EFFECT ON EMG SIGNAL FROM UPPER LIMB MUSCLE DURING CONSCIOUS AND SUBCONSCIOUS PERCEPTION

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EFFECT ON EMG SIGNAL FROM UPPER LIMB MUSCLE DURING CONSCIOUS AND SUBCONSCIOUS PERCEPTION

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Thesis submitted in partial fulfillment of the requirements for the award of the degree of
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ABSTRACT

The effect on EMG signal for upper limb muscle was investigated by two condition that is conscious and sub-conscious perception. There were six participants among University Malaysia Pahang's students chosen as subjects. The subjects were asked to fix their arm in 90° isometric position and their data were recorded by two conditions and three times for each condition. The experiment was conduct by using shimmer EMG connect to the electrodes placed on subject's muscle. The muscle chosen was forearms and biceps brachii. From the data recording, raw data was obtain and from the raw data, the Root Mean Square (RMS) and Mean Absolute Value (MAV) were calculated by using equation. The force exerted by each subject was recorded by using hand dynamometer. From RMS and MAV value, graph of mean, standard deviation and coefficient of variance were plotted after doing the calculation based on equation. As this project was comparing between conscious and sub-conscious, the results show that the highest EMG signal and muscle activation was during conscious condition. This show that during conscious condition, the electrical signal on upper limb muscle getting stronger.

ABSTRAK

Kesan ke atas isyarat EMG untuk otot anggota badan atas telah dikaji oleh dua keadaan iaitu keadaan sedar dan separa sedar. Terdapat enam peserta di kalangan pelajar Universiti Malaysia Pahang telah dipilih sebagai subjek. Subjek telah diminta untuk menetapkan lengan mereka pada kedudukan 90° iaitu kedudukan isometrik dan data mereka direkodkan oleh dua keadaan dan tiga kali pengulangan untuk setiap keadaan. Eksperimen ini dilakukan dengan menggunakan shimmer EMG disambung ke elektrod yang diletakkan pada otot subjek. Otot yang dipilih adalah otot lengan dan otot bisep brachii. Daripada data yang direkod, data mentah telah diperoleh dan daripada data mentah, punca purata persegi (RMS) dan nilai mutlak purata (MAV) dikira dengan menggunakan persamaan. Daya yang dikenakan oleh setiap subjek direkodkan dengan menggunakan dinamometer tangan. Dari RMS dan nilai MAV, graf purata, sisihan piawai dan pekali varians telah diplotkan selepas melakukan pengiraan berdasarkan persamaan. Oleh kerana projek ini telah membandingkan antara sedar dan separa sedar, keputusan menunjukkan bahawa isyarat EMG dan otot pengaktifan tertinggi adalah semasa dalam keadaan sedar. Ini menunjukkan bahawa semasa keadaan sedar, isyarat elektrik pada otot anggota badan atas semakin kuat.

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LIST OF SYMBOLS

$\tilde{x}$	Mean
N	Number of data points
σ	Standard deviation
μ	Mean

LIST OF ABBREVIATIONS

EMG	Electromyography
SEMG	Surface Electromyography
RMS	Root Mean Square
MAV	Mean Absolute Value
STD	Standard Deviation
COV	Coefficient of Variance

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Electromyography (EMG) signal is a signal recording process that translates the electrical signal into graphs, sounds and also numerical values using EMG sensor. It will measures the electrical signals that generated in the muscle of human body during any of muscle contraction. It is also a signal that we used for clinical and biomedical applications. EMG signal is a signal used to check health of the muscle and also check nerves that control the muscles. This signal acquired advanced methods for detection, decomposition, processing and classification. The signal is being analyzed from upper limb muscle. This signal can be used in various condition such as electrode placement, muscle contraction, angle measurement, different age, different gender and different position.

EMG is often used for a person who is in a condition of weakness, pain or any abnormal sensation. This device can directly tell the muscle's condition, muscle's problem and even muscle's diseases. EMG will also act as a translator which will

translates the electrical signal into graphs, sounds and also numerical values that can be interpret by a specialist.

EMG is a device that use tiny devices called electrodes used to transmit or detects any electrical signals. EMG has three types of electrodes that are surface electrodes, intramuscular electrodes and needle electrodes. Surface electrodes is an electrode being taped to the skin that use to measure the speed and strength of the electrical signals occur. The electrode will detect the signal on the surface of the skin. Intramuscular electrodes is a condition where the signals are being detect with wires insert into the muscles. Needle electrodes is when the electrode was inserted directly into a muscle thus record the muscle activity in that muscle.

This research will determine the effects on the EMG signal from upper limb muscle during two conditions that is when a person in a conscious condition and sub-conscious.

1.2 PROJECT BACKGROUND

Upper limb muscle movement are always used in our daily life for various activities. Almost all people in this world having their daily life and done most of their routine with the movement of the body muscle such as upper limb muscle forearms and biceps including the disable person. For this analysis, EMG signal are used for the condition of conscious and sub-conscious in order to observe the results and the effects of the EMG signal.

For this two different conditions, the effects on EMG signal will be analyzed where it will be placed on the upper limb muscle while a person in a state of conscious and sub-conscious. Conscious is a condition where a person's focus are fully give. Sub-conscious is a condition where a person starting to loss his focus where half of his focus are already gone. From the EMG results we can study the muscle movement through the electrical signal and also can find out the force, torque and angle from the muscle movement.

1.3 UPPER LIMB MUSCLE

Movement of human body are linked with muscular system. It was about 700 named muscles that were attached to human's bones of skeletal system. Some of the muscles are upper limb muscles such as muscle in anterior compartment of the forearm, muscle in Posterior compartment of the forearm, muscle of the arm, muscle of the hand and muscle of the shoulder region. In this project, the muscle that have been choose are forearms and biceps brachii for upper limb muscle.

1.4 CONTRACTIONS

Muscle of human body can generate force through contractions. There are many types of muscle contractions in order for muscle to generate force that are isometric where the muscle is static but have pressure, eccentric where muscles are often active while the muscles are lightening, concentric such as a person holding dumbbell

and isokinetic where the muscles are continuously move. In this experiment, isometric contractions will be used where angle of arm movement of subjects at 90°.

1.5 FEATURES

EMG signal were evaluated using the features of time domain and frequency domain. These various features can be used to calculated results from the data during muscle activity. As the data of EMG signals obtain, it was then analyzed in the time domain where the signals were calculated using root mean square (RMS) and mean absolute value (MAV). As the data were collected three times in order to get the average, after the first calculation, need to calculate for statistical signal that is mean, standard deviation (SD) and coefficient of variance (CoV).

1.6 CONDITIONS

1.6.1 Consciousness

Consciousness is a condition where a person's were awake and his focus were there. EMG is used during this condition to observe and analyze the effects such as EMG signal when a person are still in consciousness condition. For this experiment, data of the subjects will be collect while a subjects seats on a chair in a relax position and his arm in a static angle.

1.6.2 Sub-consciousness

Sub-consciousness is a condition where a person are awake but only give half of his focus as he starting to lose his focus. The data of the subjects will be collect as he doing something else besides focus on the data collecting such as data is recording while he is using the phone or while he is watching movie.

1.7 PROBLEM STATEMENT

EMG signal are placed on upper limb muscle in order to see the effects of the EMG towards the upper limb. The signal can be obtained from various condition that is during people's conscious and sub-conscious. By using EMG signal such as surface electrodes, intramuscular electrodes and needle electrodes the results of the signal can be easily obtain which in the same time need to study and know well about all three electrodes. Some features such as RMS and MAV are also used to evaluate the EMG signal during both conditions.

1.8 OBJECTIVES

- To determine the effects on EMG signal from upper limb muscle during conscious and sub-conscious
- To evaluate the EMG signal during conscious and sub-conscious using some features

1.9 PROJECT SCOPES

1.9.1 Psychological Treatment

Brain play an important role when someone is stressed. In psychological treatment, EMG are used by the psychologist to the patients. Electrodes are placed at their muscles to detect and analyze the signal on how stressed a person may be. By having a signal of the patient, it easier for psychologist to cure his patient as he knows level of stressed of that person.

1.9.2 Medical Science

EMG was used to detect the electrical signal and muscle functioning. It can be used in medical where this device will link directly to human brain and nerve system. By using EMG it is easy for doctor or researcher to detect any disease occur such as Neuromuscular disease and in the same time try to find out the solution and ways to overcome the disease.

1.9.3 Sports Activities

Every athletes of all sports are doing their sports activities using their whole body thus make the movement of muscle occur. Electrodes will be put at the leg muscle of the athletes to see the effects of EMG signal in order to analyze the movement of the muscles while moving (sub-conscious) and relax (conscious). This will help to improve the performance of an athletes in which ways to make the muscle stronger can be obtain by using EMG from the analysis of the electrical signal.

1.10 CONCLUSIONS

In short, this experiment was carried out to determine the effects on EMG signal from upper limb muscle during conscious and sub-conscious and to learn and understand well the use of EMG. The purpose of this experiment is also to detect the movement of the muscle when connect to EMG, to carry out the analysis by testing on the subject (people) using EMG and to collect the data analysis from the EMG signal. This experiment will test the effects on EMG signal from the movement of the muscle when the subject in a conscious and sub-conscious condition. In the same time, some features will be used to evaluate EMG signal.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The main objective of this chapter is to study, investigate and review all the related journal has been found. From these journal, more information related to the topic can be review such as the EMG concepts, type of method used, subject choose to undergo the experiment and also what type of devices are being used. From this literature review, the parts of upper limb muscles that has been used can also be review. From that, easy to make decision and get an idea on which muscle to be used such as biceps and triceps. In the research, only 5 articles/journals that related to the topics manage to be found by searching through Google Scholar and by using the keywords (EMG during conscious and subconscious) from 1992 until 2012. Table 2.1 below shows the details of the articles have been found.

2.2 METHOD OF SEARCH CRITERIA

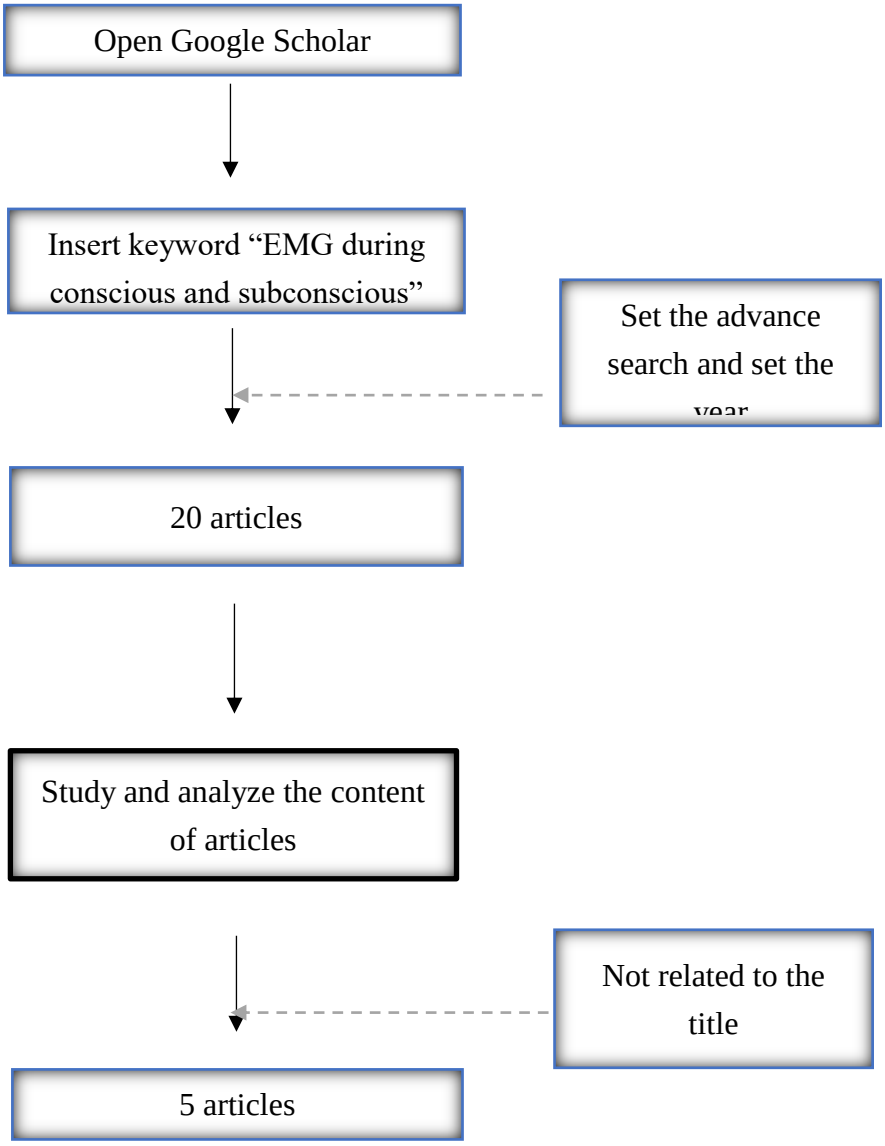

Figure 2.1: Flowchart of Methodology used for the article search

2.3 LITERATURE REVIEW RESULTS

2.3.1 Unconscious Facial Reactions to Emotional Facial Expressions

The first article is from year 2000. In this experiment, they used 60 male and 60 female as their subject. The main objective of this experiment is to identify the facial EMG response during unconsciously exposed. The subjects are test by individually in a lab room where there are pictures being projected at the screen 2m in front of them. The subjects are tested without they noticed that there are pictures projected in front of them. The facial EMG activity are measured by using bipolarly attached miniature electrodes over muscle region on left side of face. As they used facial EMG, the muscles being used are zygomatic major and corrugator supercilii. They are also use time constant of 20ms and sampling frequency of 200Hz.

2.3.2 Further evidence for unconscious learning : preliminary support for the conditioning of facial EMG to subliminal stimuli

The second articles is found from year 1998. It is an experiment which conduct to investigate the predictive validity of facial EMG in a subliminal conditioning paradigm. They used 8 males with right hand as their subject. In this experiment, the use facial EMG and the selected muscles are orbicularis oculi and corrugator supercilii. The electrodes are first attached prior to seating the subjects in a sound-proof, electrically shielded and temperature controlled chamber. This

experiment used visual stimuli, visual threshold, apparatus and masking technique which is 1.9° visual angle in diameter.

2.3.3 EEG and EMG Responses to Emotion-Evoking Stimuli Processed Without Conscious Awareness

The third article is from year 1992 which used 19 males and 21 females in between 18 to 26 years old as their subject. This experiment is to identify the responses of the EEG and EMG to Emotion-Evoking Stimuli without conscious awareness. This experiment also used facial EMG and choose corrugator supercilii and zygomatic major as the muscle to be test. The activity of right and left corrugator and zygomatic muscles were recorded by using Beckman miniature bipotential electrodes. The inter-electrodes impedance was reduced to 7000 ohms and using 90250 Hz band-pass filter. This experiment also processed using contour-following integrators with 0.025s time-constant.

2.3.4 Prediction of human voluntary movement before it occurs

In this fourth article which is from year 2011 6 males and 1 female are used as the subject. In this experiment, they used surface EMG and the selected muscles are biceps and triceps with right handed. This experiment is to determine the prediction of human natural movement before it occurs from the signals. It is also to determine when a reliable prediction can be made. The subjects are test by let them seated on a chair

with the forearm supported by a pillow. The subject performed a self-paced voluntary movement task of wrist extension. The subjects are not allowed to count time and they were asked to make the movement as they wanted to. There is a computer monitor that delivered visual information placed 1.5m in front of the subjects. The activities monitored continuously for 50ms and the detection threshold was 25μV. They used high-passed at 5Hz and the distance between electrodes was 2.5cm. The two electrodes were placed nearly 3cm below the elbow of right arm and also they used sampling frequency of 256Hz.

2.3.5 Human standing is modified by an unconscious integration of congruent sensory and motor signals

The fifth article is from year 2012. In this experiment, they used 10 males and 2 females with no history of neurological disorder. The main objective of this experiment is to investigate the relation of the muscle response during standing with congruent sensory and motor signals. This experiment use congruent sensor and motor signals and choose biphasic muscle (ankle) as the selected muscle. A motion platform was programmed with the mechanics of an inverted pendulum in order to simulate the load of the body during standing. The real-time system in this experiment were operating at 60 Hz.

Table 2.3: Literature review on EMG signals during conscious and sub-conscious perception

No	Title	Subject	Types of EMG	Muscles	Objective	Methodology
1.	Unconscious Facial Reactions to Emotional Facial Expressions. (2000)	60 M 60 F (120 students)	Facial EMG	Zygomatic major Corrugator supercilii	To identify the facial EMG response during unconsciously exposed	Subjects tested in a lab room while pictures projected onto a screen 2m in front them. Different facial stimuli are used. Facial EMG activity measured by bipolarly attached miniature electrodes over muscle region on left side of face. Using time constant of 20ms Integrated signals digitized by 12-bit ADC. Sampling frequency of 200Hz.
2	Further evidence for unconscious learning : preliminary support for the conditioning of facial EMG to subliminal stimuli (1998)	8 M (right hand males)	Facial EMG	Orbicularis oculi Corrugator supercilii	To investigated the predictive validity of facial EMG in a subliminal conditioning paradigm	Subjects seats in a sound-proof, electrically shielded, temperature controlled chamber. Use visual stimuli, visual threshold, apparatus and masking technique. -1.9° visual angle in diameter - supraliminal preconditioning and postconditioning phases consist of 48 random (24CS+ and 24CS-) at 40ms -subliminal conditioning phase consist of 72 random (36CS+ and 36CS-) at 2ms.

3.	EEG and EMG Responses to Emotion-Evoking Stimuli Processed Without Conscious Awareness (1992)	19M 21F (between 18-26 years old)	Facial EMG	corrugator supercilii zygomatic major	To identify the responses of the EEG and EMG to Emotion-Evoking Stimuli without conscious awareness	Activity of muscles were recorded with Beckman miniature bipotential electrodes. Inter-electrode impedance was reduced to 7000 ohms. Using 90 250 Hz band-pass filter. Processed using contour-following integrators with 0.025s time-constant.
4.	Prediction of human voluntary movement before it occurs. (2011)	6M 1F	SEMG	Biceps Triceps (right handed)	To determine the prediction of human natural movement before it occurs from the signals. To determine when a reliable prediction can be made.	Subjects seated in a chair with the forearm supported by a pillow. Subjects not allowed to count time Subject make movement whenever they wanted to. A computer monitor was placed about 1.5 m in front of the subjects. Detection threshold was 25μV. EMG signals high-passed at 5Hz. Distance between electrodes 2.5cm and 3 cm below the elbow of the right arm. Signals filtered (DC-100 Hz) Signals digitized (sampling frequency, 256 Hz)

5.	Human standing is modified by an unconscious integration of congruent sensory and motor signals. (2012)	10 M + 2F (no history of neurological disorder)	Congruent sensor and motor signals	Biphasic muscle (ankle)	To investigate the relation of the muscle response during standing with congruent sensory and motor signals	A motion platform was programmed with the mechanics of an inverted pendulum to simulate the load of the body during standing. Real-time system operating at 60 Hz

2.4 SUMMARIZE OF MUSCLES USED IN THE ARTICLES

The muscle used in the previous research of (Ulf Dimberg, Monika Thunberg, & Kurt Elmehed 2000) were orbicularis uculi and corrugator supercilii. Most of previous studies (Ulf Dimberg, Monika Thunberg, & Kurt Elmehed, 2000; Brue E. Waxler, Stephen Warrenburg, Gary E. Schwartz & Larry D. Janer, 1992) used zygomatic major and corrugator supercilii muscle to undergo the experiment on the upper limb muscle. Besides that, there were also researcher used biceps brachii and triceps muscle in their research study.

2.5 RESEARCH GAP FINDING

After finding all 5 related articles, there are some gap finding.

Table 2.5: Research gap finding

	Articles	Current experiment
Type of EMG	mostly done using facial EMG	surface EMG will be used to replace facial EMG
Parts of muscle	focus on the face muscle such as corrugator supercilii and zygomatic major	the selected muscles will be focus more on upper limb muscle that is biceps and triceps
Contractions	Concentric and isometric contractions	the contractions will be more specific according to isometric contractions that is from 0° to 90°
Features	Use feature such as RMS, MAV and ANOVA but not specifically	features such as RMS and MAV will be also used

2.6 CONCLUSION

From the review of all 5 articles which were found from year 1992 until 2012, most of the experiment in the journals are using facial EMG. There is also article that use surface EMG in the experiment method. As it used the same methods as this experiment, some of its criterion and requirement can be learn and used the same but have to make some improvements. Also, in most of the experiments use muscle at face as their selected muscles where there is no load carried or hold by the subject. So to make some improvements and difference, this experiment will choose upper limb muscle which is forearms and biceps also use hand dynamometer for a subject to hold as a load in order to measure the force value and electrical signal on upper limb muscle during conscious and sub-conscious condition.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

In this chapter, the method use in this experiment is discussed on what type of Electromyography (EMG) will be used, the flow and process of the analysis, the target subjects for this experiment and the type of devices that will be used. Most of the review article, they are using Facial EMG for their experiment but in this experiment, surface EMG will be used by placing the electrode on the upper limb muscle of the subjects. The part of upper limb muscle that the electrode will be placed is forearms and biceps. The subjects will be seating on a chair same goes to most of the previous review article where they let their subjects seat on a chair. Difference from some experiment where they let their subjects facing the screen without noticing, this time the subjects will be relax on a chair in this experiment but it happens while they are distracted with something such as people talking to them or also while they are using phone.

3.2 PROCESS FLOW CHART

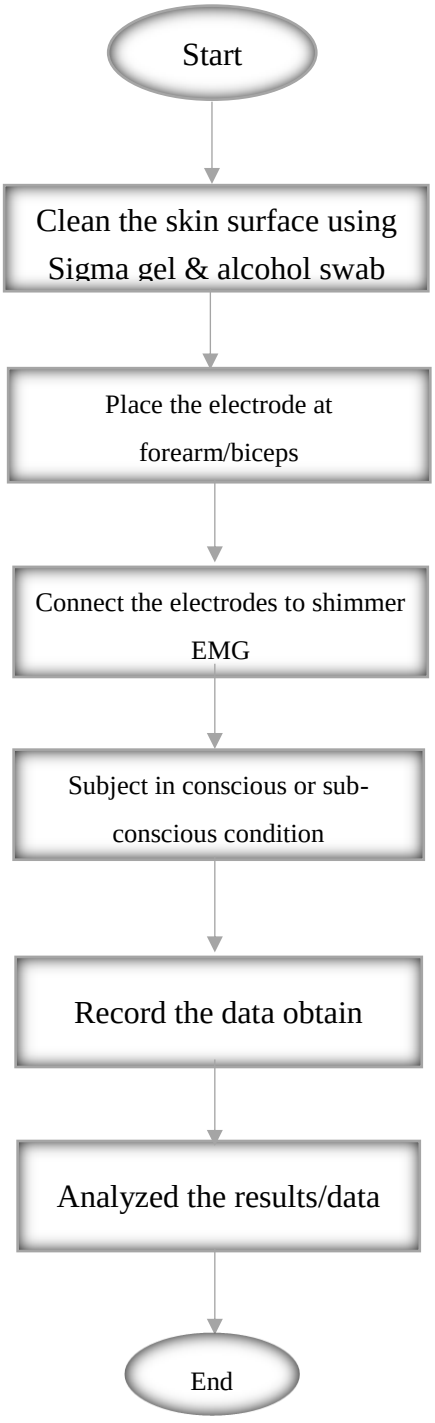

Figure 3.2 Process Flowchart

3.3 SUBJECTS

In this experiment, 6 subjects will be participants to run EMG test. EMG signal test will be test on every subjects where an electrode will be placed on their upper limb muscle of the right hand. A computer that shows the EMG signal will placed right beside them. The target subjects are among University of Malaysia Pahang (UMP) students of 3 male and 3 female students where they will be divided into two groups. The first group consist of 3 males while another group consist of 3 females.

3.4 DEVICES AND TOOLS

3.4.1 Surface electrodes

The first and main tools will be used in this experiment is surface electrodes. It will be used together with the Shimmer EMG device. Surface electrode has many shapes including straight, branched, ring type, discs, bars, diamond and rectangular. Discs shape will be use in this experiment as two electrodes will be placed on upper limb muscles with distance of 2.5cm.

Figure 3.4.1: Surface electrodes

3.4.2 Sigma gel

Sigma gel is peripheral equipment where it is used along with the surface electrodes. The surface electrodes are made by gel surface. The gel will be put first before placed the electrodes and its need to be remember that it cannot be reused after it has been removed as it will affect the results of the experiment.

Figure 3.4.2: Sigma gel

3.4.3 Alcohol Swab

It is a pad that has alcohol in it. The alcohol was saturated with the pad where it is cold and use to clean the surface skin of the subject before the electrodes being placed. This can lead to a better and accurate results.

Figure 3.4.3: Alcohol Swab

3.4.4 Hand Dynamometer

Dynamometer is a tool which acting as a load. This tool will be hold by the subjects while the experiment is run. As they hold the hand dynamometer and press it, the force value will be recorded by the dynamometer in kg unit.

Figure 3.4.4: Hand Dynamometer

3.4.5 Goniometer

Goniometer is used for angle. It is used to measure the elbow joint angle. As in this experiment, the subjects need to stand the forearm in 90° position. So this goniometer will be used to measure that angle on order to make sure the angle is exact and no error occur which any error can affect the results of electrical signal.

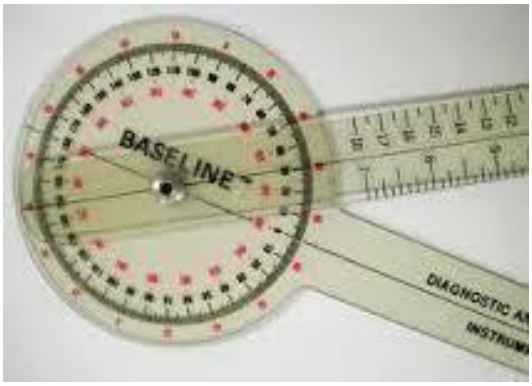

Figure 3.4.5: Goniometer

3.4.6 Shimmer EMG

The Shimmer EMG use to measure and records the electrical activity with muscle contractions, nerve conduction, muscle response in any injured tissue and activation level. This device is also use to analyze and measure the biomechanics of human or also animal movement. It is a device with wireless solution for an access to host of muscle and also posture data analysis. The specifications of this device is has two channels of EMG data and the EMG data can be measured with Shimmer.

Figure 3.4.6: Shimmer EMG

3.5 EXPERIMENTAL SET UP AND PROCEDURES

The procedures of this experiment is first the subject will be test one by one. A subject will be placed on a chair. He will seat on a chair in a comfortable position. The sigma gel will be put on his muscle before placed the electrodes. The surface electrodes are placed on the subject muscle that has been put gel. The muscle being selected is forearms and biceps upper limb muscle. While the electrodes placed on him, he need to hold a dynamometer on the same hand electrodes are placed. The electrodes are connected to the shimmer EMG thus the electrical signals can be obtained during muscle contractions. The signals were recorded three times for each subject in order to take average and also to ensure that the results are more accurate.

3.5.1 EMG RECORDING

In this experiment, 6 participants consist of 3 males and 3 females will be selected to carry out the experiment. The subjects are among students of University Malaysia Pahang (UMP) of age between 20 to 25 years old and in a condition of healthy without any problems of health. Among the volunteer participants there will be some of right-handed and some of left-handed. The selected muscle of the upper limb are forearms and biceps.

While conduct this experiment, the subjects will be seat on a chair with the forearm in 90° position with hand grip the hand dynamometer. Dynamometer is a device

used to measure the EMG signal when the subjects in a condition of conscious and sub-conscious. Goniometer will be used to measure the angle of the forearm. The subjects will be distracted while they grip the dynamometer and while someone talking to them. This is to make them in a condition of sub-conscious while the test were run.

The distance between the electrodes will be 2.5m and the computer monitor will be placed beside the subjects. The sampling frequency will be 1kHz and this experiment will use band pass filter to filter up the electrical signal. The data will be analyzed using feature of extraction method to find out RMS and MAV. This experiment will be carry out based on the stated criterions and requirements in order to get the data and the results.

Figure 3.5.1: Conscious condition

Figure 3.5.2: Sub-conscious condition

3.6 FEATURES OF EXTRACTION

Time domain and frequency domain are two domain which were used to evaluate the EMG signal. These two domain of features are mostly used in hand movement along with the detection of muscle contraction and muscle activity. There are some features being computed to muscle activity during conscious and subconscious for forearms and biceps muscles. These various features can be used to calculated results from the data.

3.6.1 TIME DOMAIN

(i) Root Mean Square (RMS)

The root-mean-square (RMS) of the EMG signal is calculated using the following equation:

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

where S = the window length (points)
f(s) = the data within the window

The RMS calculation provide the most insight on the amplitude of the EMG signal as it gives a measure of the power of the signal and it produce a waveform that is easily analyzable.

(ii) Mean Absolute Value (MAV)

The Mean Absolute Value (MAV) of raw EMG data is the average distance between each EMG value and the mean.

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

$\tilde{x}$- Mean

N- The number of data points

3.7 STATISTICAL SIGNAL

- **Mean**

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

- **Standard Deviation (SD)**

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

- **Coefficient of Variation (CoV)**

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

3.8 CONCLUSION

As conclusion, this experiment will done on 6 participants of 3 males and 3 females from UMP students of age between 20 to 25 years old which some with right-handed and some with left-handed. All the subjects will hold dynamometer as a load and the data obtained will be recorded by using the surface Electromyography and the analysis method of the data will used RMS and MAV as the feature of extraction.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 INTRODUCTION

In this chapter, the results has been discussed based on the data obtain. The experiment was conducted on six subjects. The data was recorded and from the raw data, the value of Root Mean Square (RMS) and Maximum Absolute Value (MAV) were calculated. The RMS and MAV formula were applied in the MATLAB for calculation of RMS and MAV. There were data table included in this chapter along with graph being plotted. In this experiment, data was recorded by two conditions that is conscious and sub-conscious and each conditions has 3 trial for one subject.

4.2 RESULTS

4.2.1 Force Value from Data Recording

Force value was obtained from hand dynamometer during data recording. The value was taken in the same method but different condition with three trials. The data recording was shown in the table below. The value of the forces were recorded in unit of kg.

Table 4.2.1.1: Force value for forearm muscle

Subject/Condition		Force for Conscious(kg)	Force for Sub-conscious(kg)
Subject 1	1st trial	25.4	11.0
	2nd trial	24.6	7.40
	3rd trial	24.1	7.20
Subject 2	1st trial	28.3	20.1
	2nd trial	30.2	18.1
	3rd trial	19.9	16.2
Subject 3	1st trial	13.7	6.5
	2nd trial	14.3	7.0
	3rd trial	12.4	7.6
Subject 4	1st trial	40.6	35.3
	2nd trial	33.4	35.5
	3rd trial	38.7	35.2
Subject 5	1st trial	22.8	21.2
	2nd trial	24.4	16.1
	3rd trial	15.1	16.0
Subject 6	1st trial	27.0	19.4
	2nd trial	29.1	21.4
	3rd trial	23.3	18.2

Table 4.2.1.2: Force value for biceps brachii muscle

Subject/Condition		Force for Conscious(kg)	Force for Sub-conscious(kg)
Subject 1	1st trial	25.4	11.0
	2nd trial	24.6	7.40
	3rd trial	24.1	7.20
Subject 2	1st trial	28.3	20.1
	2nd trial	30.2	18.1
	3rd trial	19.9	16.2
Subject 3	1st trial	13.9	10.5
	2nd trial	12.0	8.2
	3rd trial	14.1	6.2
Subject 4	1st trial	44.6	38.1
	2nd trial	44.4	38.3
	3rd trial	44.8	41.2
Subject 5	1st trial	29.9	25.5
	2nd trial	27.9	19.9
	3rd trial	27.7	19.8
Subject 6	1st trial	20.7	18.1
	2nd trial	21.7	15.4
	3rd trial	20.5	13.6

4.2.2 Root Mean Square (RMS) Value from Data Recording

By applying the formula of RMS in the MATLAB, its value can be obtained directly from this software. The RMS value for each trial was calculated accordingly to two conditions that is conscious and sub-conscious and two muscles forearms and biceps. The value of RMS calculated are filled in the table below.

Table 4.2.2.1: RMS value for forearm muscle

Subject	Root Mean Square (RMS)					
	1st trial		2nd trial		3rd trial	
	Conscious	Subconscious	Conscious	Subconscious	Conscious	Subconscious
Subject 1	2.060	2.053	2.063	2.059	2.051	2.054
Subject 2	2.052	2.036	2.059	2.016	2.057	2.008
Subject 3	2.039	2.039	2.036	2.030	2.042	2.033
Subject 4	2.055	2.033	2.037	2.034	2.045	2.037
Subject 5	2.022	1.979	2.031	1.967	2.040	1.972
Subject 6	2.036	2.027	2.041	2.023	2.054	2.042

Table 4.2.2.2: RMS value for biceps brachii muscle

Subject	Root Mean Square (RMS)					
	1st trial		2nd trial		3rd trial	
	Conscious	Subconscious	Conscious	Subconscious	Conscious	Subconscious
Subject 1	2.045	2.040	2.036	2.033	2.057	2.042
Subject 2	2.061	2.059	2.057	2.055	2.060	2.058
Subject 3	2.055	2.055	2.058	2.052	2.057	2.053
Subject 4	2.059	2.052	2.059	2.053	2.055	2.041
Subject 5	2.060	2.056	2.061	2.060	2.060	2.046
Subject 6	2.057	2.054	2.064	2.056	2.058	2.056

4.2.3 Maximum Absolute Value (MAV) from Data Recording

The value of MAV were obtained same way as RMS value where the formula of MAV was applied in the MATLAB. The MAV value for each trial and each subject was calculated same as RMS that is accordingly to conscious and sub-conscious and two muscles forearms and biceps. The value of MAV after being calculate were filled in the table below.

Table 4.2.3.1: MAV value for forearm muscle

Subject	Mean Absolute Value (MAV)					
	1st trial		2nd trial		3rd trial	
	Conscious	Subconscious	Conscious	Subconscious	Conscious	Subconscious
Subject 1	2.053	2.052	2.060	2.057	2.054	2.052
Subject 2	2.056	2.049	2.058	2.045	2.055	2.050
Subject 3	2.056	2.056	2.055	2.053	2.055	2.054
Subject 4	2.060	2.056	2.057	2.053	2.057	2.053
Subject 5	2.052	2.051	2.053	2.047	2.057	2.045
Subject 6	2.054	2.054	2.057	2.049	2.061	2.059

Table 4.2.3.2: MAV value for biceps brachii muscle

Subject	Mean Absolute Value (MAV)					
	1st trial		2nd trial		3rd trial	
	Conscious	Subconscious	Conscious	Subconscious	Conscious	Subconscious
Subject 1	2.062	2.055	2.057	2.057	2.057	2.056
Subject 2	2.060	2.059	2.059	2.056	2.060	2.058
Subject 3	2.055	2.055	2.057	2.056	2.055	2.053
Subject 4	2.058	2.044	2.053	2.044	2.048	2.029
Subject 5	2.060	2.056	2.061	2.059	2.060	2.037
Subject 6	2.054	2.052	2.062	2.055	2.056	2.055

4.2.4 Mean, Standard Deviation (STD) and Coefficient of Variance (CoV) Value of RMS Value for conscious and sub-conscious.

The value of mean, STD and CoV were calculated by using formula given. The value inserted in the formula are from RMS value obtain. The value are calculated for both conscious and sub-conscious for both forearms and biceps muscle. The results of the calculation are shown below.

Table 4.2.4.1: Mean, STD and CoV of RMS value for forearm muscle

Subject	Root Mean Square(RMS)					
	Mean		Standard Deviation		Coefficient of Variation	
	Conscious	Subconscious	Conscious	Subconscious	Conscious	Subconscious
Subject 1	2.058	2.055	0.0062	0.0032	0.301	0.156
Subject 2	2.056	2.020	0.0036	0.0144	0.175	0.713
Subject 3	2.039	2.034	0.0030	0.0046	0.147	0.226
Subject 4	2.046	2.035	0.0090	0.0021	0.440	0.103
Subject 5	2.031	1.973	0.0090	0.0060	0.443	0.304
Subject 6	2.044	2.031	0.0093	0.0100	0.455	0.492

Table 4.2.4.2: Mean, STD and CoV of RMS value for biceps brachii muscle

Subject	Root Mean Square(RMS)					
	Mean		Standard Deviation		Coefficient of Variation	
	Conscious	Subconscious	Conscious	Subconscious	Conscious	Subconscious
Subject 1	2.046	2.038	0.0105	0.0047	0.513	0.231
Subject 2	2.059	2.057	0.0021	0.0021	0.102	0.102
Subject 3	2.057	2.053	0.0016	0.0016	0.078	0.078
Subject 4	2.058	2.049	0.0023	0.0067	0.112	0.327
Subject 5	2.060	2.054	0.0007	0.0072	0.034	0.351
Subject 6	2.060	2.055	0.0038	0.0012	0.184	0.058

4.2.5 Mean, Standard Deviation (STD) and Coefficient of Variance (CoV) Value of MAV Value for conscious and sub-conscious.

The value of mean, STD and CoV of MAV were calculated by using formula given same as in 4.2.4. The value inserted in the formula are from MAV value obtain from the MATLAB. The results of the calculation for both conscious and sub-conscious for both muscles are shown below.

Table 4.2.5.1: Mean, STD and CoV of MAV value for forearm muscle

Subject	Mean Absolute Value (MAV)					
	Mean		Standard Deviation		Coefficient of Variation	
	Conscious	Subconscious	Conscious	Subconscious	Conscious	Subconscious
Subject 1	2.056	2.054	0.0038	0.0029	0.185	0.141
Subject 2	2.056	2.048	0.0015	0.0026	0.073	0.127
Subject 3	2.055	2.054	0.0071	0.0016	0.345	0.078
Subject 4	2.058	2.054	0.0026	0.0017	0.126	0.083
Subject 5	2.054	2.048	0.0026	0.0031	0.127	0.151
Subject 6	2.057	2.054	0.0035	0.0050	0.170	0.243

Table 4.2.5.2: Mean, STD and CoV of MAV value for biceps brachii muscle

Subject	Mean Absolute Value (MAV)					
	Mean		Standard Deviation		CoV	
	Conscious	Subconscious	Conscious	Subconscious	Conscious	Subconscious
Subject 1	2.059	2.056	0.0029	0.0010	0.141	0.049
Subject 2	2.060	2.058	0.0007	0.0016	0.034	0.078
Subject 3	2.056	2.055	0.0012	0.0023	0.058	0.112
Subject 4	2.053	2.039	0.0050	0.0087	0.244	0.427
Subject 5	2.060	2.057	0.0010	0.0142	0.049	0.690
Subject 6	2.057	2.054	0.0042	0.0017	0.204	0.083

4.2.6 Mean, Standard Deviation (STD) and Coefficient of Variance (CoV) Value of RMS Value for all subjects.

Table 4.2.6.1: Mean, STD and CoV of RMS value for forearm muscle of all subjects

Condition	Root Mean Square (RMS)		
	Mean	STD	Coefficient of Variation
Conscious	2.046	0.0067	0.327
Sub conscious	2.025	0.0067	0.332

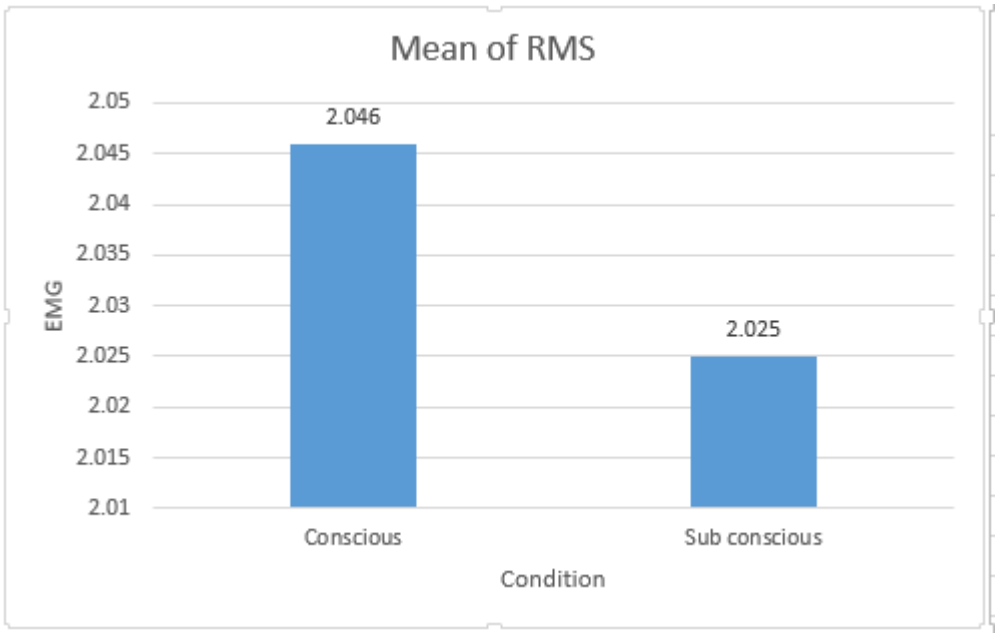

Figure 4.2.6.1: Graph of Mean of RMS for forearms

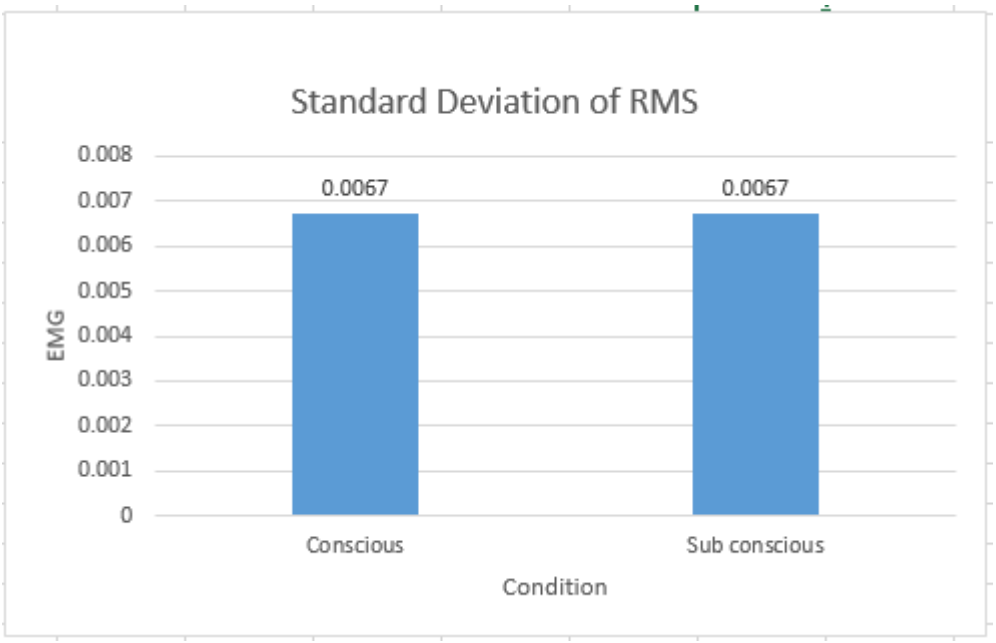

Figure 4.2.6.2: Graph of Standard Deviation of RMS for forearms

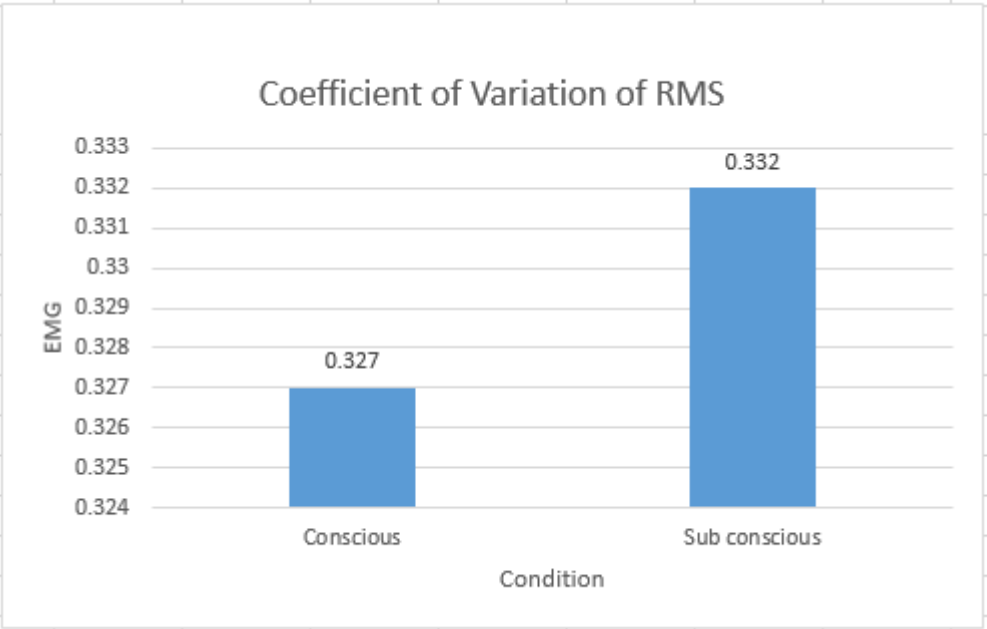

Figure 4.2.6.3: Graph of Coefficient of Variation of RMS for forearms

Based on the graph plotted above, the mean value for conscious condition is higher than sub-conscious where for conscious is 2.046 and for sub-conscious is 2.025. For standard deviation graph, the value for both condition is same that is 0.0067 while the value for graph coefficient of variation is 0.327 for conscious and 0.332 for sub-conscious where the value of conscious is lower than for CoV.

Table 4.2.6.2: Mean, STD and CoV of RMS value for biceps brachii muscle of all subjects

Condition	Root Mean Square (RMS)		
	Mean	STD	Coefficient of Variation
Conscious	2.057	0.0035	0.171
Sub conscious	2.051	0.0039	0.191

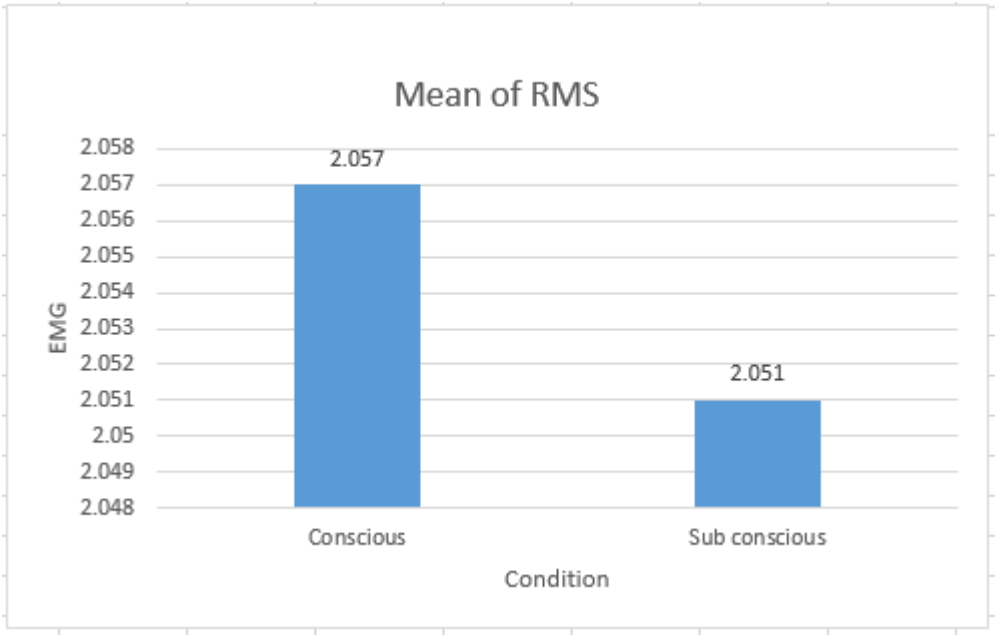

Figure 4.2.6.4: Graph of Mean of RMS for biceps brachii

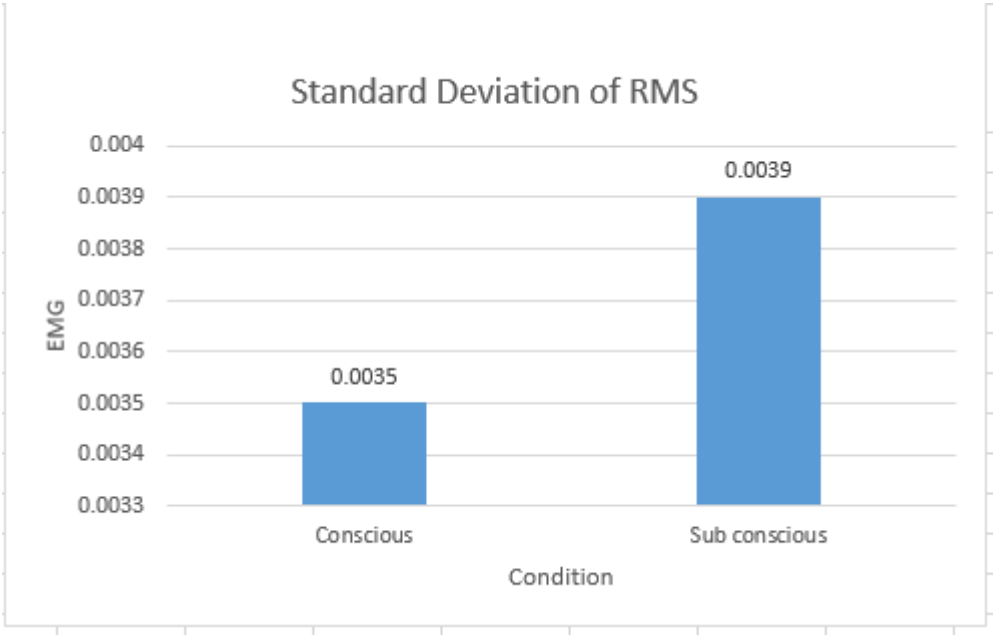

Figure 4.2.6.5: Graph of Standard Deviation of RMS for biceps brachii

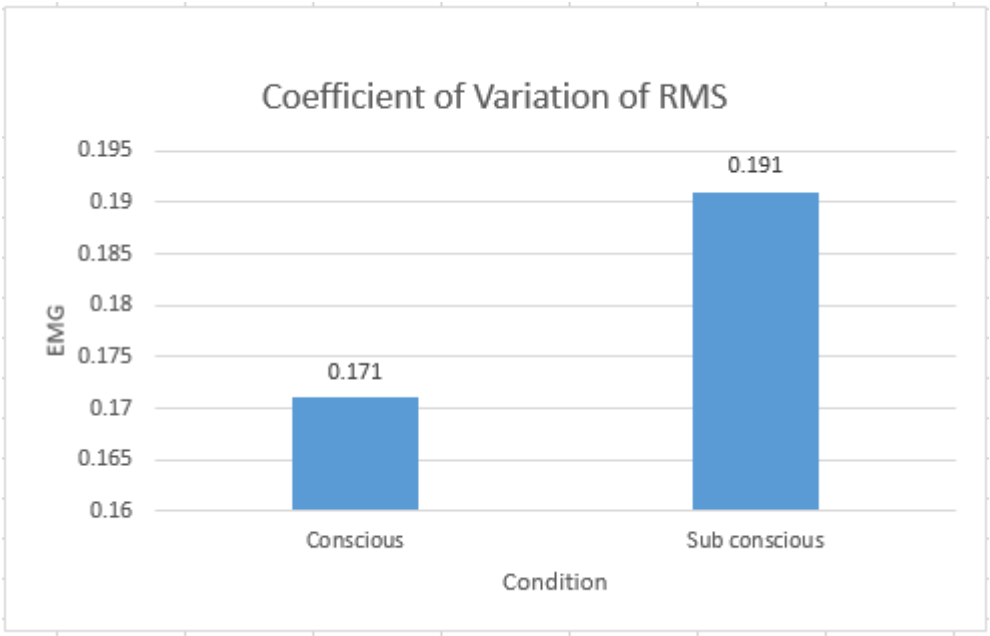

Figure 4.2.6.6: Graph of Coefficient of Variation of RMS for biceps brachii

Based on the graph plotted above, the mean value for conscious condition is higher than sub-conscious where for conscious is 2.057 and for sub-conscious is 2.051. For standard deviation graph and CoV graph, the value for sub-conscious is higher than conscious.

4.2.7 Mean, Standard Deviation (STD) and Coefficient of Variance (CoV) Value of MAV Value for all subjects.

Table 4.2.7.1: Mean, STD and CoV of MAV value for forearm muscle of all subjects

Condition	Mean Absolute Value (MAV)		
	Mean	STD	Coefficient of Variation
Conscious	2.056	0.0035	0.171
Sub conscious	2.052	0.0028	0.137

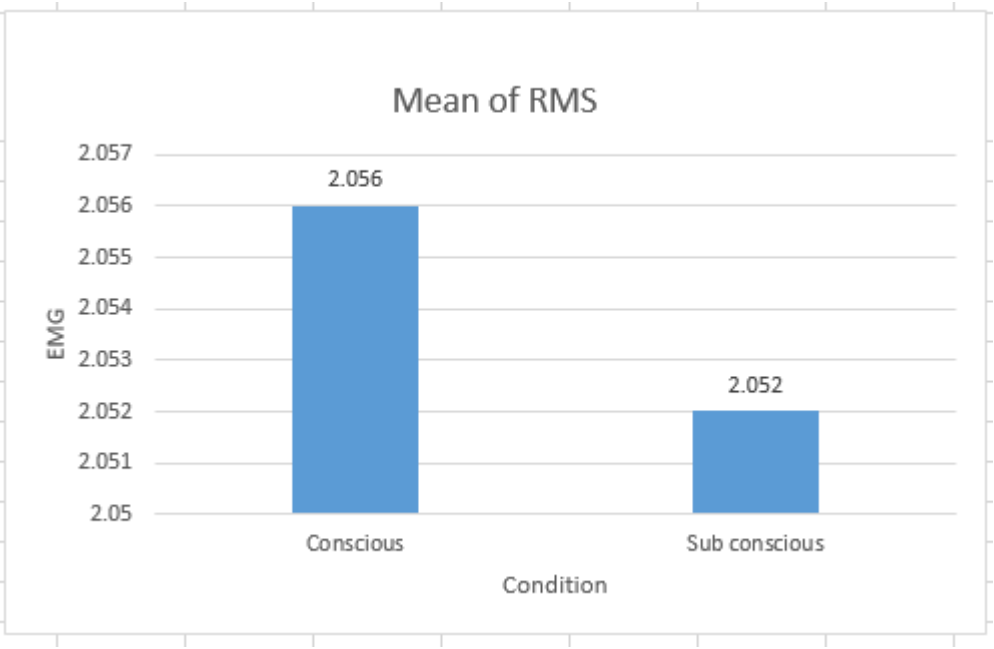

Figure 4.2.7.1: Graph of Mean of MAV for forearms

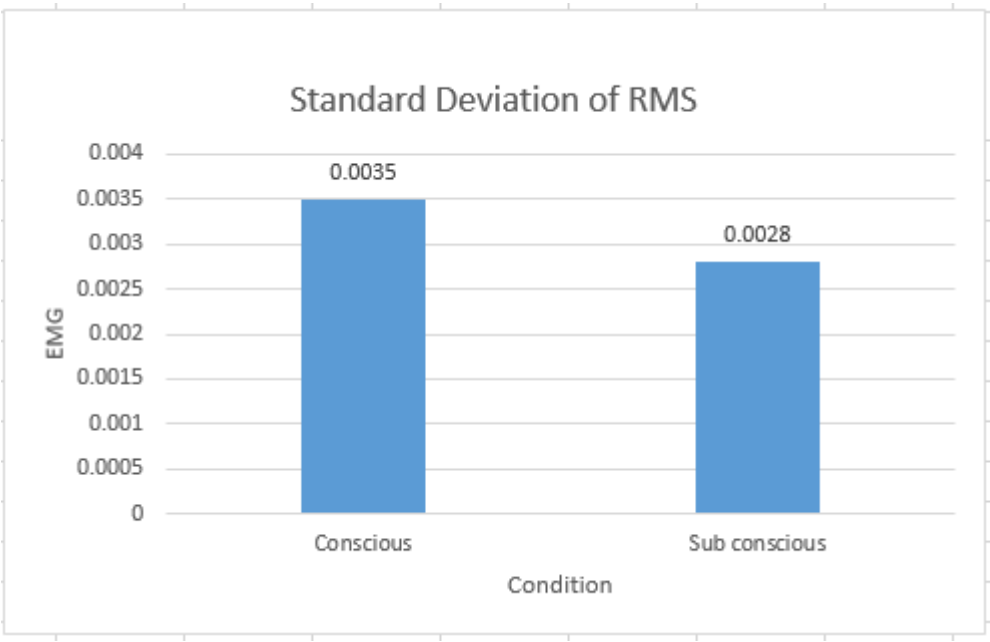

Figure 4.2.7.2: Graph of Standard Deviation of MAV for forearms

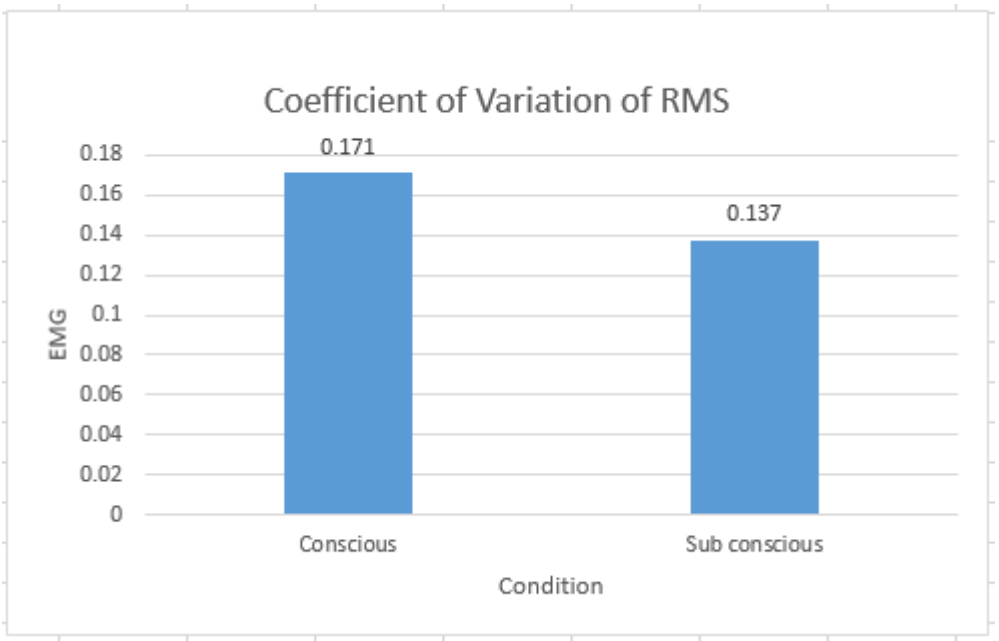

Figure 4.2.7.3: Graph of Coefficient of Variance of MAV for forearms

Based on the graph plotted above, all of the graph show that the value for conscious condition is higher than sub-conscious. For mean graph, the value is 2.056 for conscious and 2.052 for sub-conscious. For standard deviation graph, the value for is 0.0035 for conscious and 0.0028 for sub-conscious while for graph coefficient of variation is 0.171 for conscious and 0.137 for sub-conscious.

Table 4.2.7.2: Mean, STD and CoV of MAV value for biceps muscle of all subjects

Condition	Mean Absolute Value (MAV)		
	Mean	STD	Coefficient of Variaton
Conscious	2.058	0.0025	0.122
Sub conscious	2.053	0.0049	0.240

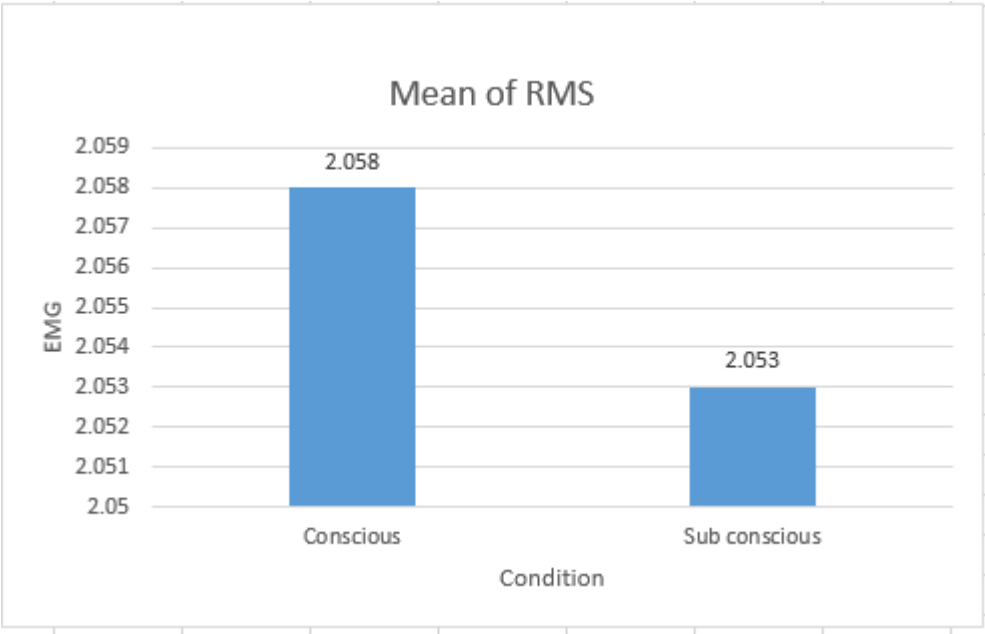

Figure 4.2.7.4: Graph of Mean of MAV for biceps brachii

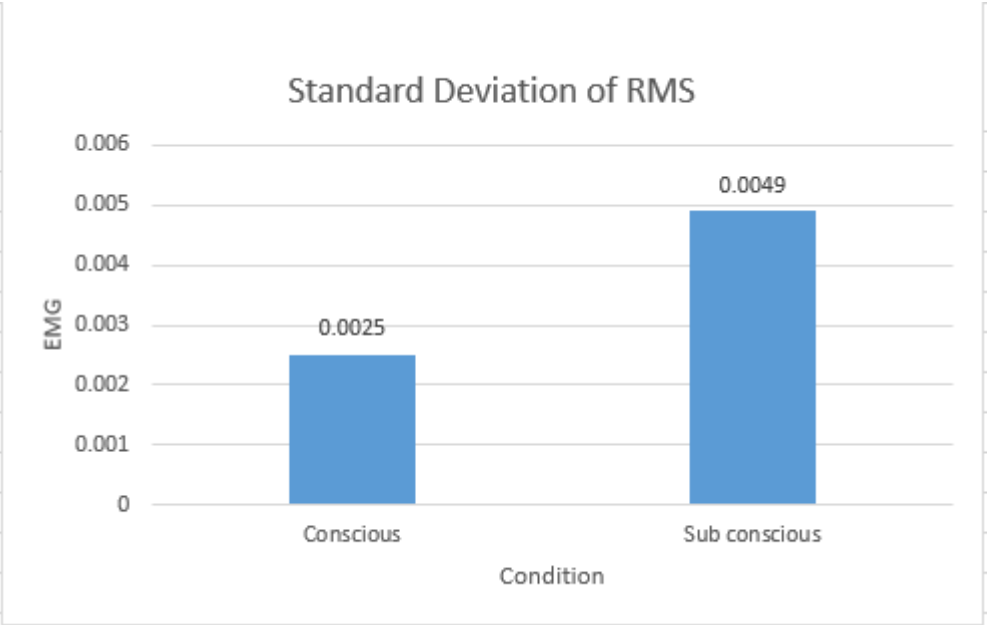

Figure 4.2.7.5: Graph of Standard Deviation of MAV for biceps brachii

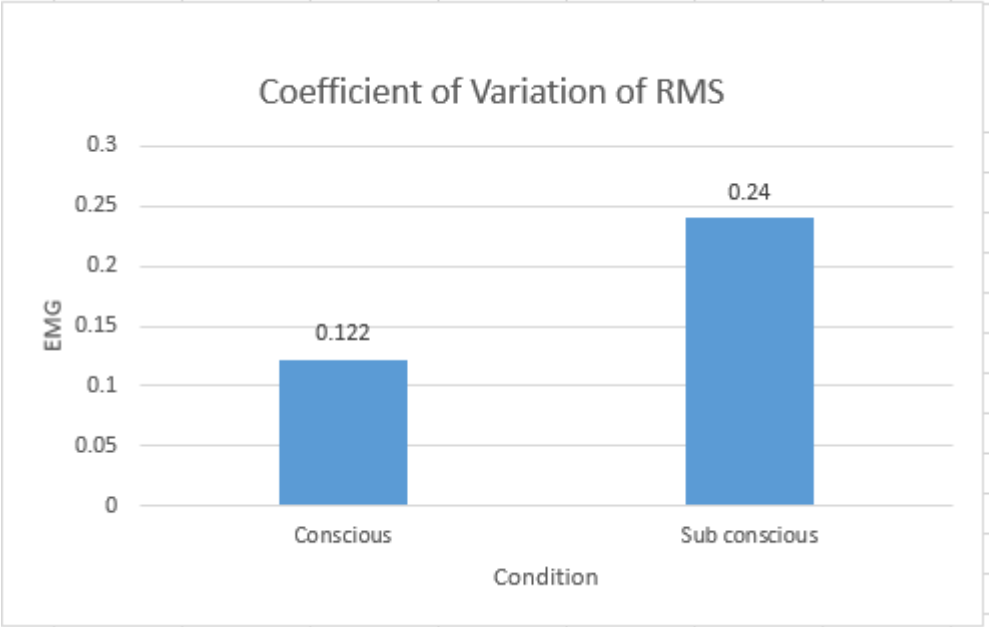

Figure 4.2.7.6: Graph of Coefficient of Variaton of MAV for biceps brachii

Based on the graph plotted above, the mean value for conscious condition is higher than sub-conscious where for conscious is 2.058 and for sub-conscious is 2.053. For standard deviation graph and CoV graph, the value for sub-conscious is higher than conscious.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter will explain about all the results obtain from data recording and calculation. From the results, conclusion and recommendation for future work can be made so that the experiment, methodology and results can be upgrading to a better way.

5.2 CONCLUSION

Based on the research and experiment conduct by previous researcher, a few conclusions can be made. Due to the journals and previous experiment related to this topic, there were some research gap found such that the conditions they use, the muscle they choose, the type of EMG and the type of contractions they focused on.

Based on the table and graph, it is shown that the value for conscious condition are mostly higher than sub-conscious condition for forearms while for biceps muscles, the value of sub-conscious are mostly higher than conscious. EMG signal for conscious is more significant compared to EMG signal for sub-conscious as the EMG recording of conscious is higher.

From the results, it can also be concluded that the forearm muscle are more significant compared to biceps muscle which mean the muscle of forearm are more active during conscious compared to sub-conscious.

5.3 RECOMMENDATION

Some recommendation can be made based on results and data obtain. First, the position of holding hand dynamometer need to be fixed at 90° which means the subjects need to hold the dynamometer in a static position along the time data was recorded. This is because different position of holding the dynamometer can affect the result as it was not in fixed position.

Then, the condition while taking the data need to be specific and details. Subjects should be cleared on how condition they should react while data taking. As example during conscious, they need to give fully concentration and focused only on data recording.

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APPENDIX A

Data Collection Form

Effect on EMG Signal From Upper Limb Muscle During Conscious And Sub-conscious Perception

Principle Investigator: Dr. Nizam Uddin Ahamed
Co-Investigator: Fatin Zulaika bt Hasan

DATA COLLECTION FORM

Session 1: Familiarization (5 minutes)

Session 2: Details of subject and details of subject's anthropometric (10 minutes)

Part A. Details of subject (Filled by subject and confidential)

Name	
Occupation	
I/C No.	
Email	
Phone No.	

Part B. Details of subject's anthropometric (Filled by investigator)

Gender		Age (Years)	
Weight(kg)		Height(cm)	

Session 3: Explanation of arm position and condition keeping protocol (5 minutes)

Session 4: Grip force recording

Arm position: Arm should be fixed at 90° angle with hand grip dynamometer.

Condition keeping:

Conscious: stay at the same arm position without doing something else include talking and focused at the data recording.

Sub-conscious: stay at the same arm position while the other not used hand holding phone (message/call & etc.).

Part A. Determination of force:

Duration of each trial = 10 seconds; 2 minutes rest between trials;
Duration of one muscle = (10 seconds x 3) + {2 minutes x (3-1)} = 4 minutes 30 seconds.
total time of both muscle = [(4 minutes 30 seconds) x 2] = 9 minutes.

Condition	Force (kg)		
	1st trial	2nd trial	3rd trial
Conscious			
Sub-conscious			

Forearms muscle

Condition	Force (kg)		
	1st trial	2nd trial	3rd trial
Conscious			
Sub-conscious			

Biceps muscle

Total time for one subject = (5 minutes + 10 minutes + 5 minutes + 9 minutes)
= **29 minutes**

Condition:

Conscious: stay at the same arm position without doing something else include talking and focused at the data recording.

Sub-conscious: stay at the same arm position while the other not used hand holding phone (message/call & etc.).

Arm position: fixed at 90° angle.

APPENDIX B

Consent Form

CONSENT FORM FOR PARTICIPANTS

Project title: Effect on EMG signal from upper limb muscle during conscious and sub-conscious perception
Project Investigator: Fatin Zulaika bt Hasan
Faculty: Faculty of Manufacturing Engineering

I have been given enough information about this experiment. The details of the experiment has been explained well to me. I agree to undergoes this experiment and be a participant. I understand the protocols need to do while being test as a subject. I promise that I will follow the instruction and rules during the experiment and will ensure there is no broken of instrument or any equipment. With that, I give permission to run a test on me and make me as a subject.

Name : ……

Date : ……

Age : ……

Gender : ……..

APPENDIX C

FYP 1 GANTT CHART

ACTIVITIES/WEEK		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Meeting with SV for confirmation of title	Plan														
	Action														
Understand the title of project	Plan														
	Action														
Identify objective and problem statement of project	Plan														
	Action														
Study and analyse the previous journal that related to the title	Plan														
	Action														
Complete chapter 1 until chapter 3	Plan														
	Action														
Submission slide and preparation of FYP 1 presentation	Plan														
	Action														
Presentation o FYP 1	Plan														
	Action														
Submission of FYP 1 report	Plan														
	Action														

APPENDIX D

FYP 2 GANTT CHART

ACTIVITIES/WEEK		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Finalize the method and process flow	Plan															
	Action															
Prepare consent form and data collection form	Plan															
	Action															
Collect data from subjects	Plan															
	Action															
Analyse the data obtain	Plan															
	Action															
Recommendation and conclusion	Plan															
	Action															
Presentation of FYP 2	Plan															
	Action															
Report Writing	Plan															
	Action															
Submission of final report	Plan															
	Action															