Faculty of Electrical and Electronic Engineering Technology

DEVELOPMENT OF ELECTROMYOGRAPHY SIGNAL ANALYSIS TECHNIQUE FOR MUSCULOSKELETAL DISORDERS

MUNIR NAFIS BIN NORDIN

Bachelor of Electronics Engineering Technology with Honours

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DEVELOPMENT OF ELECTROMYOGRAPHY SIGNAL ANALYSIS TECHNIQUE FOR MUSCULOSKELETAL DISORDERS

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A project report submitted
in partial fulfillment of the requirements for the degree of
Bachelor of Electronics Engineering Technology with Honours

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2021

DECLARATION

I declare that this project report entitled "Development of Electromyography Signal Analysis Technique Using Spectrogram For Musculoskeletal Disorders" is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Student Name : MUNIR NAFIS BIN NORDIN

Date : 11/01/2022

APPROVAL

I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electronics Engineering Technology with Honours.

Signature :

Supervisor Name : TS. DR. NORHASHIMAH BINTI MOHD SAAD

Date : 11/01/2022

DEDICATION

Firstly, I dedicate this project to my beloved parents for providing all the support and assistance that have made this project complete worth the efforts. Their support truly helps me in the process of complete this project.

Next, I also dedicate this project to my supervisor, Ts. Dr. Norhashimah binti Mohd Saad for all the guidance, knowledge and encouragement word that gave me strength throughout this project.

Not forgotten also to my friends for their cooperation, advice and motivation during this final year project and last but not least, thank you for the Universiti Teknikal Malaysia Melaka for the lab usage to complete this a truly meaning during my degree's life.

ABSTRACT

Musculoskeletal disorders (MsD) are an injury that affects human body movement. One of the common MsD problems is back pain and slipped disc. Early detection of MsD can be detected using an electromyography (EMG) signal. The suggested method is being introduced because MsD detection using standard physical assessment is not reliable and accurate. For example, at Social Security Organization (SOCSO) rehabilitation centre, a health screening exam was performed on patients to evaluate MsD problem. The activity is completed manually by the patient and with the assistance of an instructor. This current method fails to identify which specific muscle is in the problem, so the patient cannot be declared as a MsD patient accurately and scientifically. This study proposes a signal processing approach to detect muscular disorder using signal analysis techniques. EMG can detect the electrical signal produced by the muscles and will be used to assess muscle health and establish whether the patient is at risk of acquiring a musculoskeletal condition or is already suffering from it. In addition, the test can evaluate muscle fatigue by performing some activities using the Functional Range of Motion (FROM) task. Shimmer devices and software collect the muscle data at a specific region: the biceps, erector spine and trapezius muscles, both left and right. The data collected based on the task given will be processed using the Matlab software. Two methods, Fast Fourier Transform (FFT) and spectrogram will apply in command of the Matlab. By doing so, the output result shown is the activity of the muscle health condition. Then, the respondent can be categorized into fit and fatigued muscle conditions.

ABSTRAK

Gangguan muskuloskeletal (MsD) adalah kecederaan yang menjejaskan pergerakan badan manusia. Salah satu masalah MsD yang biasa adalah sakit belakang dan cakera tergelincir. Pengesanan awal MsD boleh dikesan menggunakan isyarat elektromiografi (EMG). Kaedah yang dicandang diperkenalkan kerana pengesanan MsD menggunakan penilaian tahap fizikal tidak cukup tepat dan dipercayai. Sebagai contoh, di pusat pemulihan Pertubuhan Keselamatan Sosial (PERKESO), pemeriksaan saringan kesihatan dijalankan ke atas pesakit untuk menilai masalah MsD. Aktiviti ini dijalankan secara manual oleh pesakit dan dengan bantuan pengajar. Kaedah semasa ini gagal untuk mengenal pasti otot tertentu yang bermasalah, jadi pesakit tidak boleh diisytiharkan sebagai pesakit MsD dengan tepat dan cara saintifik. Kajian ini mencadangkan pendekatan pemprosesan isyarat untuk mengesan gangguan otot menggunakan teknik analisis isyarat. EMG boleh mengesan isyarat elektrik yang dihasilkan oleh otot dan akan digunakan untuk menilai kesihatan otot dan menentukan sama ada pesakit berisiko mendapat keadaan muskuloskeletal atau sudah mengalaminya. Selain itu, ujian tersebut boleh menilai kelesuan otot dengan melakukan beberapa aktiviti menggunakan tugasan Fungsi Julat Pergerakan (FROM). Data yang dikumpul berdasarkan tugasan yang diberikan akan diproses menggunakan perisian Matlab. Dua kaedah, Fast Fourier Transform (FFT) dan spektrogram akan digunakan dalam perintah Matlab. Dengan berbuat demikian, hasil keluaran yang ditunjukkan adalah aktiviti keadaan kesihatan otot. Kemudian, responden boleh dikategorikan kepada keadaan otot yang cergas dan letih. Penyelidikan ini membantu menganalisis dan mengkaji lebih lanjut tentang MsD untuk mengelakkan kecederaan atau keadaan ini.

ACKNOWLEDGEMENTS

First and foremost, I would like to express my gratitude to my supervisor, Ts. Dr. Norhashimah Binti Mohd Saad for their precious guidance, words of wisdom and patient throughout this project.

I am also indebted to Universiti Teknikal Malaysia Melaka (UTeM) allow me to use the Advance Digital Signal Processing (ADSP) lab which enables me to accomplish the project. Not forgetting my fellow colleagues for the willingness of sharing his thoughts and ideas regarding the project.

Finally, my highest appreciation goes to my parents and family members for their love and prayer during the period of my study. Last but not least, I would like to thank all the individuals who being co-operative and helpful to me during this project.

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LIST OF SYMBOLS

$\int$	-	Integral
π	-	Pi
τ	-	Tau
v	-	Voltage
∞	-	Infinity
f	-	Frequency

CHAPTER 1

INTRODUCTION

1.1 Background

Musculoskeletal disorders (MsD) are injuries or conditions that can affect the human body movement. One of the common MsD problems is the slip disc. This is due to reasons such as weight lifting over the limit that can cause harm to the area mentioned. MsD also can affect lifestyle, occupation, and age. Another example is that an office worker is constantly sitting in the same position at a computer every day to complete the assigned tasks. By doing so, this also can lead to MsD condition such as back pain.

Electromyography (EMG) is the most popular technique to diagnose musculoskeletal disorders (MsD). EMG is an electrodiagnostic procedure that examines nerve and muscle health. An EMG nerve test will give your doctor clear information about the state of a nerve or muscle injury. By doing so, will allow the doctor to pinpoint the precise location of the injury.

In this research, a signal processing technique of electromyography (EMG) muscle analysis will be investigated to classify musculoskeletal disorders (MsD) for health screening system. The EMG signals from the human muscles in upper limb side will be analyzed during positional test using Functional Range of Motion (FROM). There are two signal analysis technique use in this experiment which is Fast Fourier Transform (FFT) and Spectrogram.. Then, the muscle performance between healthy and MsD can be classified. These criteria are very important to implement this research so that can be used to measure the overall performance of rehabilitation patients.

1.2 Problem Statement

Despite the availability of mechanical and automated technology, manual handling is an essential method of performing material handling tasks. These bodily movements frequently result in musculoskeletal diseases. As a growing country focusing on the industry sector, Malaysia is seeing an increase in the number of patients treated at SOCSO rehabilitation centres for MsD. In a rehabilitation centre, a health screening exam was performed to instruct and detect MsD patients using standard physical assessment techniques. However, the activity is completed manually by considering physical assessment only with the instructor's full assistance. Based on this evaluation, the patient will be evaluated for treatment or fitness to return to work. However, researchers are currently looking for the best way or technique to analyse the human muscle condition in muscle fatigue monitoring.

There is a various selection of tests for diagnosing musculoskeletal disorders (MsD). In addition to medical imaging such as X-rays, Computed Tomography (CT) scans and Magnetic Resonance Imaging (MRI) can be used because both provide much more detail than typical X-rays. The extent of these machines can detect fractures that are not visible on x-rays. However, both machines specialize in different things. For example, MRI is best for imaging muscles and tendons; meanwhile, CT scan is good in bone images. This raises the problem of which method is an excellent way to determine the MsD condition. This is where the use of electromyography (EMG) comes in. Hopefully, this EMG technique analysis can serve as a primary method to detect MsD conditions. During the EMG procedure, data will collect from design activities. Then, proceed with data analyzing which is an electrical signal from body parts such as the biceps, erector spine and trapezius muscle. After thorough data analysis, the researcher can conclude whether the subject have musculoskeletal disorders condition or not.

1.3 Project Objective

The primary goal of this project is to propose a systematic and effective methodology for assessing a person's musculoskeletal disorder condition efficiently and accurately. Specifically, the objectives are as follows:

a) To analyze electromyography (EMG) signals using signal processing technique for musculoskeletal disorders (MsD) during muscle health screening task.

b) To estimate the muscle characteristics from the signal analysis technique during Functional Range of Motion (FROM) task.

c) To evaluate the performance of the signal analysis technique by using spectrogram.

1.4 Scope of Project

To achieve the goals of this study, some requirements must be met to decide if electromyography signals can be evaluated and categorized using analysis techniques that can detect the presence of musculoskeletal disorders (MsD):

1. Ten randomly chosen respondents were eligible to participate.
2. Shimmer EMG board device is use to collect the data during Functional Range of Motion(FROM) Task.
3. Only 1 respondent selected used for analysis.
4. Analysis is done using Matlab software as the platform.
5. Use Fast Fourier Transform (FFT) to analyze the frequency spectrum of the EMG.
6. Use of spectrogram to analyze the time-freq distribution of the EMG muscle.
7. Muscle involve in this experiment are trapezius, biceps and erector spine.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Chapter 2 explains and proposes some literature review related to the proposed projects. Some terms need to be understood well, so then this project can be understood well. Previous studies and works in this field will be used for covered this chapter.

2.2 Structures of Neuron

According to (Tim Newman, 2017), neurons are responsible for carrying information throughout the human body. They use electrical and chemical impulses to assist in the coordination of all of life's necessary functions. For information, the brain and the spinal cord have approximately 100 billion and 13.5 million of neurons.

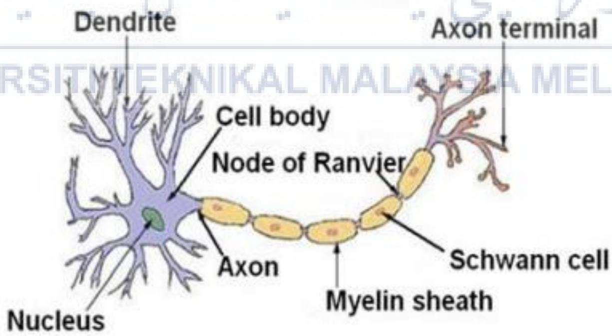


Figure 2.1 Structures of neuron

(Ericca Cirino, 2019) mentioned that neurons are made of three components which are dendrite, Axon and cell body. Dendrite is tree-like structures that function in receives messages 13 from other neurons. On the other hand, Axon is a long cable-like part that conducts electrical impulse away from the cell body.

2.2.1 Motor Neuron

(Nicolas Stifani, 2014), study state that motor neurons are central nervous system neuronal cells that influence a variety of downstream targets. Motor neurons are classified into two categories. Upper motor and lower motor neurons. An upper motor neurone resides in the brain. It provides higher-level motor information to the medulla located in the brain or to the appropriate spinal cord level outside the brain. Lower motor neurons transport motor information from the medulla or the spinal cord to muscle fibres, making them far more directly responsible for movement than upper motor neurons. Furthermore, The lower motor neuron controls the signal from the upper motor neuron to the effector's muscle to conduct a movement. Motor neurons in the brain and spinal cord transmit commands from the brain to the muscles, allowing them to perform actions such as moving and breathing.

2.3 Electromyography (EMG)

Based on (Danielle Moores, 2018), electromyography (EMG) is a test that evaluates the health of muscles and the nerve cells that control them. These nerve cells are known as motor neurons. They deliver electrical signals to the muscles, which cause them to contract and relax. Doctors can use the data generated by the EMG to help them make a diagnosis.When a patient exhibits muscle or nerve disease symptoms, a doctor will usually prescribe an electromyography test. These symptoms may include tingling, numbing, or limb fatigue. Electromyography data can assist doctors in diagnosing muscle problems, nerve illnesses, and injuries affecting the nerve-muscle link. EMG can also identify a difference between the wasting and exhaustion of myopathic and neurogenic muscles. By evaluating the 14 distribution of neurogenic abnormalities, EMG can further differentiate focal nerve, plexus or radicular disorders. EMG also is an obligatory test of the motor neuron disease, which shows the broad denervation and fasciculation needed for a safe diagnosis.

2.4 Electromyography Signal

Refer from (Chowdury et al, 2013), there are two types of electromyography (EMG) signal which the first is surface electromyography and the other is intramuscular electrmyography. Both EMG signals can be recorded by non-invasive and invasive electrodes. Non-invasive electrode that used on surface EMG while invasive electrode needed to use of needle to track movement of the muscle. Due to its non-invasive features, surface electromyography was the favoured approach. That is mean surface electromyography easy to apply and free from pain. EMG signal commonly be used for the area that has muscle fatigue where it is a decline in performance the longer the activity does.

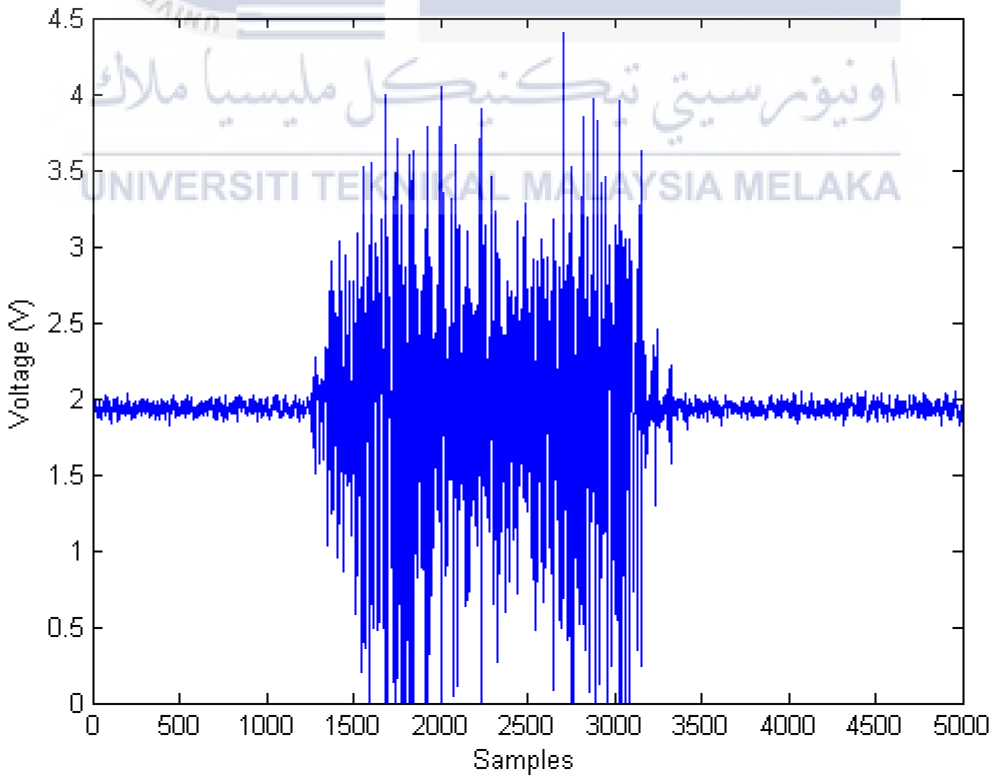


Figure 2.2 Example of raw EMG signal

Based on (Ezreen Farina Shair et al., 2016), mentioned that electromyography (EMG) signal could be categorized into two main components: baseline and muscle activation. Past research has been done to segment muscle contraction based on either time or frequency domain. These methods do not precisely segment signal by the nature of the signal itself, which changes the statistical properties over time in the time domain. Therefore, it is stated that EMG signals are complicated and non-stationary signal with highly complex time and frequency characteristics controlled by nervous signal because it is directly involved in muscle activity.

2.5 Musculoskeletal Disorders (MsD)

2.5.1 What are Musculoskeletal Disorders

According to (Matt Middlesworth,2019), musculoskeletal disorders (MsD) are injuries and disorders that impact the movement of the human body, such as muscles, tendons, etc. Some of the most common musculoskeletal disorders problems include carpal tunnel syndrome (CTS), ligament sprain and tension neck syndrome. The phrase "musculoskeletal disorder" is used because it accurately reflects the situation. To simplify this problem understanding to the general public, musculoskeletal disorders also named "repetitive motion injury".

2.5.2 What causes of Musculoskeletal Disorders

A study by (Isabel L. Nunes, 2020) found that a factor that leads to musculoskeletal disorders (MsD) is exposure to work-related. Some of the activities that contribute to the MsD are repetitive work and working in awkward or bad posture. Data recorded from this study shows that work-related MsD affects the lower back, neck, shoulders and upper limbs.

Supported by (Danuta Roman-Liu,2020), an employee's working posture is the position he or she adopts while doing work duties. It can be changed often, or a single posture can be maintained for a lengthy period of time. There is a possibility that the risk of acquiring neck and shoulder discomfort symptoms increases when neck twisting or bending postures are employed regularly at work, as opposed to when they are used infrequently.

The human body can be divided into two categories: the upper limb has musculoskeletal disorders (MsD) symptoms like neck and shoulder pain, while also has lower limb. The lower back of a person also can have musculoskeletal disorders condition due to the same reason. From (Nicolien de Langen, 2020), activity like prolonged standing affects the lower limb body. Standing for an extended period reduces blood circulation and nutrient supply to muscles, allowing muscular fatigue to develop. There is also prolonged sitting or static sitting. For example, office worker spends a lot of time at their desk or assigned workplace. The usual hour for an office worker is from 8 A.M. – 5 P.M. Without an excellent quality chair such as an ergonomic chair; people usually feel numb if they stay in the same position for several hours. It also a stated from (Viorica Petreanu and Aurelia-Mihaela Seracin, 2020), that the symptoms of the musculoskeletal disorder can develop over weeks, months, or even years, so it is critical to detect and treat them as soon as possible.

2.5.3 How to diagnose and treat Musculoskeletal Disorders

(Kristeen Cherney, 2018) mentioned that depending on the cause of your symptoms, your treatment plan will differ. As a result, it is critical to obtain an accurate diagnosis. Make an appointment with your doctor if you are experiencing symptoms of musculoskeletal disorders (MsD). They will most likely perform a physical exam to diagnose your condition. The doctor will check for the symptoms like stiff joints, swelling, and redness. Additionally, they may put your reflexes to the test. Irregular reflexes may be indication of nerve injury.

Furthermore, imaging tests such as X-rays or magnetic resonance imaging (MRI) scans may also be performed by your doctor. These tests can help in the examination of your bones and soft tissues.

Based on the doctor's imaging tests and physical exam, the doctor will recommend the best treatment to treat the musculoskeletal disorders (MsD). For minor discomfort, they may recommend moderate activity and over-the-counter medication such as Ibuprofen. This medication is supported by (Yvatte Brazier, 2021) stated that Ibuprofen is used to relieve pain such as strain and sprain. If the symptoms are severe, medications to relieve inflammation and pain may be prescribed. In some situations, doctors may recommend physical therapy, occupational therapy, or a combination of the two. These therapies can assist you in developing coping mechanisms for pain and discomfort. Additionally, therapy is beneficial for maintaining strength and movement for daily tasks. Supported from (T.N.S.T Zawawi et al, 2018) mentioned that the use of appropriate measures can eliminate or limit exposure to work-related risk factors can help reduce the chance of developing MsD on the workplace.

2.6 Electromyography Machine

Consensys is the software that interacts with shimmer sensors, providing your live data, managed data and devices with considerable capacities. It is created for adaptive field 18 data collecting, repeatable large-scale tests and general multi-sensor management. A high-pass filter is used to filter the acquired material. The spare time from the raw signal is removed, and precisely the data set is needed in the processing phase. The selected technique, the spectrogram, was then applied. In order to achieve high data accuracy, four characteristics are used from the signal created, including root mean square voltage (Vrms), medium frequency (MNF), variance (VAR) and default deviation (STD).

2.7 Spectrogram

According (Jade Vande Kamp, 2020) a spectrogram shows the strength of a signal at different frequencies of a waveform over time. Spectrograms can include 2-dimensional diagrams with a third colour variable or a 3-dimensional diagram with a fourth colour variable. A time-domain signal is split into shorter segments of equal length to generate a spectrogram. The rapid transformation of Fourier (FFT) is then applied to every segment. The spectrogram is an individual segment track of the spectrum. The Frame Count parameter determines how many FFTs the spectrogram can be created and, thus, the total time signal divided into separate FFTs.

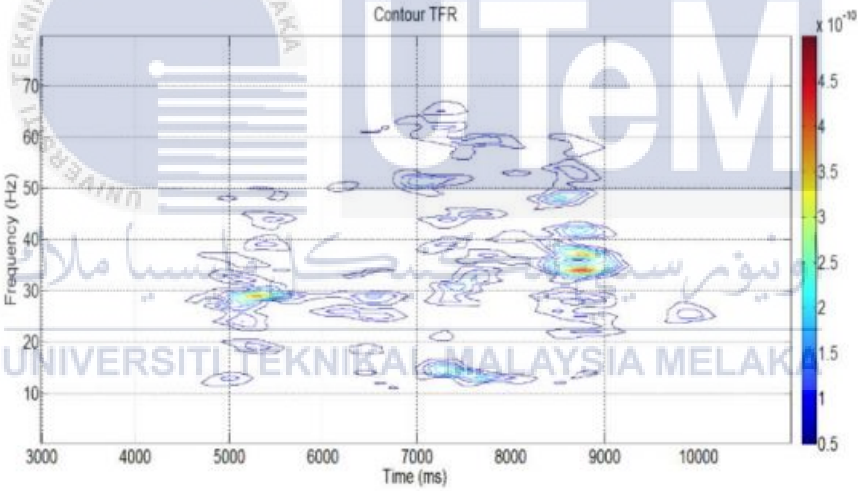


Figure 2.3 Example of Spectrogram Signal

2.8 Functional Range of Motion (FROM)

The Functional Range of Motion (FROM) pegboard can be used by evaluators to determine a patient's performance in terms of time required to place or move objects. The FROM system employs Tools Time Measurement (TTM), enabling evaluators to extrapolate regularly for periodic requests. TTM is a technique used in industrial engineering for determining the time-motion performance of workers performing work-related tasks. Evaluators can use the TTM standard score to distinguish between the quantity of a test subject's positional tolerance ability and the positional tolerance-specific productivity equivalency. Individuals must prove functionality within the specified posture and undertake positional tolerance procedures without failing a time-motion equivalence.

2.9 Summary

This chapter reviews existing research to emphasize the limitations, solutions, and benefits of the previous study of electromyography and the cause of the musculoskeletal disorder. Furthermore, this section of the study has a wealth of knowledge and insight into the method that will be implemented, which is the spectrogram analysis technique. This part also focuses on electromyography signal and the general idea of musculoskeletal disorders.

CHAPTER 3

METHODOLOGY

3.1 Introduction

In this chapter, the proposed methodology is to present the method that will be applied to carry out to this study.

3.2 Methodology

3.2.1 Flowchart

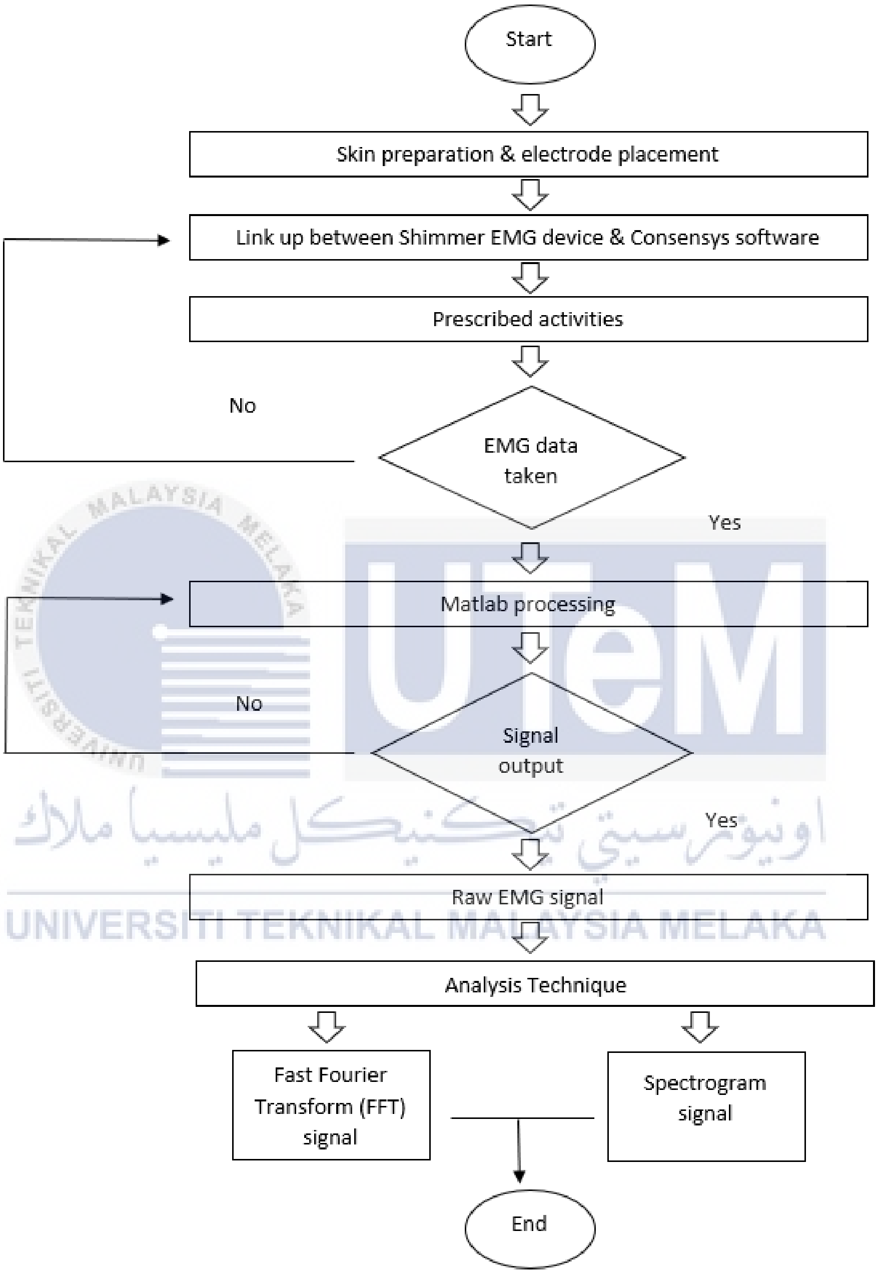


Figure 3.1 Flowchart process

3.3 Experimental Setup

3.3.1 Skin Preparation

Skin preparation necessitates the consideration of a few treatments. A good signal requires proper skin preparation. This procedure will be separated into two process, which are as follows:

1. **<u>Removing the hair</u>**

   1) Due to the EMG signal is vulnerable to noise, removing the hair is critical for reducing resistance. By doing so, also can improve the electrode's adhesion.
   2) The method is, the right biceps area would be shaved to clean the hair, which is where the electrode would be located.

Figure 3.2 Removing hair process

2. **<u>Cleaning of the skin</u>**

   1) The use of BD Alcohol Swabs of 70 % Isopropyl Alcohol apply to skin for cleanser process.
   2) Then, dry the hand before rubbed with the Electrode Gel, 227g tube

3.3.2 Electrode Placement

The electrode placement occurs after the cleaning of the skinning process. Before applying electrodes, make sure the skin surface is clean and dry. Several muscles which is upper limb has been involved in this task which is as follow and Figure 3.5 and 3.6 show the pinpoint location of the muscle.

1. Left biceps brachii
2. Right biceps brachii
3. Left erector spinae
4. Right erector spinae
5. Left Trapezius p. descendenz
6. Right Trapezius p. descendenz

1) Abrade the electrode with signa gel, then place the electrode at the desired area. Each muscle contains (+ve) and (-ve) poles also one reference electrode. The active electrode should be placed in line with the muscle fibers.
2) Ensure that the electrodes are firmly positioned on the skin to ensure that the skin and electrodes are good in contacts.
3) Next, the electrode should be tape using surgical tape to reduce mobility between the electrode and the skin.

Figure 3.3 Positioning of the electrode

3.3.3 Interfacing Between EMG Board and Consensys Software

1. The EMG Board will be set up correctly after the electrode is attached to the skin, as The channel will be connected to Consensys Software.
2. EMG Board and Consensys software switch will be turned ON, and the Bluetooth will be connected between both EMG Board and Consensys.
3. After all of the connectivity is succeed, The task can be started.

Figure 3.4 EMG Board

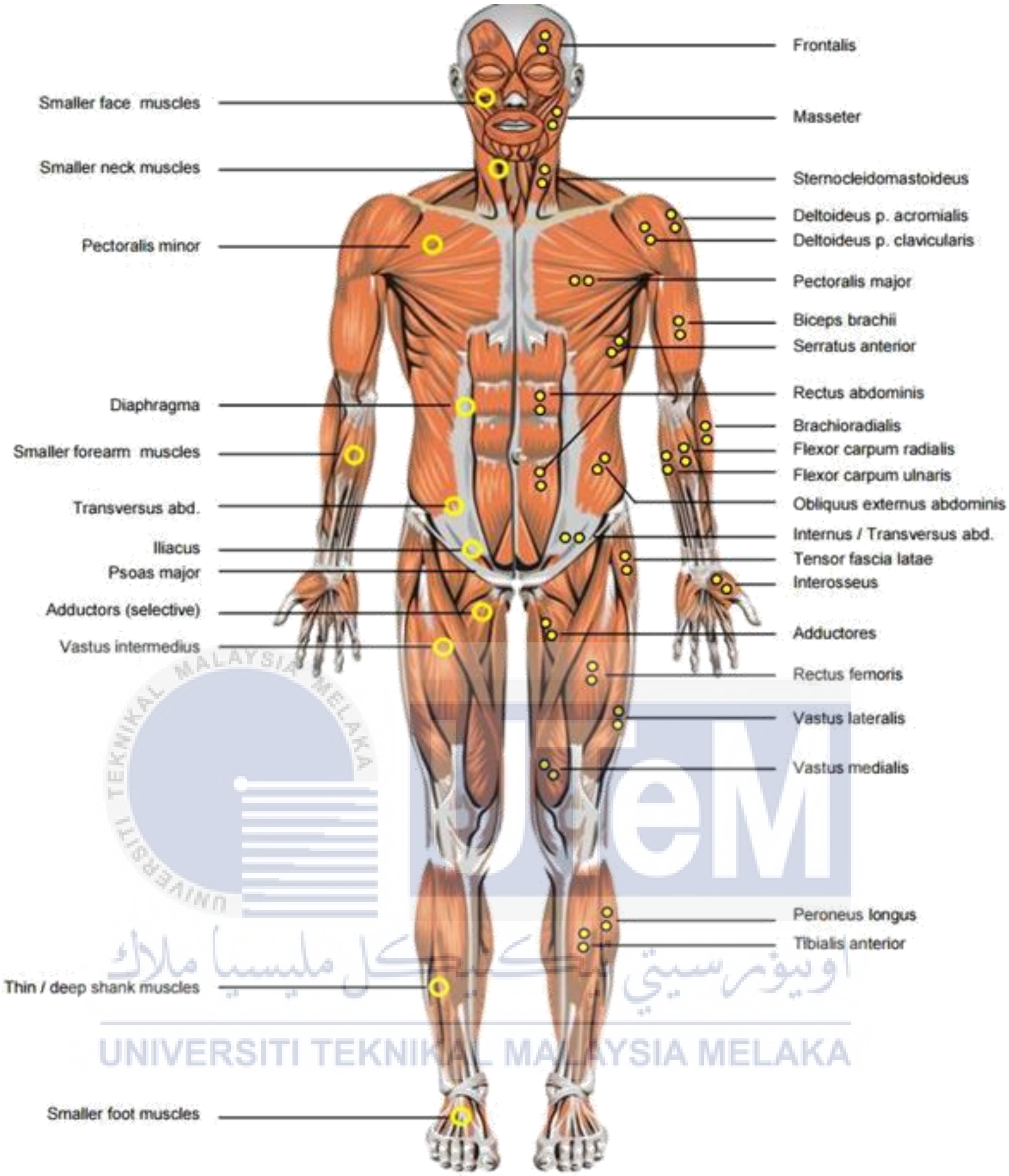


Figure 3.5 Anatomical positions of selected electrode sites, frontal view

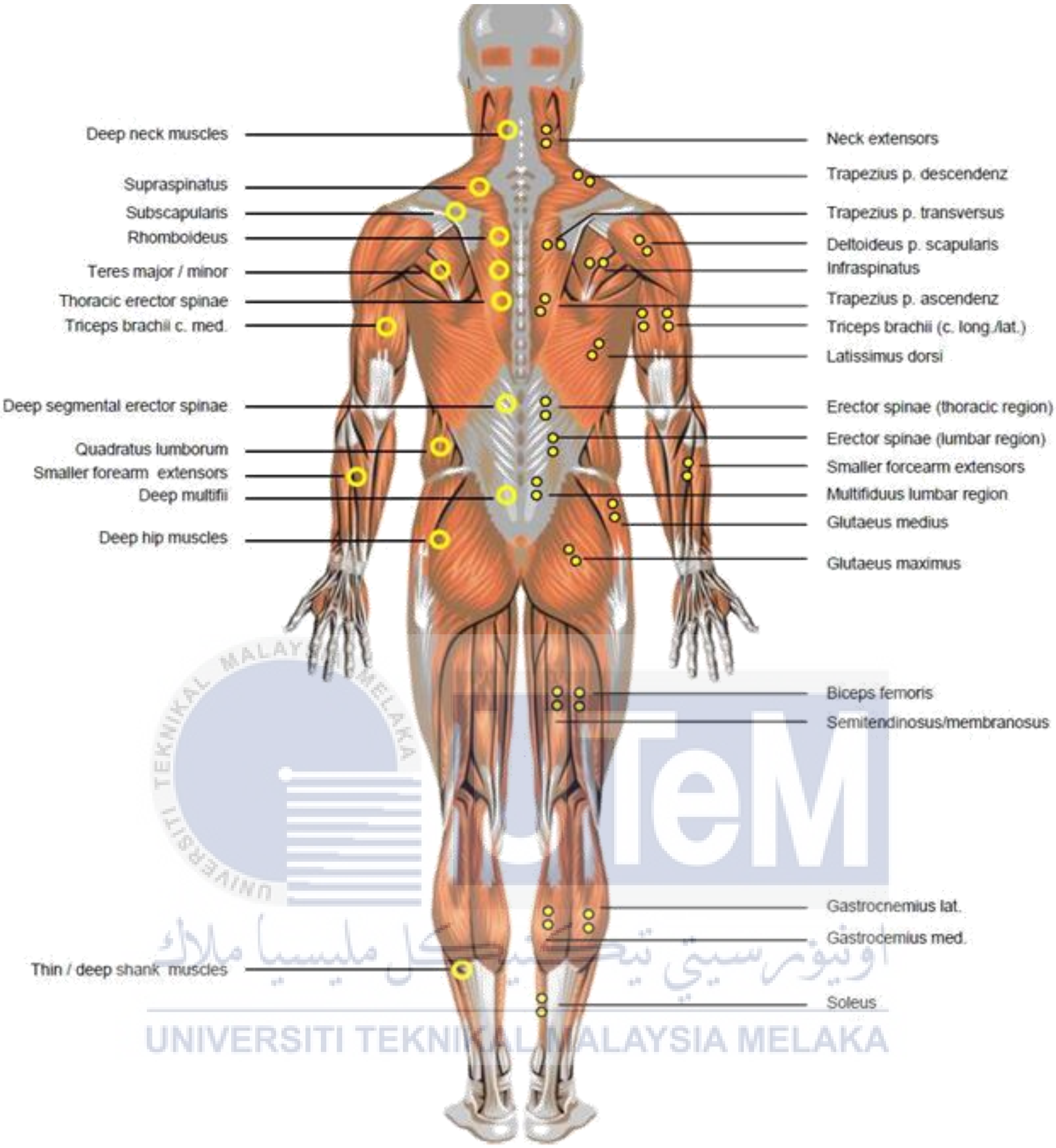


Figure 3.6 Anatomical positions of selected electrode sites, dorsal view

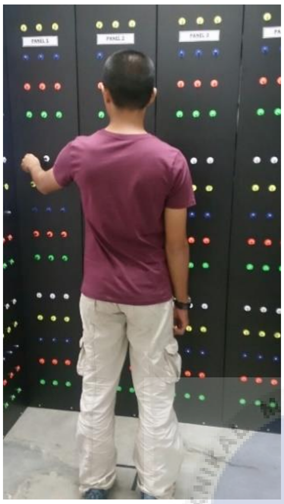
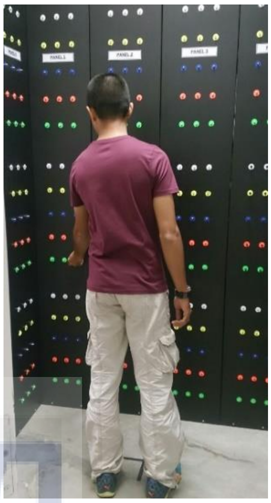
3.3.4 Utilizing the FROM Pegboard

The Functional Range of Motion (FROM) pegboard consists of 6 panels, which are placed in the following order from left to right: 6, 1, 2, 3, 4 and 5 (Figure. Each of these panels contains 45 holes of 5 different colors and 3 zones: A, B and C. The 3 zones are used to help identify the 3main levels of activity: Stooping and kneeling, standing and reaching overhead. The following list is the positional test to be used with the FROM pegboard.

1) Standing Horizontal Reach
2) Crouching
3) Kneeling Reach
4) Stooping Reach
5) Kneeling with Upper-Level Reach
6) Axial Rotation

Figure 3.7 FROM Pegboard & Peg

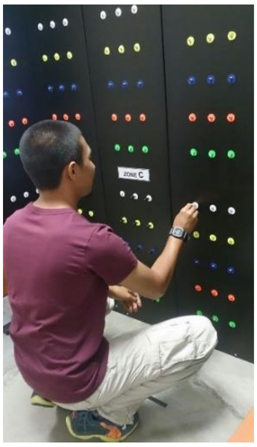
3.3.4.1 Standing Horizontal Reach

Standing Horizontal Reach			
Forward (highest)		Reverse (lowest)	
Start (Panel 1 Zone B)	End (Panel 4 Zone B)	Start (Panel 4 Zone B)	End (Panel 1 Zone B)
			

Procedure:

1. The respondent is tasked with the task of moving five rows of pegs from Panel 1 (Zone B) to Panel 4 (Zone B).
2. The client must remove the peg from the hole with left hand, transfer it to right hand, and then place the peg into the corresponding hole with the right hand.
3. The respondent begins with the lowest level row and progresses upward in order.
4. After relocating fifteen pegs, the procedure is repeated in reverse order until all fifteen pegs are restored to their original positions. This completes one repetition.
5. Repeat procedure 2, 3 and 4 until four repetition.

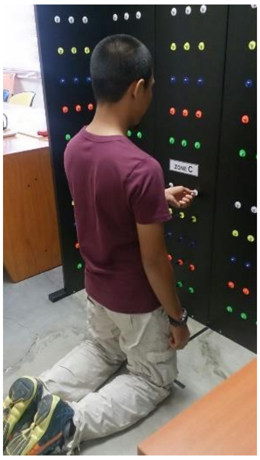
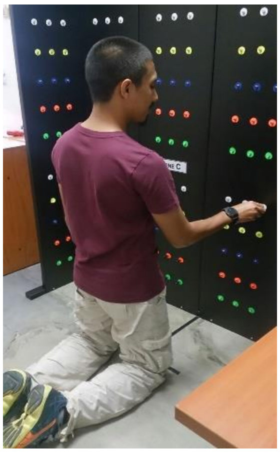
3.3.4.2 Crouching Reach

Crouching Reach			
Forward (highest)		Reverse (lowest)	
Start (Panel 2, Zone C)	End (Panel 3, Zone C)	Start (Panel 3, Zone C)	Start (Panel 2, Zone C)
			

Procedure:

1. The respondent is instructed to transfer five rows of pegs from Panel 2 (Zone C) to the holes in Panel 3 (Zone C).
2. The respondent must remove the peg from the hole with left hand, transfer it to right hand, and then place the peg into the corresponding hole with the right hand.
3. The procedure begins with the highest level row and works its way down to the lowest level row.
4. After repositioning fifteen pegs, the procedure is repeated in reverse order until all fifteen pegs are restored to their original positions. This achieves one repetition.
5. Repeat procedure 2, 3 and 4 until four repetition.

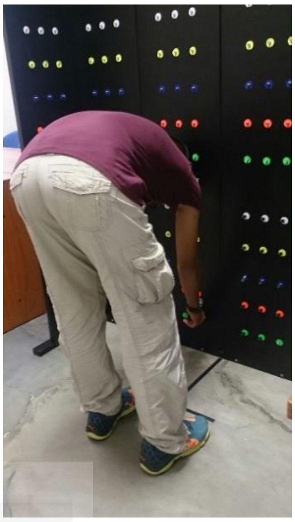
3.3.4.3 Kneeling Reach

Kneeling Reach			
Forward (highest)		Reverse (lowest)	
Start (Panel 2 Zone C)	End (Panel 3 Zone C)	Start (Panel3 Zone C)	End (Panel 2 Zone C)
			

Procedure:

1. The respondent is required to transfer five rows of pegs from Panel 2 (Zone C) to the holes in Panel 3 (Zone C).
2. The respondent must remove the peg from the hole with left hand, transfer it to right hand, and then place the peg into the corresponding hole with the right hand.
3. The process starts with the highest level row and then proceeds in order to the lowest level row.
4. After repositioning fifteen pegs, the procedure is repeated in reverse order until all fifteen pegs are restored to their original positions. This achieves one repetition.
5. Repeat procedure 2, 3 and 4 until four repetition.

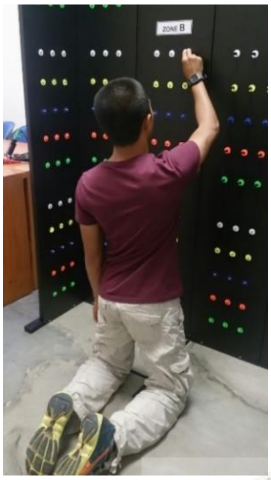
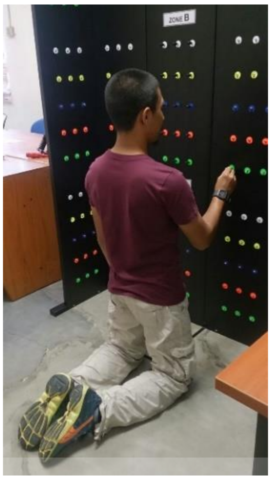
3.3.4.4 Stooping Reach

Stooping Reach			
Forward (highest)		Reverse (lowest)	
Start (Panel 2, Zone B)	End (Panel 3, Zone B)	Start (Panel 3, Zone B)	End (Panel 2, Zone B)
			

Procedure:

1. The respondent is required to transfer five rows of pegs from Panel 2 (Zone C) to the holes in Panel 3 (Zone C).
2. The respondent must remove the peg from the hole with left hand, transfer it to right hand, and then place the peg into the corresponding hole with the right hand.
3. The procedure begins with the highest level row and works its way down to the lowest level row.
4. After repositioning fifteen pegs, the procedure is repeated in reverse order until all fifteen pegs are restored to their original positions. This achieves one repetition.
5. Repeat procedure 2, 3 and 4 until **FIVE (5)** repetition.

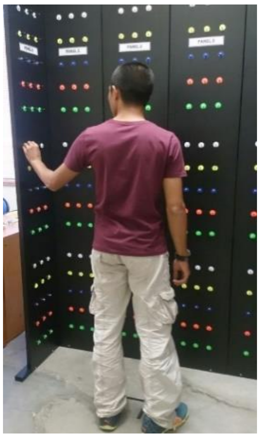
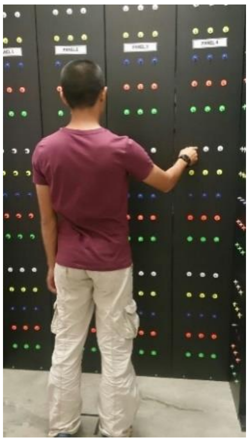
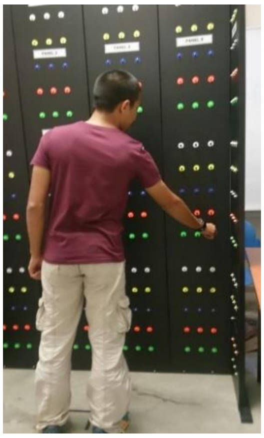
3.3.4.5 Kneeling with Upper-Level Reach

Kneeling Upper Level Reach			
Forward (highest)		Reverse (lowest)	
Start (Panel 2 Zone B)	End (Panel 3 Zone B)	Start (Panel 3 Zone B)	End (Panel 2 Zone B)
			

Procedure:

1. The respondent is required to transfer five rows of pegs from Panel 2 (Zone B) to the holes in Panel 3 (Zone B).
2. The respondent must remove the peg from the hole with left hand, transfer it to right hand, and then place the peg into the corresponding hole with the right hand.
3. The procedure begins with the highest level row and works its way down to the lowest level row.
4. After repositioning fifteen pegs, the procedure is repeated in reverse order until all fifteen pegs are restored to their original positions. This achieves one repetition.
5. Repeat procedure 2, 3 and 4 until four repetitions.

3.3.4.6 Axial Rotation Reach

Axial Rotation Reach			
Forward (highest)		Reverse (lowest)	
Start (Panel 6, Zone B)	End (Panel 4, Zone B)	Start (Panel 4 Zone B)	End (Panel 6, Zone B)
			

Procedure:

1. The respondent is required to transfer five rows of pegs from Panel 6 (Zone B) to the holes in Panel 4 (Zone B).
2. The respondent should stand in the middle of the board assembly, about 15 inches from the panel, while performing the test to achieve back rotation.
3. The respondent must remove the peg from the hole with left hand, transfer it to right hand, and then place the peg into the corresponding hole with the right hand.
4. The procedure begins with the highest level row and works its way down to the lowest level row.
5. After repositioning fifteen pegs, the procedure is repeated in reverse order until all fifteen pegs are restored to their original positions. This achieves one repetition.
6. Repeat procedure 3, 4 and 5 until another four repetition.

3.3.5 Estimation of muscle characteristic during FROM

Six activities for respondents to take part in each repeat about four repetitions. So, the data can be categorized into two conditions, which is fit and fatigued muscle. Fit muscle condition is the first two repeatition that shows the muscle not overwork while the third and the fourth procedure repeatition can achieve fatigue level to the muscle usage.

3.3.6 Matlab

After respondents do the prescribed activities above, data from the electromyography (EMG) board, Shimmer is taken and transferred to Matlab software. In the Matlab software, researcher applied the "signal analysis technique" in the coding to get the output of raw EMG signal, Fast Fourier Transform (FFT), Root Mean Square Voltage (V_{rms}) and the spectrogram.

3.3.6.1 Signal Analysis Technique

Signal analysis technique that uses in this study is mainly two which is frequency analysis technique and spectrogram analysis technique.

3.3.6.2 Frequency Analysis Technique

Mathematical methods for converting a signal from a time domain to the frequency domain are Fast-Fourier Transform (FFT). Discrete Fourier Transform (DFT) is a digital filtration method that estimates the magnitude and phase of the discrete frequencies. The frequency characteristics of the EMG signal are evaluated via the FFT. FFT can be defined as:

$$X(f)^n = \int_{-\infty}^{\infty} x(t)\, e^{-j2\pi ft} dt \qquad 3.1$$

Where :

X(f) = The signal in frequency domain

x(t) = The signal of interest

3.3.6.3 Spectrogram Analysis Technique

Spectrogram is to make up the limitation of Fast Fourier Transform (FFT) to catering for non-stationary signals with spectral features over time. It gives a time frequency representation (TFR) energy signal distribution and can be calculated as follows:

$$S(t,f) = \left| \int_{-\infty}^{\infty} x(\tau) w(\tau - t) e^{-j2\pi t o \tau} dt \right|^2 \qquad 3.2$$

Where :

x(τ) = The input signal

w(t) = The observation window

3.3.7 Frequency Resolution

$$\text{Frequency Resolution, } F_{res} = \frac{fs}{N} \qquad 3.4$$

Where :

f_s = sampling frequency

N = No. of sample

3.3.8 Peak Frequency

Peak Frequency, $F_{peak} = F_{res} \times n$ (3.5)

Where :

F_{res} = Frequency Resolution

n = x-axis peak value

3.4 Equipment

Equipment that use in this project

3.4.1 Shimmer EMG

The electromyography (EMG) device Shimmer is equipped with a digital front end which can be adjusted for physiology detecting signals for EMG. A Shimmer EMG sensor is used to research and analyse the biomechanics of human or animal movement and measures nerve conduction, tissue-wound muscle response, and activation levels. Become a non-invasive (surface) EMG sensor of the Shimmer EMG. It represents the entire muscle activity. The wireless technology offers cost-effective access to various muscles, motion and posture information. EMG data are available in two channels which the data can be measured at the same time simultaneously.

Figure 3.8 Shimmer EMG board

3.4.2 Consensys Software

Consensys is software that interacts with Shimmer's sensors and provides your live data, control data and devices with plenty of capability. It is developed for the fieldappropriate collection of human data, large scale repeat trials, and the control of several sensors in general. There are Consensys software functionalities that configure Shimmer sensors. In addition, consensys software can use real-time data, and obtained data can also be managed. There are two different types of consensys software. Consensys basic and consensys pro.

Figure 3. 9 Consensys Software

3.4.3 Matlab Software

MATLAB can do matrix operations, visualize functions and data, implement the algorithm, design the user interface, and interact with programme in other languages.

Figure 3.10 Matlab Software

3.4.4 Pegboard

To test a patient's capacity to move things, the examiner may utilize the Functional Motion Range (FROM) pinboard.

Figure 3.11 Pegboard

3.4.5 Summary

This chapter starts with the representation flowchart regarding this project. Then, there is an explanation about the experimental setup with details about capturing data EMG signal using Shimmer equipment that been connected with Consensys Software. Based on the procedure, there is six prescribe activity that needs to do to get the data. In addition to that, the use of signal analysis technique which is FFT and spectrogram to the EMG signal obtained from the previous activity to get the information of muscle condition. Lastly, there are listed equipment that uses in this project.

CHAPTER 4

RESULTS AND DISCUSSIONS

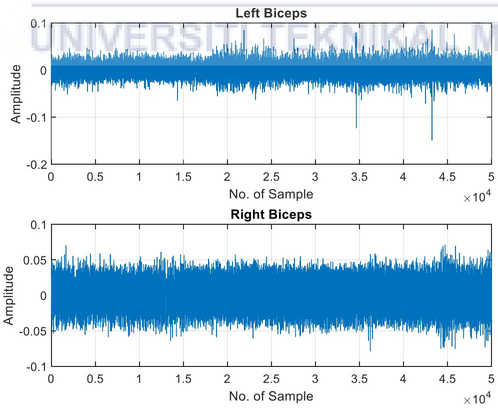
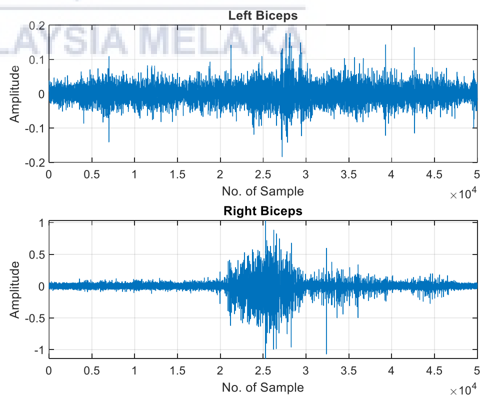
4.1 Introduction

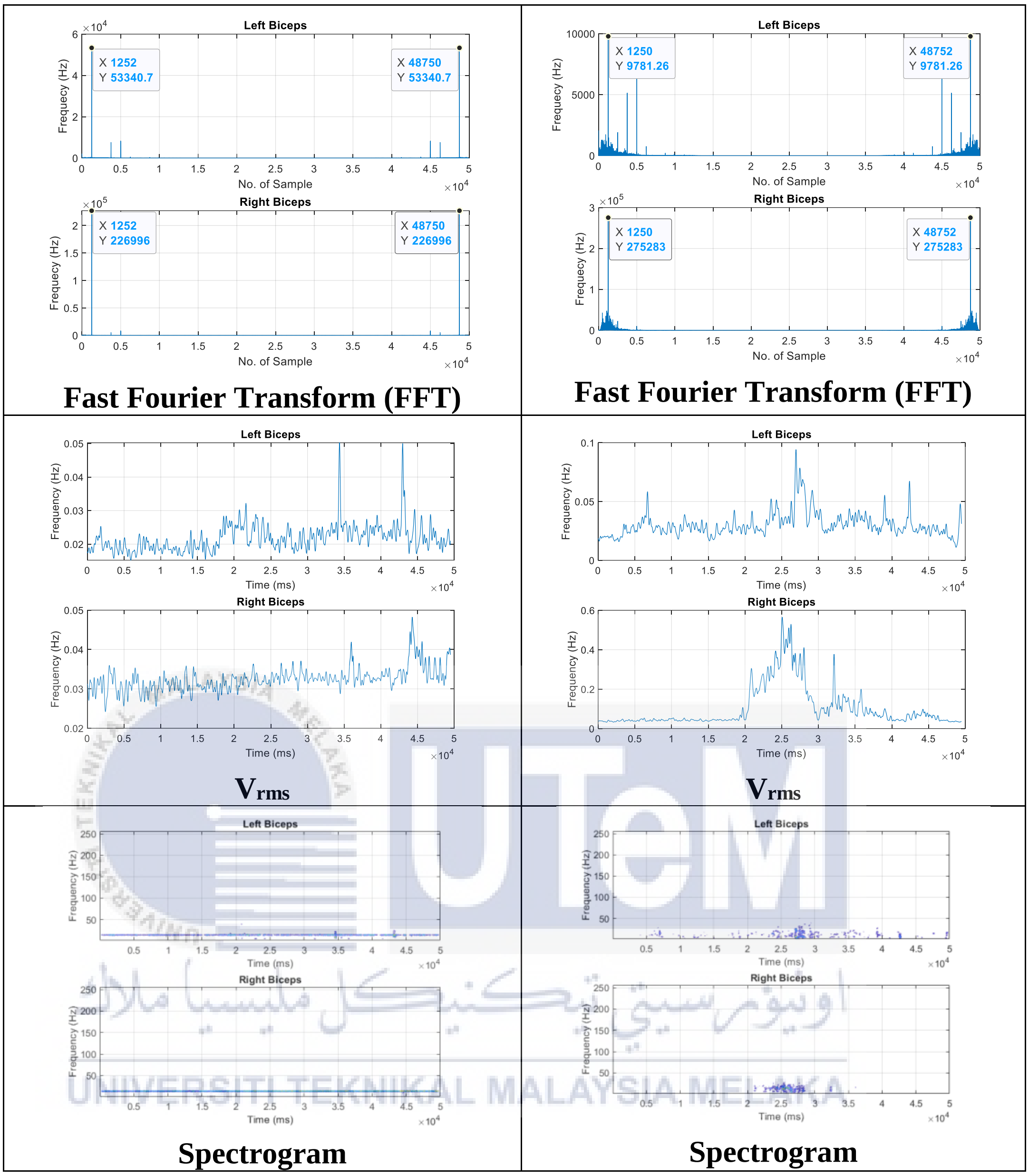
In this chapter, the result of the experiment is presented. There are three muscles involve in this experiment which are biceps, trapezius and erector spine. Each of these three muscles has thier own data. Matlab helps in getting the output such as raw electromyography (EMG) signal, fast fourier transform (FFT) and spectrogram by using the analysis technique that been put in the coding. Then, the condition for fit and fatigue can be categorized.

4.2 Results

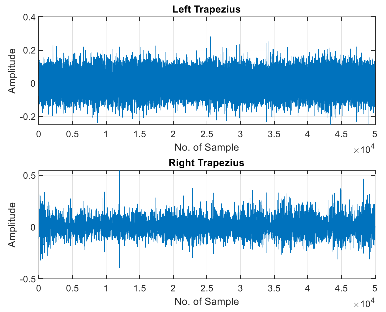
Types of muscle

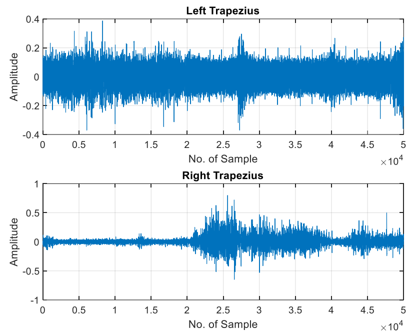
- Biceps

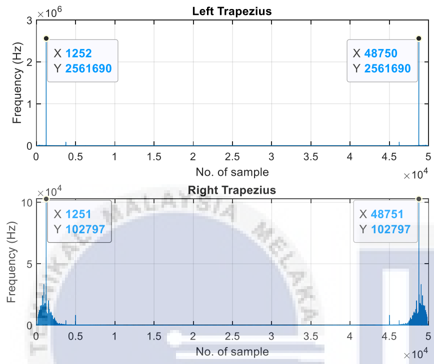
Fit	Fatigue
	
Raw EMG signal	**Raw EMG signal**

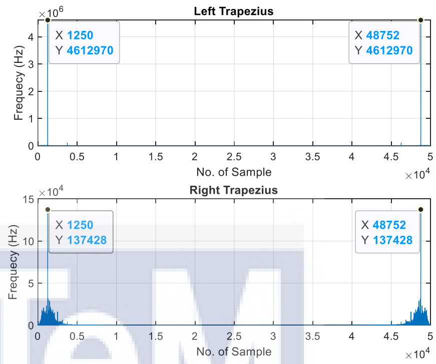

Left Biceps
Right Biceps
Frequecy (Hz)
No. of Sample
X 1252
Y 53340.7
X 48750
Y 53340.7
X 1252
Y 226996
X 48750
Y 226996
X 1250
Y 9781.26
X 48752
Y 9781.26
X 1250
Y 275283
X 48752
Y 275283
Fast Fourier Transform (FFT)
Fast Fourier Transform (FFT)
Frequency (Hz)
Time (ms)
Vrms
Vrms
Spectrogram
Spectrogram

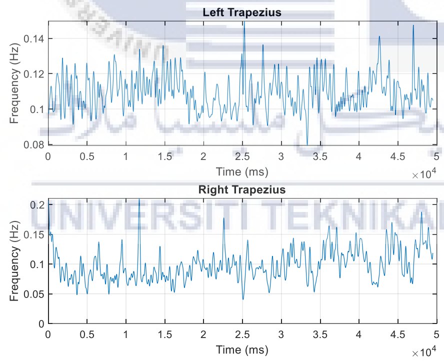
- Trapezius

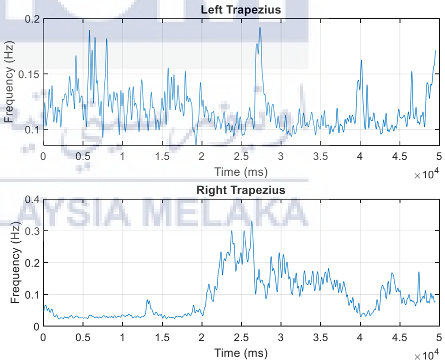
<table>
<tr><th>Fit</th><th>Fatigue</th></tr>
<tr><td>

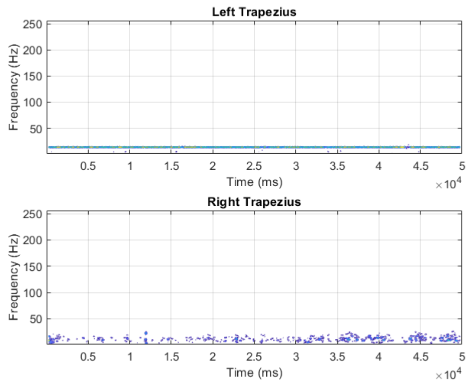
Raw EMG signal</td><td>

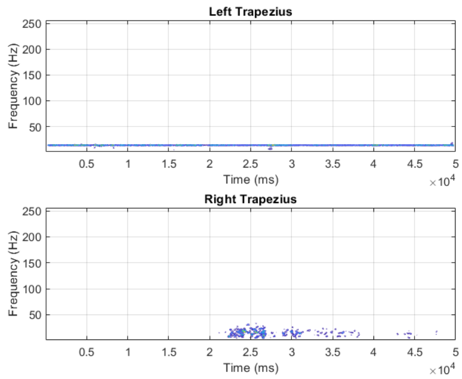
Raw EMG signal</td></tr>
<tr><td>

Fast Fourier Transform (FFT)</td><td>

Fast Fourier Transform (FFT)</td></tr>
<tr><td>

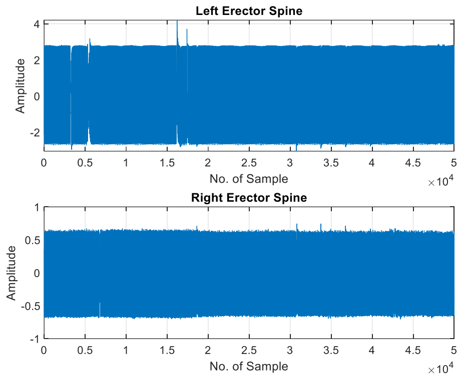
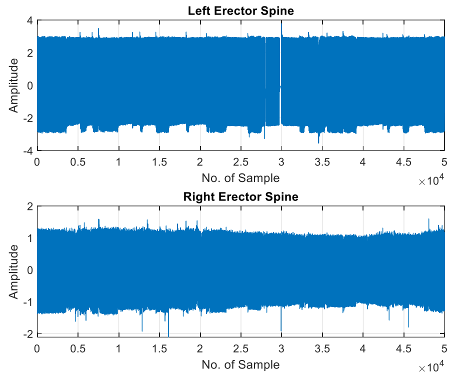
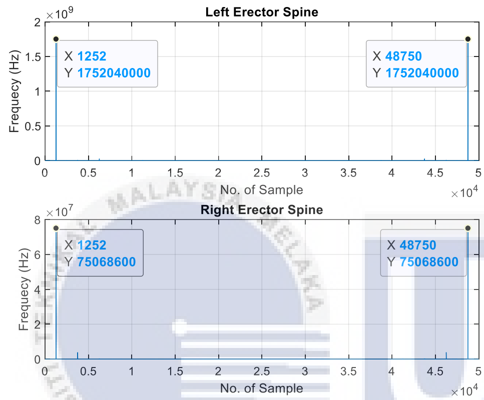
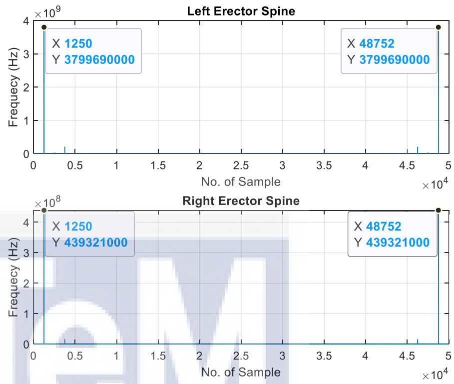
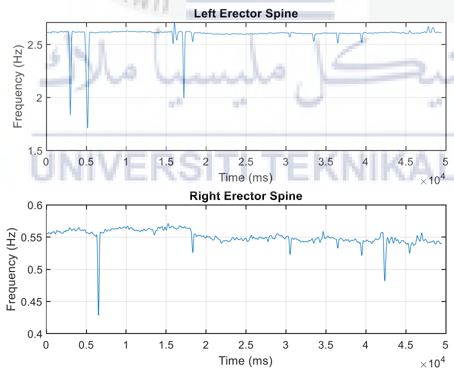
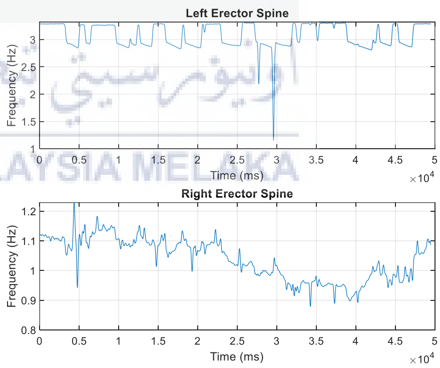
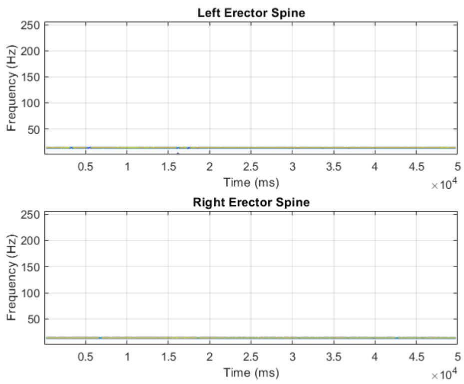
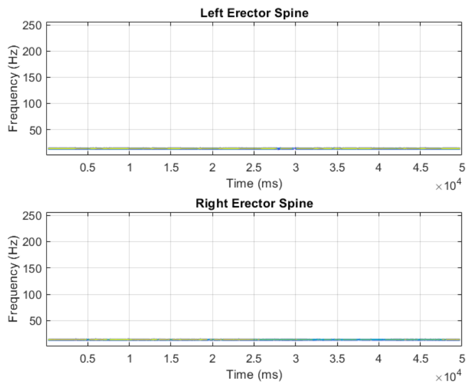
V_{rms}</td><td>

V_{rms}</td></tr>
<tr><td>

Spectrogram</td><td>

Spectrogram</td></tr>
</table>

- Erector Spine

<table>
<tr><th>Fit</th><th>Fatigue</th></tr>
<tr><td>
Raw EMG signal</td><td>
Raw EMG signal</td></tr>
<tr><td>
Fast Fourier Transform (FFT)</td><td>
Fast Fourier Transform (FFT)</td></tr>
<tr><td>
V_{rms}</td><td>
V_{rms}</td></tr>
<tr><td>
Spectrogram</td><td>
Spectrogram</td></tr>
</table>

4.3 Fast Fourier Transform (FFT) Analysis

Based on the graph output for Fast Fourier Transform (FFT), the theoretical value for Frequency Resolution, F_{res} and Peak Frequency, F_{peak} can be calculated.

Due to the value of each muscle is around the same which is(x-axis peak, n = 1250,1251 and 1252) value, so researcher only take the calculation for biceps muscle.

$$\text{Frequency Resolution, } F_{res} = \frac{fs}{N}$$

Where :

f_s = sampling frequency = 2000Hz

N = No. of sample = 50000

$$\text{Frequency Resolution} = \frac{fs}{N} = \frac{2000Hz}{50000} = 0.04\text{Hz}$$

Peak Frequency, $F_{peak} = F_{res} \times n$

Where :

F_{res} = Frequency Resolution = 0.04Hz

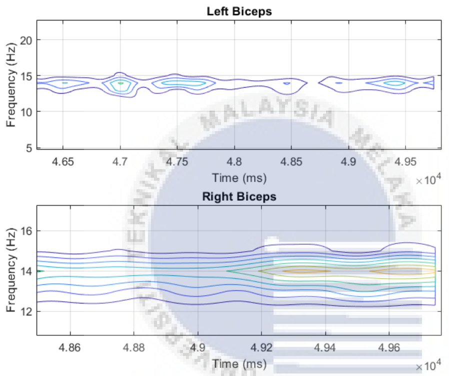
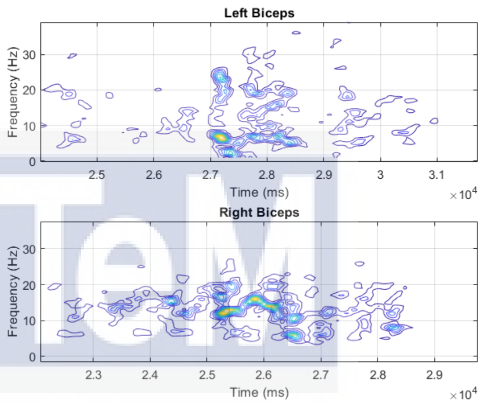
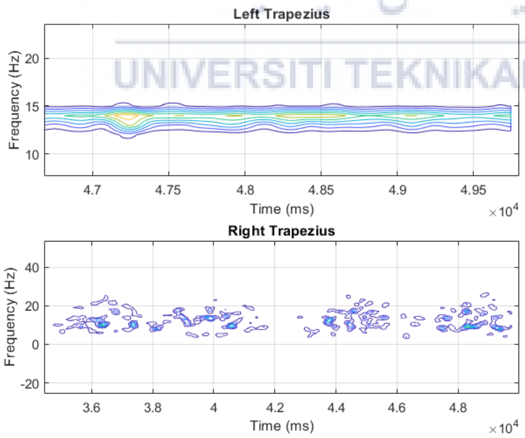
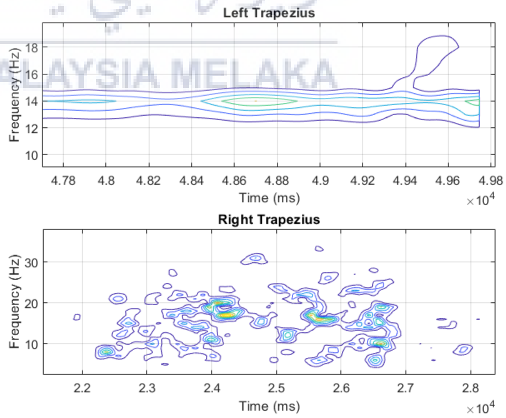
n = x-axis peak value = 1251

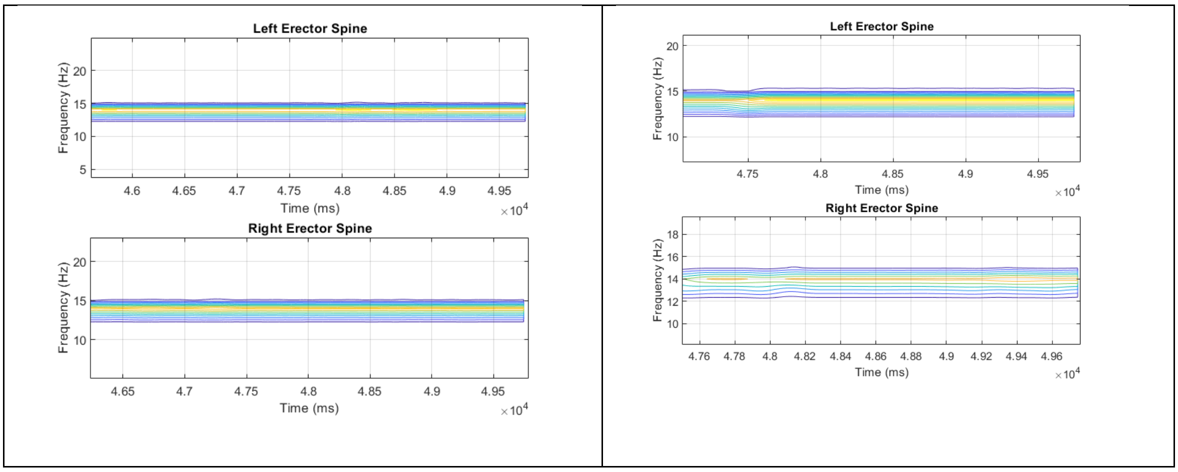
$$\text{Peak Frequency, } F_{peak} = F_{res} \times n = 0.04\text{Hz} \times 1251 = 50.04\text{Hz}$$

From the calculation, the first method FFT cannot categorized between both data which is fit and fatique muscle condition.

4.4 Spectrogram Analysis

Due to the failure of FFT analysis, researcher find another way to distinguish the muscle condition between both data. From both spectrogram signal, there is different between those two. Then spectrogram signal at each muscle part zoom in to see the details of the data taken.

Fit	Fatigue
	
	



For fit muscle conditions, the spectrogram signal shape is constant or maintained for the whole data signal. This is due to the low consumption of muscle energy use. However, fatigue muscle spectrogram shape is more compact at a specific data part. This is due to the high consumption of muscle energy use. By doing this method, this also can check whether people have condition for the musculoskeletal disorders (MsD) or not. During this test, the respondents is healthy person without MsD background. For the MsD patients, the data should be different from this data taken. This is because the MsD condition are injuries that affect the muscle. So the data electromyography (EMG) signal get from the MsD problem should be abnormal or different from the data that taken from this experiment.

4.5 Performance of spectrogram

Unlike waveform, spectrogram does not display the changes in signal amplitude over time but shows frequency over time plus amplitude as the third dimension. This means that spectrogram gives more detail and is helpful in music production. Furthermore, this paper suggests that the spectrogram's method can be used in the presence of electromyography (EMG).

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This chapter is an overview for the whole project. After completing the experiment, all of the project objectives have been met. The first objective is to analyze electromyography (EMG) signals using signal analysis technique for musculoskeletal disorders (MsD) during the health screening task. Data taken for the EMG signal is processed in Matlab to get the Fast Fourier Transform (FFT) and spectrogram. From the both signal output, muscle fatigue can be categorized that can help distinguish in the process to search the MsD patient. The next objective is to estimate the muscle characteristics from the signal analysis technique during the Functional Range of Motion (FROM) task. There are six activities that respondents need to take part in. These exercises help during data capture from each chosen muscle part: the trapezius, biceps, and erector spine. Estimation for the signal characteristic is that the signal can be categorized into two conditions which are normal and fatigued muscle conditions. The last objective is to evaluate the performance of the signal analysis technique by using a spectrogram. A spectrogram can represent time, frequency and amplitude in one output. A waveform is not as detailed as the spectrogram due to only representing amplitude and time. The use of spectrogram means the data can be analyzed more accurate and with better performance than the conventional waveform method.

5.2 Future Works

For future improvements, hoping the use of spectrogram and electromyography can be more mainstream and put into practice in the real world. Also, there are other thing that i think EMG can improve :

i) Development for advance use of electromyography (EMG) such as for bionic arm patient that make up for the lost arm.

ii) User-friendly interface for EMG software to help user do task related to EMG. EMG software for now such as Consensys software quite confusing and difficult to use.

iii) Cost for device regarding EMG is expensive for today use but hopefully the price will be more cheaper in the near future.

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