ELECTRICAL SIGNAL ACTIVITY ON UPPER LIMB MUSCLE DURING MECHANICAL LOAD CARRYING: A STUDY ON EMG-ANGLE RELATIONSHIP

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ABSTRACT

The relationships between EMG and elbow angle were investigated to identify the signal on upper-limb muscle. Ten participants were their arm fixed in an isometric position and 100% of maximum voluntary contraction (MVC). Electromyogram (EMG) is the one kind of biological signal that can be recorded to evaluate the performance of skeletal muscles by means of a sensor electrode. Usually, an estimate of the EMG amplitude is obtained from the raw waveform recorded from the surface of the skin. Root Mean Square (RMS) and Maximum Absolute Value (MAV) have been calculated by using equation and raw waveform. Each participant of exerted force was recorded by using dynamometer. The result revealed that while the force decrease when elbow joint angle increase. This show that electrical signal on upper limb muscle getting stronger when angle of elbow joint increase and make force decrease

ABSTRAK

Hubungan antara EMG dan sudut siku telah disiasat untuk mengenal pasti isyarat pada atas anggota-otot. Sepuluh peserta lengan mereka tetap dalam kedudukan yang isometrik dan 100% daripada penguncupan sukarela maksimum (MVC). Electromyogram (EMG) adalah jenis salah satu biologi isyarat yang boleh dirakam untuk menilai prestasi otot rangka melalui elektrod sensor. Biasanya, suatu anggaran amplitud EMG yang diperolehi daripada bentuk gelombang mentah direkodkan daripada permukaan kulit. Root Mean Square (RMS) dan Mutlak maksimum nilai (MAV) telah dikira dengan menggunakan persamaan dan bentuk gelombang mentah. Setiap peserta kekerasan dikenakan dicatatkan dengan menggunakan dinamometer. Hasilnya menunjukkan bahawa manakala penurunan daya apabila peningkatan sudut sendi siku. ini menunjukkan isyarat elektrik pada anggota badan atas otot semakin kuat apabila sudut peningkatan sendi siku dan membuat daya penurunan

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R^2	Regression
R	Co-Regression

LIST OF ABBREVIATIONS

EMG	Electromyography
SEMG	Surface Electromyography
GUI	Graphical User Interface for EMG Angle Analysis
RMS	Root mean square
MAV	Maximum Absolute Value
STD	Standard Deviation
CoV	Coefficient of Variance
mV	Millivolt
MVC	Maximum Voluntary Contraction

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

The upper-limb movements are essential for the human basic activities, such as lifting object, typing word, writing and etc. Some of peoples have loss of physically ability like disables to carry out daily activities and leads to poor quality life, and injured person to perform basic upper-limb activities. To overcome this problem, the existing of robotic system have been develop to assist daily life motions and rehabilitation of physically fragile people. That why it needed Electromyography to study muscle movement through the inquiry of the electrical signal the muscles give off and it is also used to detect the muscle movement to find out the force, torque and angle from robot arm movement.

Besides, Surface Electromyography (SEMG) is the signal detected by an electrode on the surface of the skin. EMG amplitude is defined as the time varying standard deviation of the surface EMG. Surface EMG (SEMG) provides a measure of the muscular effort and also serves as an input to EMG to force models, myoelectric prosthesis, gait analysis, motion control studies, and other applications. During isometric contractions and muscle length in upper-limb the elbow angle must be considered as one of the factors on the maximum muscle force. For example, the data will generate the single curve, suggesting that joint angle or muscle length. It does not have a significant effect on the angle-EMG relationship of the upper-limb muscle during load carried. Simulations it useful insight about the kind of data that needed to be collected and the length of data to be controlled in experimental studies. Moreover, for the angle measurement during this research, goniometer is used to calibrate and carried out several of angles. EMG amplitudes area a noisy signal and therefore, the impedance estimate could be noisy and it would be useful to know the accuracy of estimation in the presence of noise.

The study of this research was examined the effect of elbow joint position on angle and EMG amplitude and frequency, as well as the EMG angle relationship of the upper limb muscle during load carried.

1.1.1 ELECTROMYOGRAPHY (EMG) SIGNAL

In sarcolemma, there have a lipid bi-layer which contain certain ions move through the channels between the extra-cellular fluid and intra-cellular fluid. Besides, the sarcolemma also known as thin semi-permeable membrane that allowed some ions passed through the membrane wall. In intra-cellular fluid consist a high concentration of an organic (A-) anion and potassium (K+) ions. The potassium (K+) ions are small in size and make it can easily pass through the channels in the sarcolemma membrane as opposed to the organic (A-) anions that cannot pass through the membrane. Moreover, the extra-cellular fluid contain Chloride (Cl-) and Sodium (Na+) ions. Same case happen in intra-cellular fluid, Chloride (Cl-) has smaller in size compare to Sodium (Na+) ions so Cl- ions can pass through the membrane wall. In the between of the ions, there have some potential different occurs because of the concentration between outside and inside cell. That mean high concentration will flow to low concentration. In addition, the movement of Cl- and K+ ions creates a negative charge inside the membrane and a positive charge outside the membrane. Therefore, some chemical reaction occurs in membrane and the basic of surface electromyography (EMG) has related between the action potential of muscle fibers and the extra-cellular recording of those action potentials at the skin surface. For the stronger contraction require large number of motor units to be activated or recruited to contract, this activation motor unit is called motor unit recruitment.

1.2 PROBLEM STATEMENT

The electrical signal on upper limb muscle can be influenced by various external issues. For example, muscle contraction, relaxation, elbow join angle, muscle force, and some other issues. By measuring and analyzing the surface electromyography (SEMG) signal, it is possible to find the muscle function of upper limb muscle during various movement condition. It is therefore important to understand how well the SEMG signals of upper limb muscles are working.

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1.3 OBJECTIVES

- To determine the strongest electrical signal on upper limb muscle (Triceps, Biceps and forearm) by using EMG-Angle relationship.
- To understand the application on EMG related to angle relationship on upper limb muscle.
- To collect the data of exert force on protocol by using load carried.

1.4 SCOPES

1.4.1 Sports Science

EMG is used to study and analysis the movement of muscle and the electrical signal for improvement the strength and performance of athletes. The measurement of signal reliability and muscle activation haven been recorded by using Surface Electromyography (SEMG) to analysis the strongest electrical signal when the athletes are spotting in running, jumping, throwing and etc.

1.4.2 Medical Research

EMG is one of the device that detect the electrical signal and it is also help for medical diagnosis because some disease or condition of person's like they having the signs and symptoms of Neuromuscular disease. So, this case of disease needed EMG to detect functioning of the muscle which is directly link to nervous system in human. Moreover, it's also used for detect functional neurology like person's having disorders include cerebrovascular accident (stroke), Parkinson's disease, multiple sclerosis, Huntington's disease (Huntington's Chorea) and Creutzfeldt-Jakob disease. In this case, the electromyography (EMG) is very useful for the signal of muscle movement to overcome or analysis the disease to find out the ways to overcome it.

1.4.3 Rehabilitation

Robot system like prosthesis hand control or robotics arm/leg to organize the active training and physical therapy for those peoples are lose their arm or leg during car accident or working accident. Besides, electromyography (EMG) is very useful those are disability doing the daily activity in their life. Then, the prosthesis device will replace their lost his/him hand or arm. So, the muscle movement is controlled by electrical signal and prosthesis device needed this signal to activate it.

1.4.4 Ergonomics

Some research or survey have been done to reduce the risk for prosthesis device and occupational medicine, and early detection of disorder development by periodic monitoring. Moreover, after the survey or research haven been done to improve the comfortable for using the prosthesis device like robot arm or leg. For example, the maximum angle and specific angle can be done for daily activity like carry the load, play sport, and etc. Besides, the reducing side effect like after installed the prosthesis device into human because the electrical signal is given out by nervous system in human being. Maybe it’s will be damaged the nervous system or causes the situation more badly than before.

CHAPTER 2

LITERATURE REVIEW

2.0 INTRODUCTION

The main purpose of this chapter is studies and review existing literature to find out more information on basic concepts and many type of methodologies used Surface Electromyography (SEMG) to determine and analysis the signal on the upper-limb muscles like biceps, triceps, forearm and etc. Besides, there have found out 17 articles on google scholar based on keyword (EMG angle relationship, Electromyography angle relationship) and years from 2014 until 1995, but there have only 6 articles are related and shown in table 2.1 below. This table has make according to title, year, subject, angle, type of EMG, objective and methodology.

Table 2.1 Literature Review on EMG Angle Relationship with compare of subject, type EMG, Angle, Muscles and Methodology.

Key Word- EMG ANGLE RELATIONSHIP

SL.NO	TITLE	SUBJECT	TYPE OF EMG	ANGLE	MUSCLE	OBJECTIVES	METHODOLOGY
1	Effect of elbow joint angle on force–EMG relationships in human elbow flexor and extensor muscles **(2008)**	Twelve healthy volunteers (seven female and five male)	Surface Electromyography (SEMG)	45° and 120°	biceps, brachioradialis and triceps **isometric contractions**	To study the effect of elbow joint position on joint force and EMG amplitude and median frequency and force EMG relationships of the biceps, brachioradialis and tri triceps muscles acting as agonists during elbow flexion and extension	forearm was held in a neutral position with respect to supination and pronation, to avoid the effects of wrist geometry , and it was strapped securely to an adjustable link. Beneath the wrist, to measure force orthogonal to the direction of the forearm during elbow flexion and extension. **bandpass filter: 20–450 Hz sampling rate: 1250 Hz, and force data at 250 Hz.**
2	*Relationship Of Muscle Fiber Pennation Angle To Emg And Joint Moment During Graded Isometric Contractions Using Ultrasound Imaging **(2000-2006)**	group A 20 healthy subjects with no history of musculoskeletal injuries to either leg, and group B subjects with acute or chronic unilateral injuries to the lower limb	Surface Electromyography (SEMG)	90° degrees to the shank	tibialis anterior (TA), and the muscles of the triceps	To establish predictive relationships between pennation angle, moment, and EMG in healthy subjects as well as subjects with unilateral lower limb injuries	The subject is then seated in a Biodex dynamometer and performs a series of isometric dorsiflexion and plantarflexion contractions with the leg extended parallel to the floor and the ankle fixed in neutral (the foot at 90 degrees to the shank). The root mean square amplitudes of the EMG and moment signals for 2 seconds of each contraction are taken as the representative signal
3	A Study on Human Upper-Limb Muscles Activities during Daily Upper-Limb Motions **(2010)**	26 and 28 years old healthy male	Surface Electromyography (SEMG)	0°,20°, 40°,60°	biceps brachii, brachialis, and brachioradialis	To study relationship between the upperlimb motions and the activity levels of main related muscles concerning the daily upper-limb motions	The basic motions and the selected daily activities of upper-limb were performed three times by each subject. The daily activities were performed in either standing or sitting posture in accordance with the nature of the daily activity **the sampling frequency is 2kHz**
4	EMG of arm and forearm muscle activities with regard to handgrip force in relation to upper limb location **(2002)**	Right hand dominant men age 20 to 24 years	Surface Electromyography (SEMG)	30°,45°, 135°	Two muscles of the forearm(extensor carpi radialis longus and flexor carpi ulnaris) **isometric contraction**	To determine how the value of maximum force changes in relation to upper limb location.	Build up force gradually without jerking and to hold the exertion for 3 seconds. During exertion of force, the participants were in a sitting position with their back straight and left limb relaxed. **the sampling frequency is 2kHz and 12bit- analogue-digital converter**
5	*Estimation of Upper Limb Joint Angle Using Surface EMG Signal **(2013)**	two females and two males, with ages ranging from 25 - 80 years old	Surface Electromyography (SEMG)	N/A	deltoid, posterior deltoid, biceps brachii and triceps brachii muscles	To improve or recover from their lost physical functions due to spinal cord injury (SCI), traumatic brain injury (TBI) or cerebrovascular accident (CVA)	Four types of movement. In each session there were six repeats of continuous movement with almost the same speed and amplitude and there were five sessions for each type of movement **sampling frequency of 2048 Hz and use low-pass-filtered signals**

Key Word- ELECTROMYOGRAPHY ANGLE RELATIONSHIP

1	*Quantitative Relationship Modelling between Surface Electromyography and Elbow Joint Angle **(2010)**	N/A	Surface Electromyography (SEMG)	0°, 20°, 40°, 60°, 80°, 100°, 120°, 140°	triceps brachii, anconeus, biceps brachii and brachioradial **isometric contractions**	the Mean value and RMS value of the error between predicted joint angle and actual joint angle which are represented by ME and RMSE respectively	The onset position of the elbow motion is set at the thread line of trousers and the offset is set at the horizontal position. Bend the elbow first and then stretch. The subjects should relax the muscles by the way of shaking the arm quickly in the motion interval and keep the motion in the vertical plane and the palm up **(sampling frequency is set to 2048Hz filtered (50Hz) to eliminate the power frequency disturbance and then IIR band-pass (10 ~ 500Hz)**

2.1 METHOD OF SEARCH CRITERIA

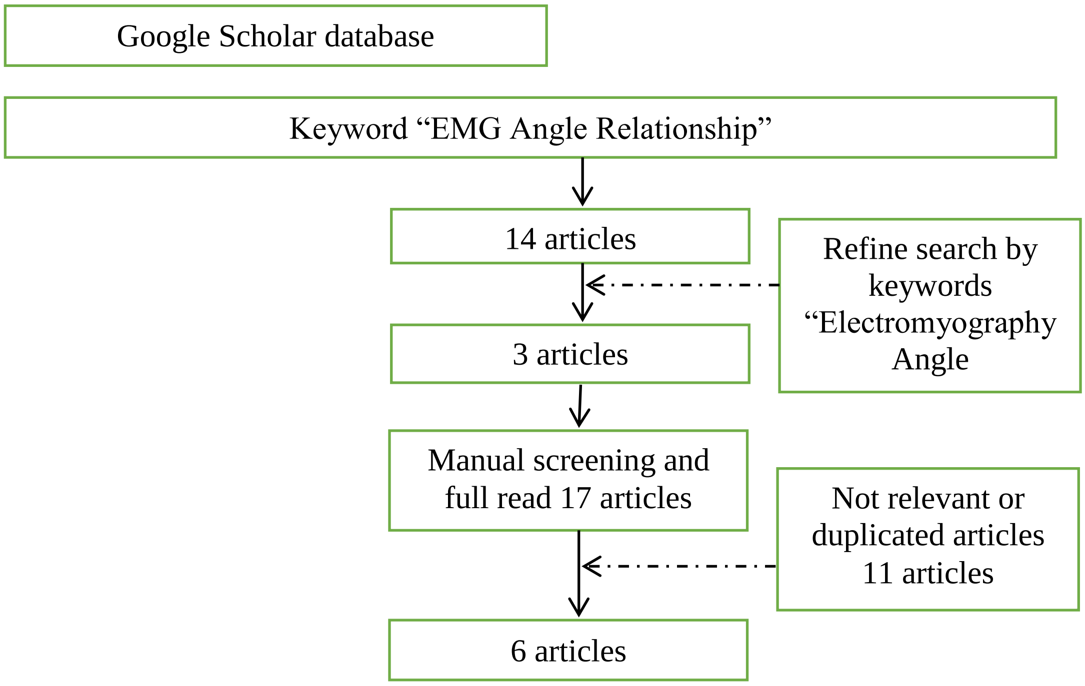

Figure 2.1 Flow Chart of Methodology used for the article search

A precise search of the exiting literature was directed using the keyword "EMG Angle Relationship" on studies published between year 1995 and 2014, in the Google Scholar database. Then, a refined search was changed by replacing the keyword of "Electromyography Angle Relationship".

2.2 LITERATURE SEARCH RESULTS

From Figure 2.1 shown that a total 14 articles have been found with keyword "EMG Angle Relationship". A refine search using the keyword "Electromyography Angle Relationship" was found 3 articles. Then, 6 out of 17 articles are matched and related with this research which is EMG angle relationship on upper-limb muscles. There have short summaries on this 6 articles and listed in below.

2.2.1 Effect of elbow joint angle on force-EMG relationships in human

The first article on google scholar in 2006. Based on the experiment of subject was used twelve healthy volunteers which included seven female and five male. During the experiment, the Surface Electromyography (SEMG) is used to find out electromyography (EMG) signal and amplitude and the reaction of elbow joint position on force. Moreover, the force electromyography (EMG) relationships of the triceps and biceps muscle same as against when elbow extension and flexion. Elbow joint angle of 45° and 120° are selected for this experiment and the isometric contractions muscle are used to measurement effect. Besides, the methodology for this experiment is the forearm was placed in initial direction with regard to pronation and supination. It's to impoverished securely to a flexible link and avert the effects of wrist geometry. In this experiment, bandpass filter is used and the value is between 20-450 Hz. The sampling rate is 1250 Hz and force date at 250Hz.

2.2.2 Relationship of Muscle Fibre Pennation Angle To EMG And Joint Moment During Graded Isometric Contractions Using Ultrasound Imaging

The second article on google scholar in 2000. In this experiment, the subject was used which divide into two group A and B. For group A consists 20 healthy people with no history of musculoskeletal injuries to either hands or legs and group B consists acute or chronic unilateral injuries to the lower limb. Surface Electromyography (SEMG) is used for this experiment and the muscle involved tibialis anterior (TA), and the muscles of the triceps. The joint angle is 90 degrees to the shank and the aim for this experiment is to determine predictive relationships between moment, pennation angle, and Electromyography (EMG) in healthy subjects as well as subjects with unilateral lower limb injures. The methodology for this experiment, the subject require to seated in a Biodex dynamometer and the subject need to performs a series of isometric dorsiflexion and plantarflexion contractions with the leg extend parallel to floor and the ankle fixed in neutral. Root mean square (RMS) amplitudes of the Electromyography (EMG) and moment signals have been taken every 2 seconds of each contractions are taken as the representative signal.

2.2.3 EMG To Torque Dynamic Relationship for Elbow Constant Angle Contractions

Third article on google scholar in 1999. Based on this experiment, the subject was used 16 people and Surface Electromyography (sEMG) is choose instead of needle electromyography. The elbow angle is unstated in this experiment and the muscles involved four on the biceps and four on the triceps. The purpose for this experiment is to find out the excellent Electromyography (EMG) torque relationship using four type of Electromyography (EMG) processor in association with several of system identification (ID) procedure for energetic torque changing elbow consistent angle contractions. The methodology for this experiment is to changing elbow torque determined by an optical signal on a PC monitor, a maximum of 50 percent of MVC every 30 seconds.

2.2.4 Quantitative Relationship Modelling between Surface Electromyography and Elbow Joint Angle

The fourth article google scholar in 2007. In this experiment, the subject is unstated and Surface Electromyography (SEMG) is used to find to out the RMS and mean value of the failure between actual joint angle and predicted joint angle which expressed by RMSE and ME accordingly. The methodology of this experiment is the position elbow direction set at the thread line of offset and trousers were set at the horizontal position. First step, by bending the elbow and then stretch. They must be calm the muscles by shaking the arm fastest in the motion interval and the subject also need to control the motion in the palm up and the vertical plane. Moreover, the sampling frequency rate was set to 2 KHz and filtered is 50Hz to filter up the frequency disturbance and the bandpass rate is 10-500Hz.

2.2.5 A Study on Human Upper-Limb Muscles Activities during Daily Upper-Limb Motions

The fifth article on google scholar. Based the experiment, the subject was used 26 age and 28 age healthy male by using Surface Electromyography (SEMG). The upper-limb motions angle is 0, 20, 40, 60 and muscles used include biceps bacchii, brachioradialis, and etc. The aim of this experiment is to find out the relationships between the activity on muscle concerning the daily upper-limb motions and normal upper limb motion. The methodology for this experiment is used fundamental moves and the chosen regular activities of upper-limb were behaved by sitting or standing posture in conformity with the essence of the regular activity. The sampling frequency rate is 2 kHz.

2.2.6 EMG of arm and forearm muscle activities with regard to handgrip force in relation force in relation to upper limb location

In this experiment, the subject was used right hand dominant men age 20 to 24 years by using Surface Electromyography (sEMG). The joint angle is 30, 45, 135 and muscles were used includes two muscle of the forearm which flexor carpi ulnaris and extensor radialis longus and the isometric contraction muscle method is used. The aim for this experiment is to find out greater force value varying in relation to upper limb location. The methodology for this experiment is the subject required to increase force consistently without jerking and the subject require hold the exertion for 3 seconds. During exertion of force, the participants must in sitting position with their left limb relaxed and back straight. The sampling frequency rate is 2 kHz and 12 bit- analogue-digital converter is used to filter up the signals.

2.2.7 SUMMARIZE OF MUSCLES USED IN THE ARTICLES

Most of the research (Wu et.al. (2010, October); Akira, et.al. (2010); Bouchard et.al. (1999); Roberts& Buchanan) used biceps and triceps to carry out the experiment [1][3][5][4][2]. Other research, (Roman et.al. (2002)) focus on forearm muscle to carry out the experiment [6].

2.2.8 THE METHODOLOGIES USE IN THE ARTICLES

The first method of the research on (Gopura et.al. (2010)) was focus on regular activity was perform in either sitting or standing [5]. But, (Roman et.al. (2002)) was focus on sitting position by fixing the left limb relaxed and back straight [6]. (Akira, M. MOTC_P1. 8) was made forearm in neutral position with measure force of elbow flexion and extension [3]. Based on (Bouchard et.al. (1999)), changing elbow torque determined by a visual signal on PC [4]. (Wu et.al. (2010, October)) used by bending the elbow and then stretch and shaking the arm fastest in motion interval [1].

2.2.9 SUMMARIZE OF SAMPLING FREQUENCY USE IN THE ARTICLES

Most of the research was (Gopura et.al. (2002); Wu et.al. (2010, October)) used 2 kHz for the sampling frequency [5][6][1]. One article (Roberts et.al. (1999)) didn't mention about the sampling frequency [4][3]. One research (Akira, M. MOTC_P1. 8) used 1250 Hz as sampling frequency [2].

2.3 RESEARCH GAP FINDING

From all 6 relevant articles, the gap of EMG angle relationship on upper-limb muscle contraction has been found out and focus on non-existing research or experiment has been done before. For improve the prosthesis device in several of angle on elbow join and to find out poor signal when user carried load in different of angles. There have some ways haven't been done as discuss as below.

2.3.1 Angle on Elbow Joint

Based on the articles, the maximum angle is 140 °and minimum angle is 0 °. So, this experiment was suggested to take 30 °, 60 °, and 90 °, 120 ° to carry out the experiment. Then, it will be different from previous paper has been done before and it can take new data in new angle for prosthesis device improvement.

2.3.2 Upper-Limb Muscle

Many of previous papers have been done on biceps, triceps and forearm. Then, this experiment will select biceps muscle to carry out experiment. Although, previous papers were took the same muscle to carry out the experiment but this experiment has measure the different of elbow joint angle so the data or result will totally different from previous papers. Besides, biceps muscle on upper-limb was known as common muscle and easier to measure the signal frequency. In addition, most of the previous papers have been done on isometric contraction. This is because of contraction was most suitable to measure muscle signal on various angle. So, this research or experiment has been chosen the isometric contraction too.

2.3.3 Type of Load Carried

Based on the article, one previous paper has mentioned on handgrip to carry out experiment and other articles don't mention about any load carried or object during the experiment. So, this experiment will take dynamometer as load carried.

2.3.4 Subject on Experiment

On the article, the age of subject on previous papers were around 20 above and 26-30 age with healthy or unhealthy condition. So, this experiment will take the around 10 people and below 25 age to carry out experiment.

2.4 CONCLUSION

According to the literature or articles were found on google scholar from 2014 to 1995 year. There have some common characteristic or common type which used the same Surface Electromyography (sEMG) method. Besides, the elbow join angle was varied depend on the experiment criterion and requirement. But, none of the literature has mention about the load carried on the experiment. So, this research was used the subject to carry the dynamometer as load for measure the force value and also electrical signal on upper-limb muscle by changing the elbow joint angle. The purpose for record the electrical signal is to analyze the data by using feature of extraction method to find out the root mean square (RMS), and Maximum Absolute Value (MAV). The previous papers were took 20 people and above to carry out the experiment with different age, gender, health condition and etc. So, this research will take around 10 people and below 25 age to take the data on Electromyography (EMG) signal. The sampling frequency rate for previous papers were found different which included 2 kHz. Moreover, most of previous papers were used the band-pass filter to filter up the electrical signal. Therefore, this experiment will carry out based on above criterions to get the data and this also to avoid the same or existing research has been done before.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter is mainly discussed about the measurement and analyzing process of the Electromyography (EMG) signal on upper-limb muscle with elbow joint angle relationship and the procedures for the experiment or recording process. A previous developed experimental was used Surface Electromyography (sEMG) and same goes to this experiment. Some improvements are going to be done on this measure and analyze of EMG signal by changing the elbow joint angle so that more accurate date could be obtained for better prosthesis device.