3: BD Alcohol Swab

3.2.4 Electrodes Location

Electrode location is important in determining which muscle in been taken into account to analyze. The muscle uses in this experiment is the biceps brachii as describe in the scope. As biceps brachii divided into two types which were Long Head and Short Head shown in Figure 3.4.





3.3 Experimental Procedure

3.3.1 Flowchart of the Experimental Procedure

This experimental procedure was compulsory to ensure the process in acquiring the EMG signal is uniformly conduct to ensure the validity of the data collected. Figure 3.5 shown complete step by step experimental specification.

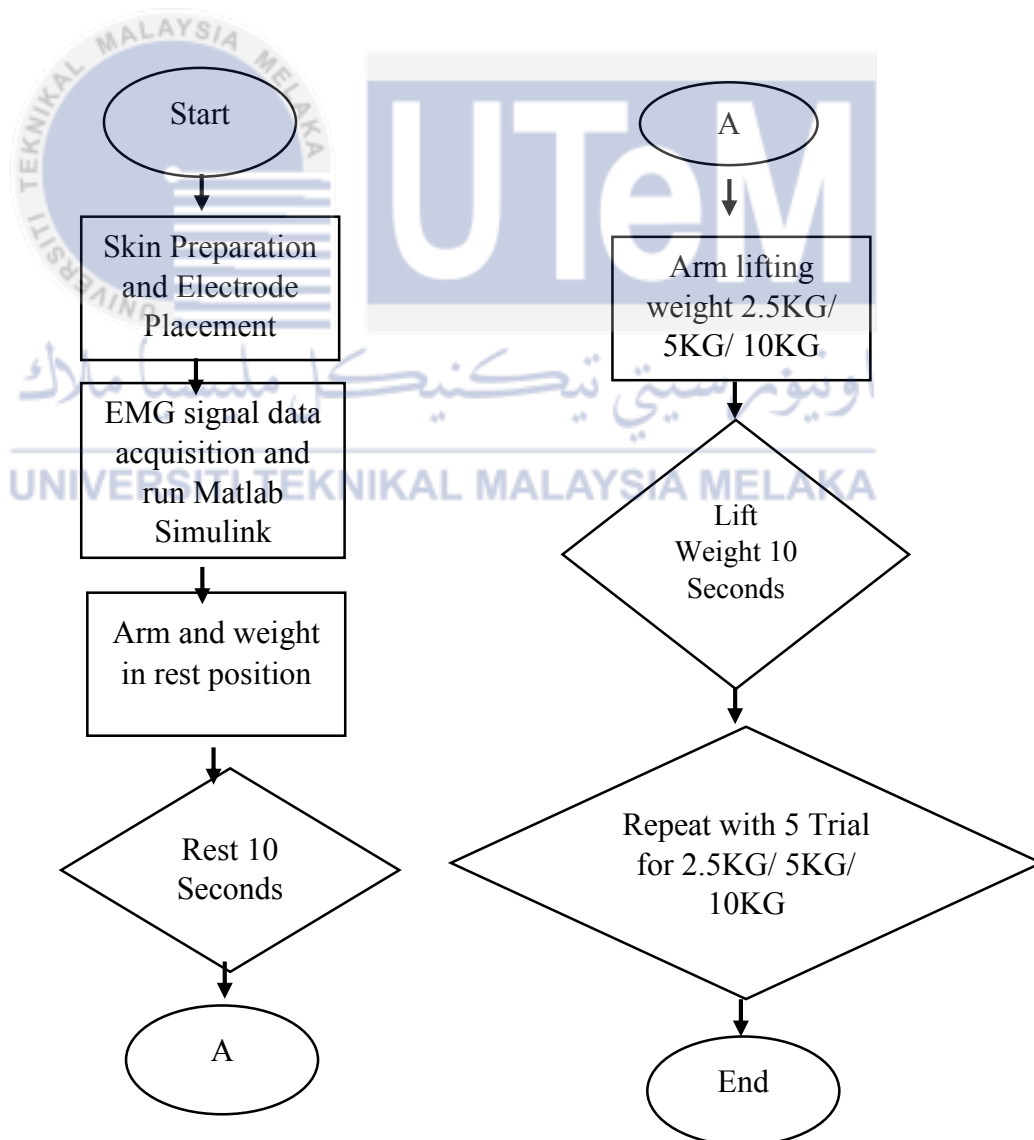


Figure 3.5 :Flowchart of Experimetal Procedure

3.3.2 Exercise Procedure

The experiment was conducted in standing position. This prevent the test subject to use their body to support the weight and to ensure they use all they bicep brachii muscle. They will experimented within 20 seconds which 10 seconds arm rest and 10 second bicep curl with the weight. This is repeat 5 times for one test subject. In between the trial the test subject will be times to rest to prevent muscle injuries. One test subject will lift 3 different weight which are 2.5KG, 5KG and 10KG. Figure 3.6 show how the test subject arm rest and biceps curl.



Figure 3.6: Exercise Procedure. (A) Arm Rest (B) Bicep Curl

3.4 Data Collection and Feature Extraction of Electromyography (EMG) Signal

The data collection of 5 person as test subject with 3 different weight and 5 trial give a total of 75 amount of 20 seconds EMG signal. These signal was recorded by Matlab and the data is save in Matlab file. The recorded EMG signal are then calculate for it Max Value, Mean Value, Median Value, Variance Value, Standard Deviation and Root Mean Square (RMS) Value. Then these 75 EMG signal transformed into Power Spectral, to be analysis by using Matlab Wavelet Design and Analysis. The Max Value, Mean Value, Median Value, Variance Value, Standard Deviation Value and Power for Power Spectral also been calculated. Both of the voltage and power of the EMG signal will be analyze based on the weight test subject lifted.

Mean General Formula

$$X = \frac{1}{n} \sum_{i=1}^n x_i \quad (\text{Equation 3.6.1})$$

Median General Formula,

$$\text{Median} = \left(\frac{n+1}{2}\right)^{th} \text{ term} \quad (\text{Equation 3.6.2})$$

Variance General Formula,

$$S_x^2 = \left(\frac{1}{n-1}\right) \sum_{i=1}^n (x_i - x)^2 = \frac{1}{n-1} (\sum_{i=1}^n x_i^2 - nx^2) \quad (\text{Equation 3.6.3})$$

Standard Deviation General Formula,

$$S_x = \sqrt{\frac{\sum_{i=1}^n (x_i - x)^2}{n-1}} \quad (\text{Equation 3.6.4})$$

Root Mean Square (RMS) General Formula

$$X_{RMS} = \sqrt{\frac{1}{N} \sum_{i=1}^N X_i^2} = \sqrt{\frac{X_1^2 + X_2^2 + \dots + X_N^2}{N}} \quad (\text{Equation 3.6.5})$$

Power (dB) General Formula,

$$\text{Decibel} = 20 \log_{10} \frac{V_{in}}{V_{out}} \quad (\text{Equation 3.6.6})$$

Fourier Transform General Formula,

$$X(f) = \int_{-\infty}^{\infty} x(t) e^{-i2\pi f t} dt \quad (\text{Equation 3.6.7})$$

i = square root of -1

f = frequency in Hertz

t = time in second

3.5 Evaluation of Features Extractions Data

The evaluation of data of this experiment are based on statistical analysis on the EMG signal collected from the test subject. The statistical analysis was done using Matlab statistical analysis function. This statistical analysis of voltage is then related to the Power Spectral to show their relationship between potential different generated by muscle with the Power Spectral which is in frequency domain.

3.6 Reliability of the Data

The reliability of the data will be compared with each weight lifted. The data collected from the test subject show an increase in EMG signal (RMS) and Power (dB) as the weight is getting heavier from 2.5KG, 5KG, and 10KG. These comparisons also prescribe as the more muscle active, more electromyography is produced. [1, 2]. Also, the other 5 test subjects shown rather the same pattern EMG signal.



CHAPTER 4

RESULTS AND DISCUSSIONS

Chapter 4, will provide the research achievement for Power Spectral Analysis of Surface EMG for weight lifting athletes. This data collection results shown that EMG signal already able been recorded. The recorded EMG signal will be analyze using through Power Spectral to show the different between EMG signal created by using different test subject load and load. The MUAP between people are different in value because of the different in amount of firing Motor Unit and the frequency of Motor Unit firing

4.1 Noise Analysis

One of the important in recording the EMG signal is to know which is the EMG signal and which the noise produce by surrounding area and internal component of the hardware. The EMG signal when recorded by Matlab Scope show a variety of the signal even when the EMG sensor still not connected to the test subject. Then when the test subject is connected to the sensor the amount of EMG signal increase. This can be filter when change the data recorded from time-domain to frequency-domain, the actual signal is the lower frequency with high amplitude and the other than that is noise. This show a signal to noise ratio is low, which mean the data recorded have high noise and low signal. This because of the surrounding noise and also poor hardware condition.

4.2 EMG Signal Collected and Power Spectral Analysis

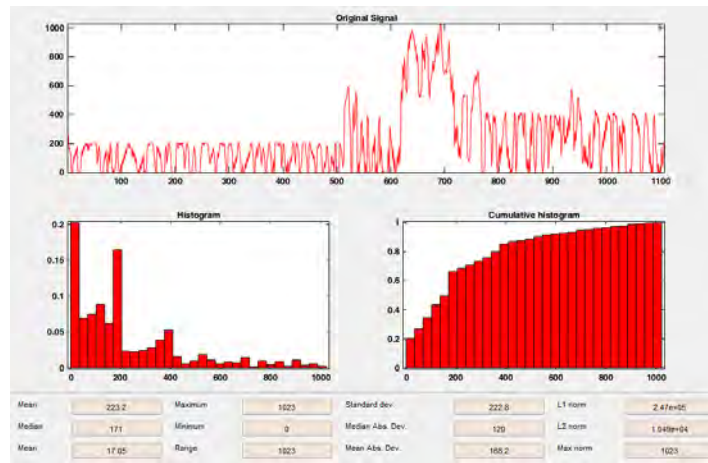
The EMG signal collected are recorded using Matlab file and tabulated in Appendix G. The overall data collected show high level of variance of data which mean a further Power Spectral Analysis is required to be used. The data collected are using the Matlab Wavelet Design and Analysis to get the Maximum Value, Mean Value, Variance Value, Standard Deviation Value and RMS value. Figure 4.1 shown an example of recorded EMG signal, which is the less amplitude signal is where the arm of the test subject are at rest condition and the high amplitude of the signal shown are when the test subject are doing biceps curl exercise. Figure 4.2 and 4.3 shown an increase in EMG signal cause of weight of the test subject is increased.

The goal of Power Spectral Analysis is to estimate the Spectral Density of the random signal from a sequence of time samples of a signal. Meaning the peaks of the signal in frequency-domain can be describe. Also the PSA describe the distribution in frequency of the power contained in a signal based on the finite set of data. PSA is useful in detection of signal buried in wideband noise and related closely to the Fourier Transform which convert time-domain signal to frequency-domain signal.

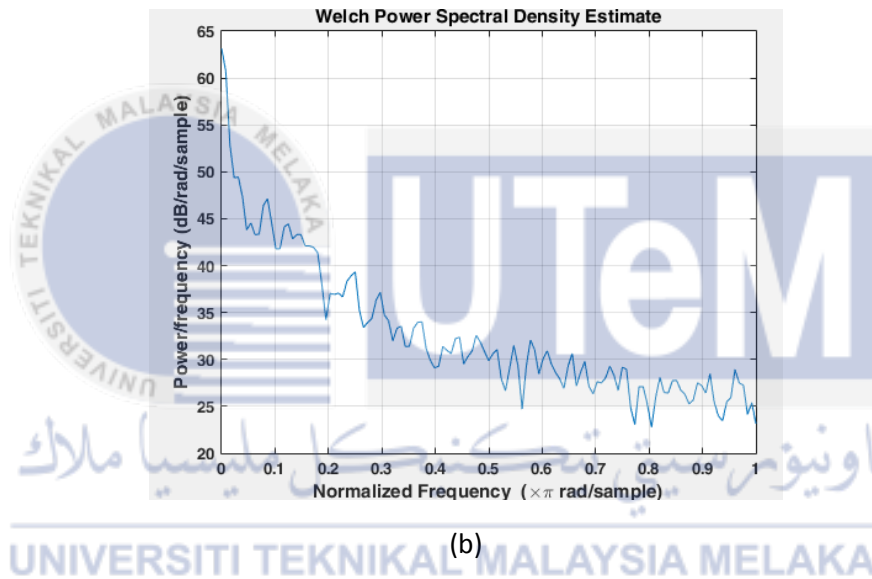
There are many Power Spectral Analysis method such as Bartlett's Method, Blackman-Tukey Method, Autoregressive moving average Method, and others. Welch's Method is selected among the others because of the estimator and the average it is more clearly shown in the graph. The Welch's technique reduced the variance of the signal by breaking the periodogram time series into segment and modified the segment into estimated average power spectral density. This guard against data loss by windowing. Figure 4.1 shown an example of Power Spectral of the recorded EMG signal. From Figure 4.1, 4.2 and 4.3 there is an increases shown in Mean Value of the Power Spectral when the weight lifted by the test subject are

increase. From figure 4.1 the Mean Value is 32.82 dB, Figure 4.2 Mean Value 34.23 dB, is and Figure 4.3 Mean Value is 38.79 dB as shown in Figure 4.4. Overall data of the Power Spectral is tabulated in Appendix H.

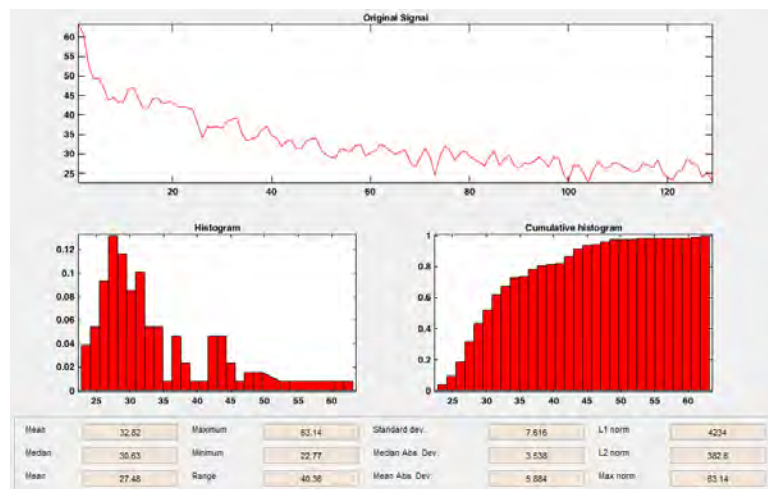




(a)

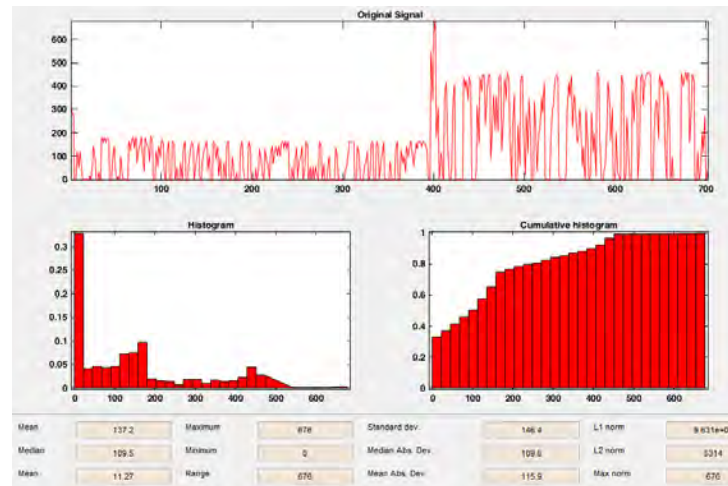


(b)

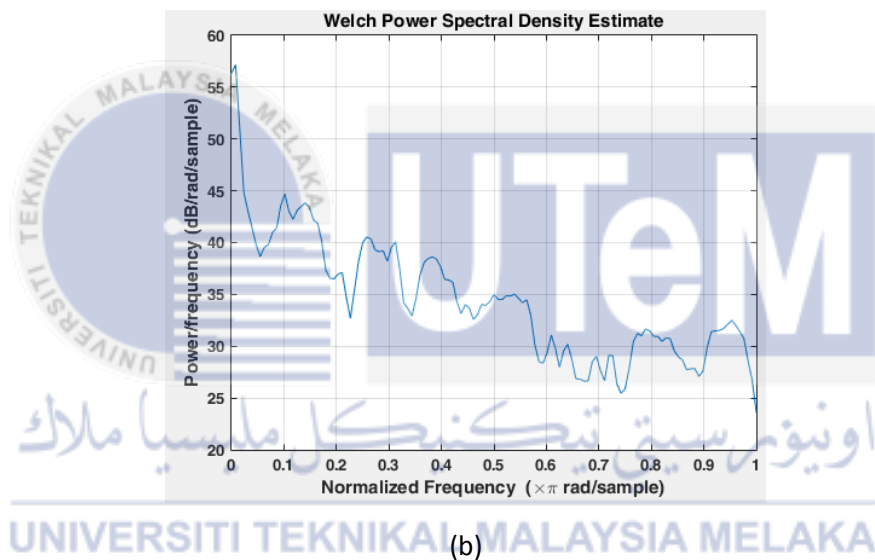


(c)

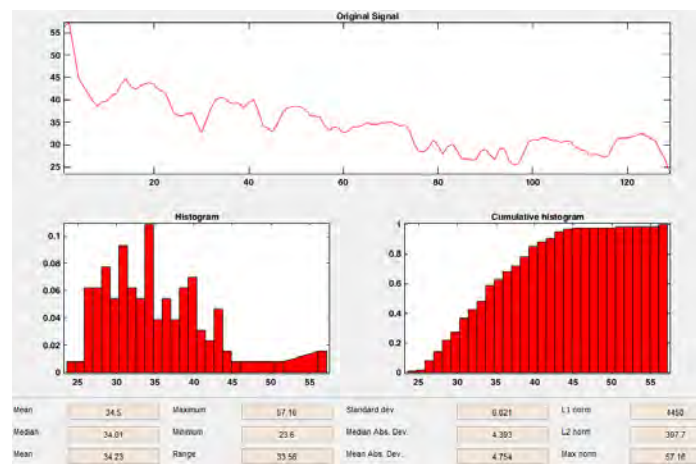
Figure 4.1: Data for 2.5KG (a) Statistic EMG Signal (b) PSD Graph (c) Statistic PSD



(a)

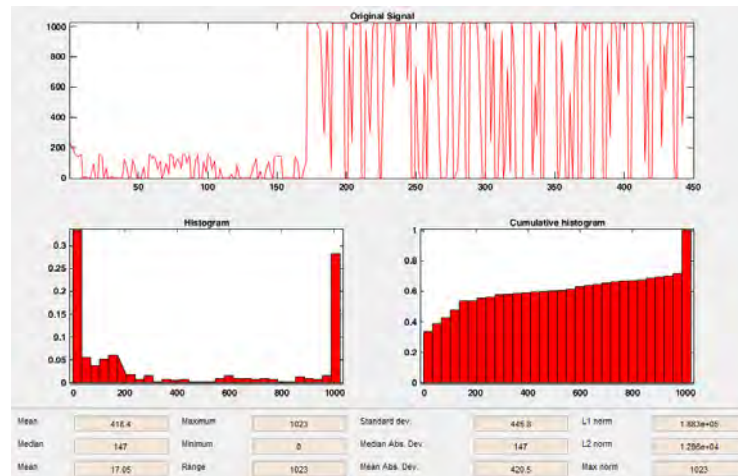


(b)

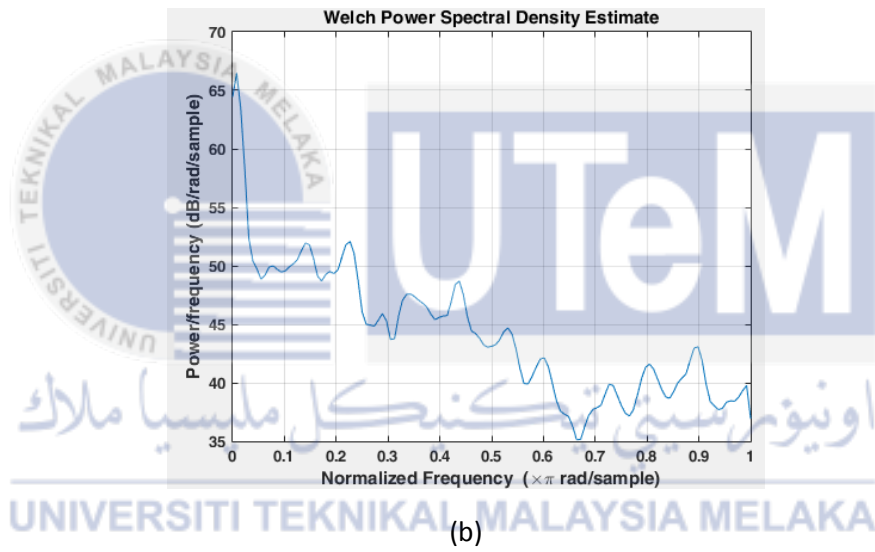


(c)

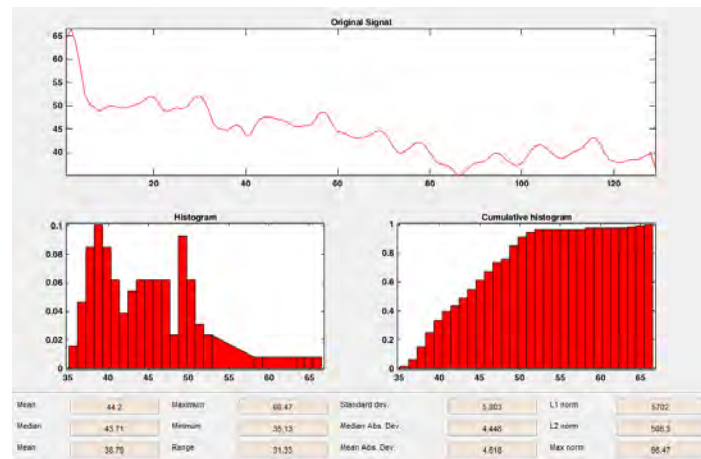
Figure 4.2: Data for 5.0 KG (a) Statistic EMG Signal (b) PSD Graph (c) Statistic PSD



(a)



(b)



(c)

Figure 4.3: Data for 10.0 KG (a) Statistic EMG Signal (b) PSD Graph (c) Statistic PSD

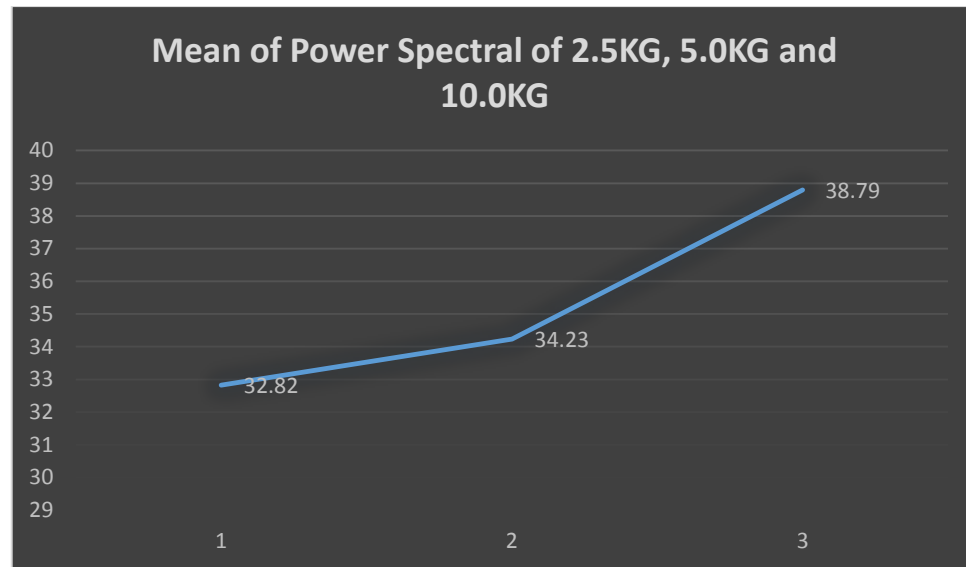


Figure 4.4: Mean of Power Spectral of 2.5KG, 5.0KG and 10.0KG



CHAPTER 5

CONCLUSION AND RECOMMENDATION

Chapter 5 will conclude all the finding of the research, from the beginning of the experiment until the end of the analysis of the collected data. Also the recommendation of the experiment are suggested.

5.1 Conclusion

Electromyography, EMG signal is a bio potential produced human muscle movement. Itself generated electrical activities produced can be recorded and be analyze through an instrument called electromyograph. The signal record by electromyography is called electromyogram or widely known as EMG signal. This EMG signal can be analyze for further research. Also EMG signal can be greatly benefit weight lifting athlete for their medical research, rehabilitation, ergonomics and sport science.

The first objective of the experiment to record the EMG signal or Motor Unit Action Potential (MUAP) from sEMG by using developed acquisition system was achieved in this experiment. The sEMG using Arduino and EKG/EMG Shield prove to be alternative hardware to extract EMG signal from biceps muscle. The Matlab software also prove to be a suitable interface in showing and recording the EMG signal.

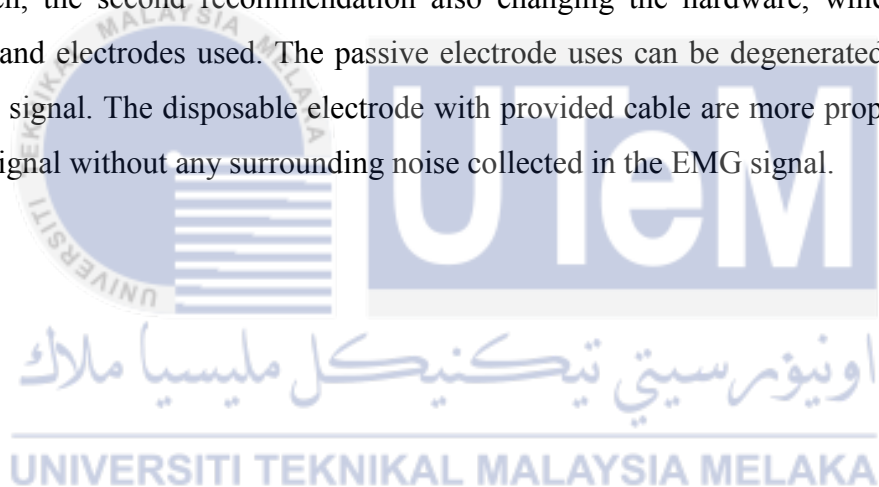
The second objective to analyse and validate the EMG signal using Power Spectral Analysis also achieved in this experiment. The analyse for recorded EMG signal using statistic

method and Power Spectral by varying the weight lifted by the test subject shown an increasing in the EMG signal as the weight lifted increase.

5.2 Recommendation

The first recommendation of the experiment is to change the sensor from EKG/EMG Shield to Muscle Sensor v3. This is because the Muscle Sensor v3 do not output raw EMG signal but provide an output of amplified, rectified, and smoothed signal that work well with a microcontroller analog-to-digital converter (ADC).

Then, the second recommendation also changing the hardware, which is the cable electrodes and electrodes used. The passive electrode uses can be degenerated and provide a false EMG signal. The disposable electrode with provided cable are more proper in recording the EMG signal without any surrounding noise collected in the EMG signal.



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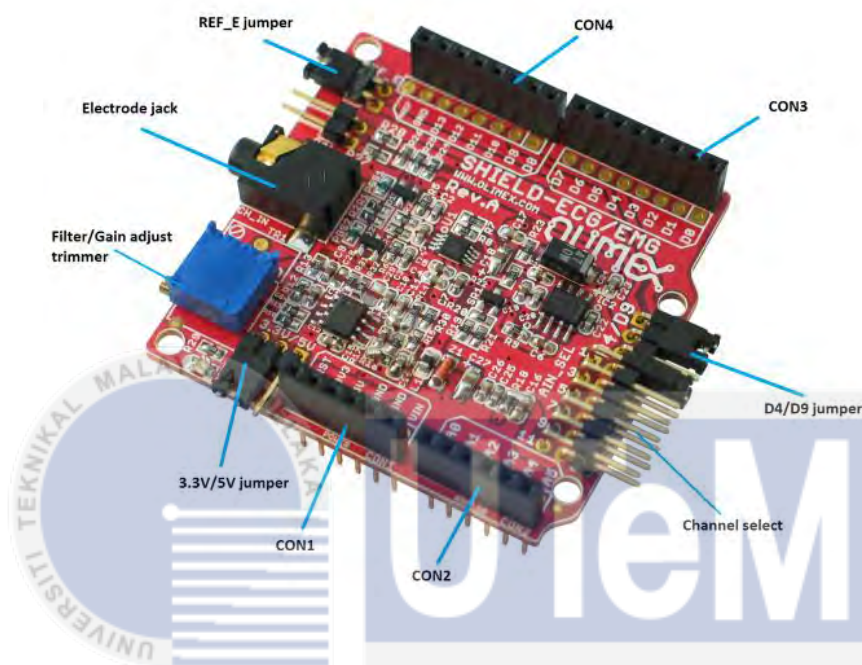
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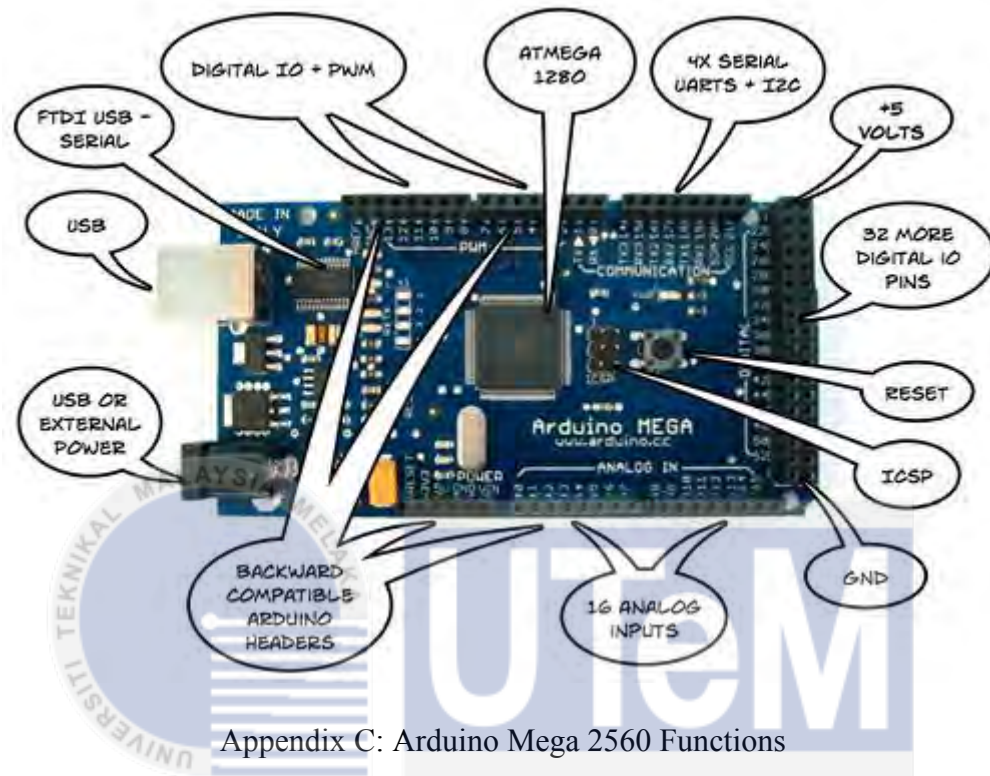
APPENDICES



Appendix A: EKG/EMG Shield

Pin #	POWER CON1	ANALOG CON2	ANALOG CON 3	DIGITAL CON4
1	A0	D0	D0	D8
2	A1	D1	D1	D9
3	A2	D2	D2	D10
4	A3	D3	D3	D11
5	A4	D4	D4	D12
6	A5	D5	D5	D13
7	-	-	D6	GND
8	-	-	D7	AREF

Appendix B: Electrocardiography Electromyography Shield connector



Part	Description
Type of microcontroller	AT Mega 1280
Operating voltage	5V
Input Voltage (Recommended)	7V-12V
Input Voltage (Limits)	6V-20V
Digital I/O Pins	54 (of which 14 pins are PWM outputs)
Number of analogue input pins	16
DC current per I/O pin	40mA
DC current for 3.3V pin	50mA
Flash memory	128KB of which 4KB used by bootloader
SRAM	8KB
EEPROM	4KB
Clock speed	16MHz

Appendix D: Technical specifications for Arduino Mega 2560

Part	Functions
Power Pins	
a.) VIN	Input voltage to the Arduino Mega 2560 when it is using an external power supply
b.) 5V	- Regulated power supply - As a power to the board
c.) 3V3	3.3V which is generated by FTDI chip
d.) GND	Ground pin
Memory	To store code
Input and Output pins	
a.) TX/RX	To receive and transmit TTL data
b.) External Interrupt	To trigger an interrupt
c.) PWM	Provide 8-bit PWM output
d.) SPI	Support SPI communication
e.) LED	Built in LED
f.) I ² C	Support I²C (TWI) communication
g.) AREF	Reference voltage for the analogue input
h.) Reset	To reset the microcontroller when it is LOW
Communication	To enable communication between a computer, another Arduino or another microcontroller

Appendix E: Function of each part on Arduino Mega 2560



Appendix F: Passive Electrodes for Electrocardiography Electromiography Shield

Appendix G: EMG Signal

Test Subject 1

	Max Value (mV)			Mean Value (mV)			Median Value (mV)		
Trial\Weight	2.5KG	5.0KG	10.0KG	2.5KG	5.0KG	10KG	2.5KG	5.0KG	10KG
1	690	1023	916	99.34	170.62	104.13	15.66	16.42	15.17
2	431	842	1023	74.55	148.81	183.58	2.64	14.79	15.47
3	1023	676	1023	132.63	73.75	194.71	16.58	13.90	15.92
4	1023	1023	1023	122.64	113.91	169.88	16.97	15.41	15.64
5	1023	1023	1007	164.97	134.35	148.12	17.73	14.94	15.49
	Variance (mV)			Standard Deviation(mV)			RMS value (mV)		
Trial\Weight	2.5KG	5KG	10KG	2.5KG	5.0KG	10KG	2.5KG	5.0KG	10KG
1	2.57+e4	7.30e+4	3.49e+4	160.23	270.19	186.90	87.48	91.48	88.48
2	9.54+e3	5.19+e4	8.85e+4	97.66	227.73	297.50	91.56	91.53	88.53
3	4.74+e4	1.48+e4	9.00e+4	217.71	121.46	299.97	91.62	91.58	88.57
4	3.92+e4	3.43+e4	9.04e+4	198.06	185.27	300.00	91.67	91.63	88.62
5	6.24+e4	5.72+e4	7.09e+4	249.82	239.21	266.27	91.78	91.68	88.67

Test Subject 2

	Max Value (mV)			Mean Value (mV)			Median Value (mV)		
Trial\Weight	2.5KG	5.0KG	10.0KG	2.5KG	5.0KG	10KG	2.5KG	5.0KG	10KG
1	827	126.52	1023	100.80	15.06	201.66	16.93	15.06	17.08
2	1023	155.59	1023	142.69	15.30	215.92	17.39	15.30	15.97
3	840	155.67	1023	115.06	15.96	189.68	16.89	15.96	14.78
4	1023	130.76	1023	117.33	14.86	220.22	17.11	14.86	15.75
5	1023	129.35	1023	135.48	14.77	86.41	16.18	14.77	11.85
	Variance (mV)			Standard Deviation(mV)			RMS value (mV)		
Trial\Weight	2.5KG	5KG	10KG	2.5KG	5.0KG	10KG	2.5KG	5.0KG	10KG
1	2.17+e4	5.32+e4	8.92+e4	147.28	230.56	298.68	87.48	87.37	84.33
2	5.66+e4	6.62+e4	1.40+e4	237.93	257.15	374.58	87.54	87.42	84.39
3	2.83+e4	5.20+e4	1.25+e4	168.30	228.01	353.58	87.59	87.48	84.43
4	3.60+e4	5.60+e4	1.40+e4	189.81	236.59	353.74	87.65	87.54	84.49
5	5.77+e4	5.57+e4	2.80+e4	240.14	236.00	353.74	87.71	87.60	84.55

Test Subject 3

Trial\Weight	Max Value (mV)			Mean Value (mV)			Median Value (mV)		
	2.5KG	5.0KG	10.0KG	2.5KG	5.0KG	10KG	2.5KG	5.0KG	10KG
1	795	1023	1023	106.45	90.80	179.32	17.03	15.11	14.58
2	1023	770	1023	90.06	101.34	187.39	14.84	14.37	14.84
3	1023	864	1023	91.13	124.66	202.85	14.37	15.59	15.11
4	1023	958	1023	119.83	129.77	11.16	15.28	15.20	16.25
5	1023	914	1023	74.36	102.97	17.37	15.54	14.65	16.55
Trial\Weight	Variance (mV)			Standard Deviation(mV)			RMS value (mV)		
	2.5KG	5KG	10KG	2.5KG	5.0KG	10KG	2.5KG	5.0KG	10KG
1	2.43+e4	2.43+e4	9.79+e4	155.91	155.85	312.91	88.88	88.78	85.93
2	4.51+e4	2.86+e4	1.01+e4	212.56	169.06	317.93	88.93	88.83	85.97
3	5.19+e4	4.72+e4	1.06+e4	227.73	217.30	325.45	88.99	88.89	86.02
4	5.67+e4	5.69+e4	6.61+e4	238.12	238.60	81.30	89.04	88.94	86.07
5	2.09+e4	3.49+e4	1.07+e4	144.42	186.85	103.73	89.09	89.00	86.12

Test Subject 4

Trial\Weight	Max Value (mV)			Mean Value (mV)			Median Value (mV)		
	2.5KG	5.0KG	10.0KG	2.5KG	5.0KG	10KG	2.5KG	5.0KG	10KG
1	1023	1023	935	61.35	101.11	204.11	14.38	14.86	16.61
2	1023	961	1023	100.18	104.23	166.45	13.80	15.10	15.20
3	1023	906	1023	117.69	144.34	120.82	14.86	15.89	13.99
4	1023	931	1023	130.46	115.15	200.00	13.95	14.59	14.91
5	1023	1023	1023	132.81	105.32	145.18	14.77	13.91	15.77
Trial\Weight	Variance (mV)			Standard Deviation(mV)			RMS value (mV)		
	2.5KG	5KG	10KG	2.5KG	5.0KG	10KG	2.5KG	5.0KG	10KG
1	2.67+e4	3.97+e4	9.06+e4	163.26	199.23	300.96	91.68	91.59	88.82
2	6.17+e4	3.17+e4	7.70+e4	248.38	178.18	277.40	91.72	91.63	88.86
3	5.81+e4	5.22+e4	5.60+e4	240.98	228.63	236.56	91.77	91.68	88.91
4	8.22+e4	4.27+e4	1.14+e4	286.74	206.61	338.00	91.81	91.73	88.95
5	7.89+e4	3.70+e4	6.90+e4	280.85	192.23	262.70	91.86	91.77	89.00

Test Subject 5

Trial\Weight	Max Value (mV)			Mean Value (mV)			Median Value (mV)		
	2.5KG	5.0KG	10.0KG	2.5KG	5.0KG	10KG	2.5KG	5.0KG	10KG
1	1023	935	888	81.04	107.68	98.50	9.88	14.07	15.45
2	1023	834	1023	123.05	107.72	112.00	13.40	14.80	13.34
3	1023	1023	1023	67.51	131.74	142.76	13.11	15.15	13.91
4	893	1023	1023	96.48	154.57	146.64	13.94	15.14	14.56
5	1023	1023	1023	134.65	178.87	144.32	13.00	15.42	14.60
Trial\Weight	Variance (mV)			Standard Deviation(mV)			RMS value (mV)		
	2.5KG	5KG	10KG	2.5KG	5.0KG	10KG	2.5KG	5.0KG	10KG
1	3.41+e4	3.75+e4	2.18+e4	184.54	193.68	147.61	88.88	88.78	85.92
2	7.66+e4	3.55+e4	3.42+e4	276.85	188.49	184.92	88.93	88.83	85.97
3	2.29+e4	5.74+e4	7.41+e4	151.48	239.61	272.17	88.98	88.88	86.02
4	4.64+e4	8.06+e4	7.34+e4	215.47	283.98	270.94	89.03	88.93	86.07
5	8.86+e4	1.00+e4	7.00+e4	297.73	317.00	264.61	89.08	88.99	86.12



Appendix H: Power Spectral

Test Subject 1

Trial\Weight	Max Value (dB)			Mean Value (dB)			Median Value (dB)		
	2.5KG	5.0KG	10.0KG	2.5KG	5.0KG	10KG	2.5KG	5.0KG	10KG
1	60.61	64.72	59.89	31.83	40.36	37.67	51.99	40.25	36.14
2	51.55	62.86	65.37	29.75	40.20	41.47	26.33	38.85	40.47
3	66.67	57.16	65.00	32.82	34.50	42.36	30.75	34.01	41.44
4	65.08	60.99	65.34	32.20	37.75	38.97	29.28	37.48	37.91
5	68.41	62.85	65.19	32.83	40.14	38.75	29.85	39.86	36.64
Trial\Weight	Variance (dB)			Standard Deviation(dB)					
	2.5KG	5KG	10KG	2.5KG	5.0KG	10KG			
1	51.99	34.48	36.94	7.21	5.87	6.08			
2	72.73	31.28	41.81	8.53	5.59	6.46			
3	53.94	36.26	36.22	7.34	6.02	6.02			
4	63.84	38.66	50.13	8.00	6.22	7.08			
5	65.50	38.33	52.08	8.09	6.19	7.22			

Test Subject 2

Trial\Weight	Max Value (dB)			Mean Value (dB)			Median Value (dB)		
	2.5KG	5.0KG	10.0KG	2.5KG	5.0KG	10KG	2.5KG	5.0KG	10KG
1	62.96	62.12	65.18	32.07	38.24	40.26	29.50	36.57	39.55
2	67.70	63.13	55.83	30.55	41.18	33.56	27.94	39.72	33.07
3	63.13	63.24	65.09	32.20	40.00	43.29	29.90	39.55	42.39
4	63.14	63.03	55.60	32.82	37.24	33.57	30.63	36.38	33.49
5	67.54	64.19	62.56	32.25	38.71	35.28	29.53	37.22	33.24
Trial\Weight	Variance (dB)			Standard Deviation(dB)					
	2.5KG	5KG	10KG	2.5KG	5.0KG	10KG			
1	52.60	41.20	39.89	7.25	6.42	6.32			
2	68.08	33.91	33.68	8.25	5.82	5.80			
3	55.00	39.31	38.65	7.42	6.27	6.22			
4	58.00	42.36	30.20	7.62	6.51	5.50			
5	63.06	45.25	47.73	7.94	6.73	6.91			

Test Subject 3

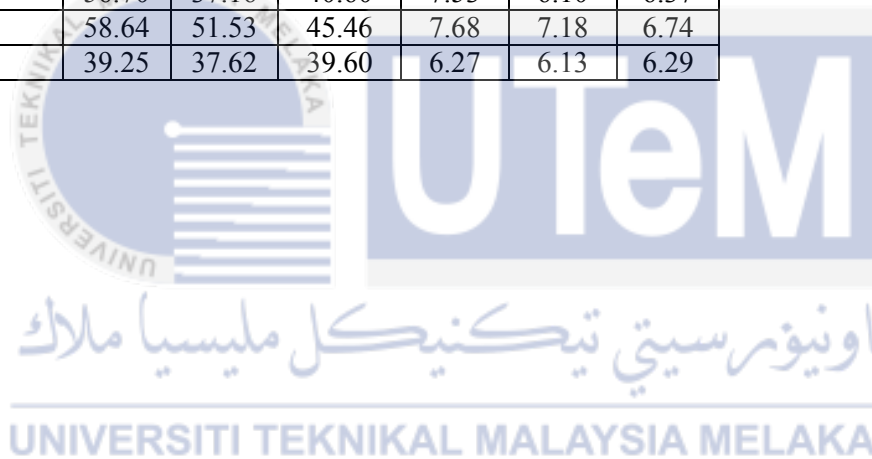
	Max Value (dB)			Mean Value (dB)			Median Value (dB)		
Trial\Weight	2.5KG	5.0KG	10.0KG	2.5KG	5.0KG	10KG	2.5KG	5.0KG	10KG
1	63.64	59.15	65.61	31.92	37.18	41.73	29.59	37.21	40.03
2	64.05	58.65	64.49	37.54	37.36	43.95	36.33	36.46	43.11
3	63.29	62.42	66.57	37.53	37.28	42.39	36.70	36.33	40.89
4	65.30	62.89	60.17	38.93	37.83	36.42	37.07	37.26	34.56
5	61.26	58.87	53.29	32.23	35.52	30.23	29.83	33.91	29.10
	Variance (dB)			Standard Deviation(dB)					
Trial\Weight	2.5KG	5KG	10KG	2.5KG	5.0KG	10KG			
1	55.59	35.25	45.44	7.46	5.94	6.74			
2	44.33	38.73	34.08	6.66	6.22	5.84			
3	53.61	45.40	42.74	7.32	6.74	6.54			
4	50.53	45.81	44.91	7.11	6.77	6.70			
5	64.07	39.17	42.76	8.00	6.26	6.54			

Test Subject 4

	Max Value (dB)			Mean Value (dB)			Median Value (dB)		
Trial\Weight	2.5KG	5.0KG	10.0KG	2.5KG	5.0KG	10KG	2.5KG	5.0KG	10KG
1	60.58	60.19	66.04	32.70	36.92	40.79	30.45	36.11	40.09
2	65.24	60.59	64.43	40.43	37.08	40.35	39.91	35.29	40.37
3	65.74	62.58	48.59	38.56	39.18	26.27	36.47	39.07	26.03
4	66.16	61.29	71.86	39.80	37.86	41.24	37.60	37.75	40.73
5	66.91	61.30	68.98	38.88	37.41	39.09	37.23	36.31	39.45
	Variance (dB)			Standard Deviation(dB)					
Trial\Weight	2.5KG	5KG	10KG	2.5KG	5.0KG	10KG			
1	65.89	37.53	39.21	8.12	6.13	6.26			
2	41.46	42.11	47.19	6.44	6.49	6.87			
3	51.28	35.05	41.86	7.16	5.92	6.47			
4	45.86	36.34	49.75	6.77	6.03	7.05			
5	57.49	36.83	62.69	7.58	6.07	7.92			

Test Subject 5

Trial\Weight	Max Value (dB)			Mean Value (dB)			Median Value (dB)		
	2.5KG	5.0KG	10.0KG	2.5KG	5.0KG	10KG	2.5KG	5.0KG	10KG
1	59.96	59.10	58.78	36.16	37.27	35.57	34.80	36.38	32.96
2	65.94	61.89	66.62	40.74	35.97	36.33	39.23	33.19	35.98
3	60.30	62.89	62.24	33.85	39.76	40.78	32.33	38.77	40.31
4	61.31	66.15	62.38	35.07	39.02	38.98	33.49	37.50	36.68
5	65.07	65.96	62.85	40.84	39.93	39.96	39.60	37.62	38.89
Trial\Weight	Variance (dB)			Standard Deviation(dB)					
	2.5KG	5KG	10KG	2.5KG	5.0KG	10KG			
1	72.22	35.57	42.32	8.50	5.96	6.51			
2	41.40	53.19	61.15	6.43	7.29	7.82			
3	56.70	37.16	40.60	7.53	6.10	6.37			
4	58.64	51.53	45.46	7.68	7.18	6.74			
5	39.25	37.62	39.60	6.27	6.13	6.29			



Appendix I: Project Gantt Chart

[illegible]