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**SEMG FEATURES EXTRACTION FOR BACK MUSCLE
IMPAIRMENT**

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SEMG FEATURES EXTRACTION FOR BACK MUSCLE IMPAIRMENT

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**A report submitted in partial fulfillment of the requirements for the degree of
Bachelor in Electrical Engineering (Control, Instrumentation & Automation)**

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2014

I declare that this report entitle “*SEMG Features Extraction for Back Muscle Impairment*” is the result of my own research except as cited in references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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ABSTRACT

Nowadays, people give an extra effort to enhance their performance as compared to health care to improve the quality of life. They just focus and evaluate their health based on the physical fitness but neglected the condition of their muscle. If those things are left continues, it will cause a problems such as Low Back Pain (LBP) and this will affect their daily lives. Within the past decade, many researchers have come out with a new method and investigation to prevent from LBP because of growing demand from healthcare provider and realization of the important of back illness care. Besides that, due to the development of bio-medical and healthcare application, there are several ways that can be used to monitor the muscle status. One of them is by using Electromyography. This research is carried out in order to detect the muscle condition of back muscle and surface electromyography (SEMG) technique that have been used to detect the electrical signal produce by multifidus muscle. A group of 10 healthy people without LBP and 5 healthy people with LBP have been chosen in order to determine the muscle fatigue index during dynamic contraction activity which are sit to stand and stand to sit activities in real life. Data collected will be extracted by using time domain and frequency domain before classify the subjects into two group respectively, normal and LBP group. Neural network is used as classification method to classify between normal and LBP group. Based on classification part, neural network able to classify between normal between LBP groups but the classification result is not good enough due to the EMG machine specification and level of back pain faced by LBP subjects. As a conclusion, SEMG is able to extract features from EMG signal and the multifidus muscle can be used to produce an electrical signal to monitor muscle condition. Besides that, the finding and limitation of this study is good tools to enhance the EMG development in the future.

ABSTRAK

Pada masa kini, orang ramai lebih memikirkan mengenai taraf kehidupan seharian berbanding kesihatan diri. Mereka cenderung untuk menilai kesihatan diri berdasarkan kecergasan fizikal luaran dan mengabaikan keadaan otot dalaman. Sekiranya dibiarkan berterusan, ia akan menyebabkan masalah seperti sakit belakang (LBP) dan ini akan memberi kesan kepada kehidupan harian mereka. Dalam beberapa tahun yang lalu, ramai penyelidik telah menyediakan satu kaedah baru dan penyelidikan bagi mengelak masalah LBP kerana orang ramai telah mulai sedar mengenai kepentingan menjaga dan mengawal penyakit berkaitan bahagian belakang selain permintaan yang semakin meningkat daripada pembekal penjagaan kesihatan. Selain itu, ekoran kemajuan dalam bidang bio-perubatan dan penjagaan kesihatan telah menunjukkan terdapat beberapa cara bagi memantau keadaan otot dalaman manusia. Salah satu daripadanya adalah dengan menggunakan Electromyography (EMG). Kajian ini telah dijalankan untuk mengesan keadaan otot belakang dengan menggunakan teknik Electromyography permukaan (SEMG) untuk mengesan isyarat elektrik yang dihasilkan oleh otot multifidus. Sekumpulan 10 orang yang sihat tanpa dan 5 orang yang sihat dengan LBP telah dipilih untuk menentukan indeks keletihan otot semasa aktiviti penguncupan dinamik iaitu duduk – berdiri dan berdiri – duduk. Data yang dikumpulkan akan diekstrak dengan menggunakan domain masa dan frekuensi sebelum diklasifikasikan subjek kepada dua kumpulan, kumpulan biasa dan kumpulan LBP. Rangkaian neural telah digunakan sebagai kaedah klasifikasi untuk mengklasifikasikan di antara kumpulan normal dan LBP. Dari bahagian klasifikasi, rangkaian neural dapat mengklasifikasikan diantara golongan normal dan LBP tetapi keputusan klasifikasi tidak cukup baik ekoran spesifikasi mesin EMG dan tahap sakit belakang yang dihadapi oleh subjek LBP. Kesimpulannya, SEMG mampu mengekstrak ciri-ciri dari EMG dan otot multifidus boleh digunakan untuk menghasilkan isyarat elektrik untuk memantau keadaan otot. Penemuan baru dan batasan kajian ini adalah cara terbaik untuk meningkatkan proses pembangunan EMG pada masa akan datang.

This research of “SEMG Features Extraction for Back Muscle Impairment” (ID-54) has been accepted to be presented in IEEE EMBS INTERNATIONAL STUDENT CONFERENCE 2014 (ISC2014).



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CHAPTER 1

INTRODUCTION

This chapter provides information regarding to background of the study, problem statements, and objectives of the study. This chapter also explains the scope of the study. The outline of how the study will be conducted also presented in this chapter.

1.1 INTRODUCTION

Health concerns and better quality of the working environment are the areas where workers from various sectors put in higher consideration today. Productive, performance and high commitments in their duty are always referred to healthy workers with the support of conducive working environment. Status of health could be determined from physical fitness, external examination, clinical diagnosis, and through other various interpretation [1]. According to Disabilities Act, person who have long term or continuous mental, physical and rehabilitation process which prevent them from participate with social and other activities are defined as persons with disabilities [2].

Malaysia Community Oriented Program for the Control of Rheumatic Diseases (COPCORD) statistic shown almost 11.6 % of Malaysian population experience or still undergo treatment on Low Back Pain Disease [3]. Low Back Pain (LBP) is defined as a disorder involving the muscle and bones of the back and there are three stages of LBP which is acute, Sub-chronic and Chronic [4]. LBP was one of the important health problems that affecting not only the workers, but also a general population all over the world. Yong Hu,

Joseph N.F. Mak, KDK Luk [4] stated that the pain can be triggered by bad body posture during standing or sitting for a long period, lifting incorrectly, bending awkwardly and repetitive activities.

Generally, Back Pain known as pain that felt in the back area of the body and usually Back Pain caused by muscular disorder that involved muscles, nerves, joints or bone structures that support the spine [5]. There are two types of Back Pain which are Lower Back Pain and Upper Back Pain [5]. Upper Back Pain is pain or uncomfortable felt in the top half of the back area and also in the neck and shoulder [6]. Meanwhile, Low Back Pain is pain or muscle tension that localized below the costal margin and above on the inferior gluteal folds [5]. In the other word, LBP is known as common disorder that involved muscle at the back area. From the medical view, LBP defined as Lumbosacral region is triggered by some combination of overuse and injury to the muscles that support the spine [7]. Besides that, LBP has become a common reason of work absence and visiting the doctor. George E. Ehrlich also mentions that there are three types of muscle that involved with the LBP [7]. Longissimus Thoracis muscle on Vertebra 1, Iliocostalis Lumborum muscle in Vertebra 2 and Multifidus muscle on Vertebra 5 are the type of muscle that always involved with the back analysis [4].

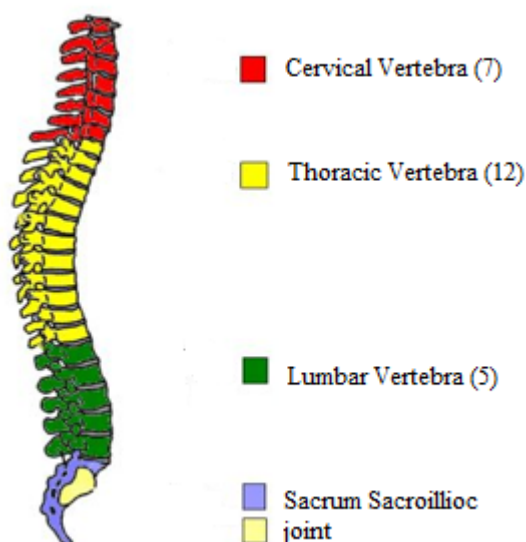


Figure 1.1: Region of spine [26]

There are several activities that will contribute to LBP problem such as lifting improperly, making a sudden movement, falling down, poor posture and carrying excess

body weight [4]. Based on statistic, 11.6% of Malaysia population have or experience the LBP and 69% of them report that LBP affected their daily activities [3]. There are three stages of LBP which are Accute (less than 6 week), Sub-chronic (between 6 – 12 week) and Chronic (12 week and above). All of these three stages are based on the duration of the pain experienced by the LBP patients.

1.2 BACKGROUND

Nowadays, there are several researchers focus mainly on integrating biological components with mechanical and electrical. Bio-signal are one type of signal that generated by the human body and produce a useful information from biological beings [8]. There are several types of bioelectric signal widely used in medical application such as Electromyogram (EMG), Electroencephalogram (EEG), and last but not least Electrocardiogram (ECG). Each of this bioelectric signal has a different purpose and application [8]. Due to the development of bio-medical and healthcare application, there are several ways that can be used to monitor the muscle status. One of them is by using Electromyography.

People today put an extra effort to enhance their performance compared to health care to improve the quality of life. They just focus and evaluate their health based on the physical fitness, but neglected the condition of their muscle. If those things are left continues, it will cause a problem such as LBP and this will affect their daily lives. Within the past two decades, many researchers have come out with a new method and investigation to prevent LBP due to the growing demand from healthcare providers and the realization of the importance of back illness care [9]. The Low Back is the connection between the lower and upper body and mostly back pain caused by the body's weight. There are several factors that will cause a LBP and this research was held in order to detect the muscle condition to prevent from the LBP problem. This research will focus more on the muscle fatigue index for several activities and the signal extraction for the Low Back Impairment. Muscle fatigue is defined as the decline in muscle ability to generate force or in other words muscle fatigue is the reduction of muscle ability to contract and exert a force for prolonged duration [9].

When human muscle undergo a similar or repetitive activities for long time, it will cause a muscle fatigue and if that situation happen, human daily activities and performance are affected [10]. There are several researches focus more on back muscle fatigue for the last two decades and the result showed that people with LBP comes out with faster response compared to normal people. Muscle fatigue can be classified by using visual inspection, either in time domain analysis, frequency domain analysis or time-frequency analysis. Frequency domain analysis will observe the power spectrum density and shift it to a lower frequency meanwhile time domain will cause an increasing in amplitude during the muscle fatigue.

This research will focus on time domain and frequency domain because the features such as root mean square (RMS), median frequency (MDF) and mean frequency (MF) are compatible to detect the muscle fatigue during activities. There are two kinds of activities related to this LBP disease which are isometric contraction and dynamic contraction. Isometric contraction is activity held without or less motion or in other words, muscle length and joint angle are not moving or change during contraction [11]. Meanwhile, dynamic contraction is activity that including motion and force, or muscle shorten and changing the joint angle while dealing with force [12]. This research will focus more on dynamic contraction because to monitor the muscle fatigue between normal people and LBP people, the best way is by doing repetitive activities [7].

1.3 MOTIVATION

Nowadays, muscular problem accounts for almost half of the cases of work absence, with the most regions involved are back area of shoulder [3]. Recently, several companies have invented equipment's that can be used to diagnose numbers of illness for human. X-ray, Ultrasound, magnetic resonance imaging (MRI), Electromyography (EMG), and CT scan are famous equipment that is widely used in diagnosis study of human problems. All of these equipment's functions are wave and resonance based. Simple, easy, effective, accurate are the reasons these equipment's is intensively used in determining and diagnosing of human illness. The numbers of people with the LBP problems are increasing not only in Malaysia but all over the world. Based on that fact, the growing demand and awareness of LBP from a health care provider are also increasing. Basically LBP problem may due to

several factors such as rugged life style, unsuitable working environment, carry out high intensive muscular activity, and other influences. This problem is believing due to strains from over exertion, tendonitis from over use, shoulder joint instability, dislocation, collar and upper arm bone fractures, frozen shoulder, pinched nerve etc. In order to identify the LBP problem in the early stage, EMG machine was used to detect the electrical signal produced by the muscle and from the collected data, we can classify either the person has a LBP problem or not. This research carried out in order to gain the knowledge about EMG and experience on how EMG data can be used in applications. Besides that, this research also will identify the significant activities that will cause a LBP problem in our daily life and how to prevent from LBP problem. Although lack of knowledge and information, by doing research, it can motivate students and other researchers to study and explore more problems related to any EMG signals.

1.4 PROBLEM STATEMENT

Most of LBP are caused when human carried out similar or repetitive tasks for prolonged periods. Statistical data shows that the most medical visit done by people are related to LBP and this proves the importance of prevention of LBP problem. There are two kinds of activities may cause a LBP which is isometric contraction and dynamic contraction. Most of the LBP patients related to their work background and in real human life, human will use most of the back area muscle to support their daily activities.

In order to detect LBP problem in the early stage, surface EMG (SEMG) had been used to analyze the characteristic between normal and LBP patient. Based on previous researches, mostly EMG has very small amplitude levels, besides different subject will vary different EMG signals even for the same muscle activity. Several factors such as skin resistance, noise interruption, muscle involved and electrode location will directly influence the dominant EMG signals. In order to avoid the incorrect signal collected, many considerations need to be given while collecting the data from the beginning until completed.

Besides that, this research will focus more on time domain and frequency domain in order to analyze the data collection and comes out with the signal extraction for normal people and LBP patient by using RMS, MF and MDF features.

1.5 OBJECTIVE

The objectives to be achieved in this project are:

1. To extract the features of SEMG in time and frequency domain.
2. To analyse and evaluate the extracted signal by using statistical analysis.

1.6 SCOPE

In order to achieve the objectives of this research, there are several scopes as listed. To determine either the EMG machine can diagnose the LBP problem, there are several criteria need to be considered. First is the subject selection which are 10 healthy people without LBP and another 5 people with LBP. Selection of participant with LBP have been conducted in Hospital Melaka and Klinik Pelajar, UTeM to ensure that only participant who have experience or undergo a treatment for LBP are involved. Next, to detect the electrical signal produce by the muscle, subject will go through a repetitive activities which are sit to stand and stand to sit and the muscle involved for this research is multifidus muscle at Lumbar Vertebra 5. Surface EMG has been used to detect the electrical signal produce by the muscle during the dynamic contraction activities.

Then after the process of collecting data finished, the next step is to analyze and evaluate the extracted signal from each participant. In this step, two methods have been used for features extraction which are time domain and frequency domain. The extracted signal will be shown in a scatter plot and histogram at the end of the research.

CHAPTER 2

LITERATURE REVIEW

This chapter provides the theoretical and information on previous study related to EMG. This chapter also explains the muscle involved, types of electrode, noise source, the relationship between EMG and LBP based on previous study.

2.1 MULTIFIDUS MUSCLE

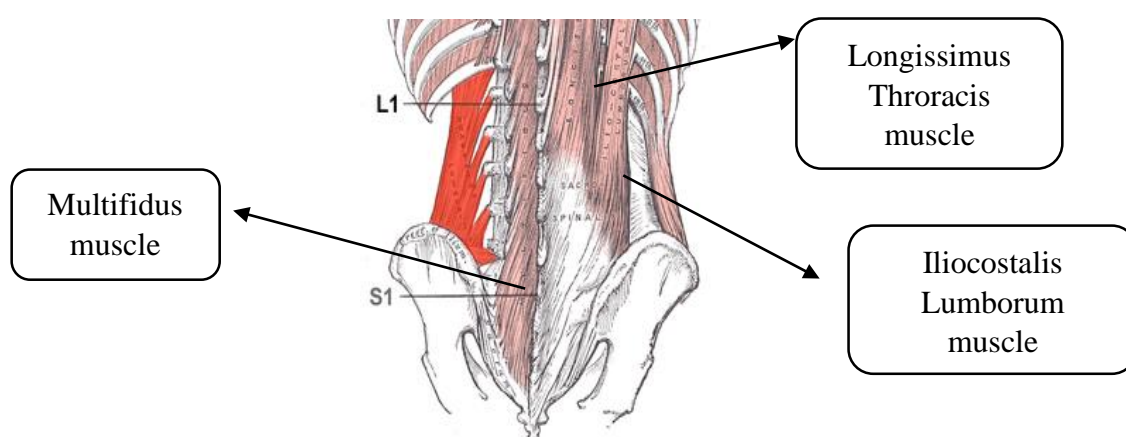


Figure 2.1: Muscle involved with LBP [13]

According to George E. Ehrlich [7] multifidus muscle consists of a number of fleshy and tendinous fasciculi, which fill up the groove on either side of the spinous processes of the vertebra, from the sacrum to the axis. In other words, multifidus muscles are muscles that run up and down along the back of the spine, and are important for keeping the spine straight

and stable during many common movements such as sitting, walking and lifting [14]. Multifidi is the plural form of these muscles and in Latin it means many to cleave. Most anatomical texts use the muscles in the singular form or multifidus. Basically, these muscles help to stabilize the sacrum, ilium and lumbar.

Nowadays, multifidus muscle has become very well-known because of new research linking it to back pain. Based on previous research, many researchers found out that in some people with low back pain, it's not always the whole multifidi muscle group that is the problem. In many cases, it's just a single multifidus muscle at only one level of the spine that's not working. Due to the fact that there are many multifidus muscles that span the vertebrae from the sacrum to the cervical spine, it makes it possible that a single multifidus muscle can act upon and articulate one vertebrae at a time. Mark S Emley, L. Donald Gilmore and Serge H. Roy proposed that multifidus muscle can be used to detect the electrical signal produce by muscle in order to diagnosis either the subject have LBP problem or not [9].

2.2 ELECTROMYOGRAPHY (EMG)

Electromyography (EMG) is a bio-signal which measures the electrical signal produced by muscle movements [15]. Gregory S. Rush [16] stated that EMG can measure a muscle strength and endurance besides, the best way to collect data from muscle especially lower back muscle. Basically, EMG signal is an electrical signal that produced by several sources during the activation of muscle motor units. All the signal are non-stationary and commonly analyze in term of signal amplitude, frequency content that referred to the reference signal [16]. There are four most common research area has been done by using EMG which are muscle activation, force, body part and movement. All these four types of research are related between each other or also known as Kinesiological analysis.

According to Peter Konrad [17], there are two types of EMG available to measure the EMG signal, which are surface (non-invasive) and intramuscular (invasive) EMG. Surface EMG will use tiny devices known as electrodes placed apply on the selected muscles skin compare with Intramuscular need wire, that use fine wire as an electrode and choose to insert into selected muscle [17]. The advantage of using Surface EMG is it can pick-up large

zone of depolarization comparing with intramuscular technique [18]. Gregory S. Rash stated that surface EMG only applies at superficial muscles and indwelling paste on profound muscles [16]. Both of them are suitable usage to measure the EMG signal but based on previous research, surface EMG is more suitable and less risk for the patient [19]. Surface EMG is extensively applied in many applications, for example, physical therapy, treatment of incontinence, sports training, motion analysis, research, studies in the workplace, product design and certification [10]. EMG process begins when a muscle is activated by the impulse to contract, will result in a movement of ions between the inside and outer membranes of muscle cells. This situation will cause depolarization. Depolarization will generate or produce an electromagnetic field around muscle fibers and will move along the muscle fibers. This can be seen when the electrodes can detect voltage contacts along the muscle fibers. This voltage pulse is defined as muscle fiber action potentials [14].

Klasser GD and Okeson JP mention that in these recent years, the demanding of surface EMG to recording the muscle activities in clinical protocols have increased [10]. The use of surface EMG nowadays are not limited only in clinical protocols such as diagnosis of neurological and spinal problems, but has been widely used in various fields such as laboratory research, biomechanics, motor control, physical therapy and movement disorders [10]. After some research and improvement, researchers have a better understanding of the properties of the surface EMG recording.

2.3 ELECTROMYOGRAPHY IN LBP

In these recent years, advances in bio-signals technology has interest many researchers to study on muscle disorder especially LBP. There are several methods can be used to diagnose LBP problem such as EMG, X-ray and etc. [10]. According to Kleissen RFM, Buurken JH, Harlaar J and Zilvold G [14], nowadays surface EMG are widely used in the rehabilitation process because it can measure the muscle condition directly while comparing with others equipment's. Besides that, EMG also don't burden the LBP patient and less risk while completed the research or rehabilitation process. EMG used an electrode pasted on the selected muscle location.

2.4 THEORY OF ELECTROMYOGRAPHY

Electromyography is a technique for evaluating and recording the electrical activity produced by skeletal muscle [9]. The electrical activities produce by the muscle fibers during any contraction will generate an EMG signal and during a contraction, nervous system will control the muscle activity [9]. EMG are performed by using an instrument called an electromyography in order to produce a signal record called an electromyogram. This process is done when the electromyography detects the electrical potential generated by muscle cells where there are activities done by electrically or neurologically [8]. An EMG uses tiny devices called as electrodes to transmit or detect the electrical signals from muscle during several activities. Surge H. Roy proposed that electromyography is a good solution to study about muscle conditions related to the Low Back Pain problem [20]. There are two types of EMG electrodes that widely used in medical field. Intramuscular fine needle electrode and Surface electrode is a type of electrodes that always been used for medical purpose especially in the rehabilitation process. Surface EMG is using surface electrode meanwhile traditional EMG uses a fine needle to detect the muscle activities [217]. There are several factors that can influence the shape and characteristic of the EMG signal. Tissue characteristics, change in geometry between muscle belly and electrode site, physiological cross talk will influence the EMG signal and this process known as a Poisson process due to the impulse process for neuron pulses [21].

2.5 TYPE OF ELECTRODE

Surface electrode is an example of non-invasive electrode that have been used for measuring muscle electrical activities during muscle contraction. The surface electrodes are divided into two main groups which are passive and active electrodes. Passive electrodes have no inbuilt circuitry including amplifiers and filter [17] besides this electrodes require gel to overcome a high impedance during muscle contraction. Meanwhile, for active electrode, it has built-in amplifier and filter which are they decrease movement artifacts and increase the signal to noise ratio [22].