UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ELECTROMYOGRAPHY (EMG) ANALYSIS OF BACKPACK WEIGHT ON MUSCLE ACTIVITIES OF THE LOWER AND UPPER EXTREMITY

This report is submitted in accordance with the requirement of Universiti Teknikal Malaysia Melaka (UTeM) for Bachelor's Degree of Electrical Engineering Technology (Industrial Automation & Robotics) with Honours

by

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DECLARATION

I hereby, declare that this report entitled "Electromyography (EMG) analysis of backpack weight on muscle activities of the lower and upper extremity" is the result of my own research except as cited in references.

Signature : ……

Name : ……

Date : ……

APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as one of the requirements for the award of Bachelor's Degree of Electrical Engineering Technology (Industrial Automation & Robotics) with Honours. The following are the members of supervisory committee:

……

(Supervisor)

DEDICATION

To my beloved parents, Hii Wie Ngii and Tiong Lee Kie for raising me become who I am today. It is also dedicated to my supervisor who taught and guided me when I faced the problem of doing this project.

ABSTRACT

Nowadays, backpack become an important part of people's everyday life. Different people carry backpacks for different purposes. For students, they normally fill backpacks with books and stationeries, while hikers fill them with hiking tools, tents and supplies. Actually, there is some significant association between backpacks weight and occurrence of back pain. When you put a heavy weight on your shoulders more than 10% of your body weight [1], the weight's force can pull you backward. To compensate, you may bend forward at the hips or arch your back. This can cause your spine to compress unnaturally. Over time this can cause the shoulders to become rounded and the upper part of back become curved. The purpose of the present study is to analyse the lower and upper extremity muscle activities during the carriage of different backpacks. In this project, the different size of backpack: (1) unloaded; (2) 10% body weight (BW) load (in the form of backpack); (3) 15% BW load and (4) 20% BW load are measured while fixing the gender as a constant. Subject is required to bear with 4 different size of load to walk 50m far of track. The electromyography (EMG) signal from erector spinae (upper extremity) and biceps femoris (lower extremity) were collected by using Visual Basic when the weight of backpack is vary. EMG signal raw data will be analysed using MATLAB 2012 by frequency and time domain algorithm. EMG signal analysis techniques which are EMG raw signal view and Fast Fourier Transform (FFT) will be used for comparison. FFT is used to identify the peak power spectrum of each different tasks. EMG signal performance is present in terms of average voltage ($\bar{V}$) against period of time (s). Through EMG signal, the performance of muscle contraction (PMC) able to be identified based on the peak voltage from the identified phases. The graphical user interface (GUI) is built to display the signal analyzed from lower and upper extremity.

ABSTRAK

Pada masa kini, beg galas menjadi bahagian penting dalam kehidupan seharian. Setiap individu membawa beg galas untuk tujuan yang berbeza. Bagi pelajar, mereka biasanya mengisi beg galas dengan buku-buku dan alat tulis, manakala pendaki bukit atau gunung mengisi beg dengan alat mendaki, khemah dan bekalan. Sebenarnya, terdapat beberapa hubungan yang signifikan antara beg galas dengan berat badan dan berlakunya sakit belakang. Apabila anda meletakkan beban berat di atas bahu anda lebih daripada 10% daripada berat badan anda [1], daya boleh menarik anda ke belakang. Untuk mengimbangi, anda boleh bengkok ke hadapan pada bahagian pinggang atau belakang. Hal ini boleh menyebabkan tulang belakang termampat secara luar biasa. Jika berterusan, boleh menyebabkan bahu menjadi bulat dan bahagian atas belakang menjadi melengkung. Tujuan kajian ini adalah untuk menganalisis aktiviti-aktiviti otot hujung yang lebih rendah dan sederhana semasa membawa beg galas yang berbeza. Dalam projek ini, saiz yang berbeza, beg: (1) tidak beban; (2) 10% berat badan (BB) (dalam bentuk beg); (3) 15% beban lebih dari BB dan (4) 20% beban lebih BB diukur manakala jantina ditetapkan malar. Subjek dikehendaki menanggung 4 saiz beban dan berjalan sejauh 50m. Electromyography isyarat (EMG) daripada pemasang spinae (hujung atas) dan bisep femoris (hujung bawah) telah dikumpulkan dengan menggunakan Visual Basic apabila berat beg galas adalah berbeza-beza. Isyarat data mentah EMG akan dianalisis menggunakan MATLAB 2012 dengan kekerapan dan masa domain algoritma. EMG teknik analisis isyarat yang melihat isyarat mentah EMG dan Jelmaan Furier pantas (FFT) akan digunakan untuk perbandingan. FFT digunakan untuk membuat analisis isyarat dengan mengenal pasti spectrum kuasa puncak dalam tugasan yang berbeza. EMG prestasi isyarat hadir dari segi purata Voltan ($\bar{V}$) berbanding dengan tempoh masa (s). Melalui isyarat EMG, prestasi penguncupan otot (PMC) dapat dikenal pasti berdasarkan voltan puncak dari fasa yang dikenal pasti. GUI akan dibina untuk memaparkan isyarat EMG dari hujung bawah dan atas badan subjek.

ACKNOWLEDGEMENT

Firstly I would like to express my utmost gratitude and appreciation to my supervisor, Madam Saleha Binti Mohamad Saleh, who has guided and encouraged me along this semester. The supervision and supports from her is truly helping the progression of my project.

The utmost appreciation also goes to my family. With their love and encouragement, I am tough to go through the obstacles come to me. Last but not least I would like to thanks all my friends especially who has helped me in every possible way to complete this report.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVATIONS, SYMBOLS AND NOMENCLATURES

EMG	-	Electromyography
BW	-	Body Weight
LBP	-	Low Back Pain
GUI	-	Graphical User Interface
FFT	-	Fast Fourier Transform
STFT	-	Short-Time Fourier Transform
RMS	-	Root Mean Square
N/A	-	Not Available
PMC	-	Performance of Muscle Contraction

CHAPTER 1
INTRODUCTION

1.1 Introduction

Nowadays, backpack become an important part of people's everyday life. Students often loaded their school bag with all the books and supplies for the whole day. Observation based on the group amongst secondary school students, the repetitive stress of carrying heavy school bags may contribute to the high prevalence of musculoskeletal symptoms [2]. Pascoe et al. (1997) investigated the impact on posture of youths aged 11-13 years while carrying a 17% BW load on their back [3]. A backpack promoted significant forward lean of head, neck, shoulders and trunk. Other studies are focused on the other backpackers like industrial, military or recreational. The carry even higher loads and backpacks compared to students. There will be high potential for back pain to occur among those backpackers.

1.2 Problem Statement

Studies over the last decade show 13-50 per cent of 11-17 year olds have experienced back pain (Gardner& Kelly 2006, Vaughan et al 2007). For most parents, it's an achievement to get the children to school in time with everything they need. The combined weight of everything they have to carry to and from school is causing growing concern among back specialists. Overburdened can led to chronic back pain, back stress fractures growth plate cartilage inflammation, back and shoulder nerve damage. Most injuries in construction workers are sprains and strains of the muscles. Construction work can also cause injuries to the joints, bones, and nerves. Workers

who do overhead work, tend to have many more shoulder and neck problems. The more force user have to exert, the greater the stress on user body.

1.3 Objective

There are several objective that need to be achieved:

i. To identify the EMG signal from the upper extremity and lower extremity during the muscle contraction with the adding of different size of loads.
ii. To analyze the EMG signal using frequency and time domain algorithm.
iii. To build a Graphical user interface (GUI) to display the performance of the analysed method.

1.4 Scope

Some of important element must be consider in order to achieve the objective of the study.

i. 10 Males university students of age 21- 24 years old, height: 170- 190cm, Weight: 60-80 kg. The subjects with this criteria are selected as the participants in this study. Those subjects with recent injury, postural deformities, spine surgery, and history of low back pain (LBP) are excluded.
ii. The backpacks was filled with sand weights to weigh 10%, 15% or 20% BW of each subject.
iii. Erector spinae (upper extremity), biceps femoris (lower extremity) muscle activities will be recorded using surface electromyography (SEMG).
iv. The data signal will be stored in Visual Basic.
v. EMG signal raw data will be analysed using MATLAB 2012 by using frequency and time domain algorithm.
vi. EMG signal analysis techniques which are EMG raw signal view and Fast Fourier Transform (FFT) will be used for comparison.

1.5 Outline of the project

This report consist of five chapter. First chapter is general introduction. In this section, the reader will know about my project background, objective, problem statement and scope in my research. The literature review in chapter 2 will indicate which studies have already done on the same or related topics in my research. Appropriate citations would include recent peer- reviewed articles published in regionally, nationally, or internationally recognized professional journals and books. Besides that, I will present about methodology in my chapter 3. In this chapter, I will explain the method that will be used to collect the data, analyse the EMG signal and display the performance of EMG signal. In chapter 4, I will present the result and discussion which include the graph analysis in MATLAB, data collection and information about the building of GUI in visual basic. Last but not the least, in chapter 5, I will cover about the summary of the research, achievement of objective, limitation of project and future work as well.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

This chapter is actually the reading of the work of others before commencing on muscle activities of the lower and upper extremity of body and electromyography signal analysis. Literature review can pave the way for better research. It help in identifying the relevance of electromyography signal analysis on muscle activities. The literature done based on the previous researches will help to recommend better methods uses in this research. It might be aid to developing my study.

2.2 Backpack as a daily load for schoolchildren

According to the research done by Stefano, there has 34.8% of Italian schoolchildren carry more than 30% of their bodyweight at least once a week, exceeding limits proposed for adults [4]. The load that children most commonly carry is their school bag or backpack. Stefano done the studied in the school catchment area of Bresso, Milan. He ascertained the weight of the backpacks of all the year 6 children at the school (n= 237, mean age 11-6 years [SD 0- 34], 119 girls). The data were collected daily on 6 days at school (from Monday to Saturday) over a period of 3 weeks. Refer to the table 2.1, the average load carried daily by Italian schoolchildren was 9.3kg (maximum 12.5kg), and the maximum load was 11.5kg (maximum 16.3kg).

	Median (Range) Average Load (Kg)			P
	All Children	Boys	Girls	Boys vs girls
Average Load	9.3 (4.4-12.5)	9.4(7.2-11.5)	9.1 (4.4-12.5)	0.171
Maximum Load	11.5 (6.8-16.3)	11.9(8.6-16.3)	11.2 (6.8-15.1)	0.048

Table 2.1: The weekly average of daily backpack loads of Italian schoolchildren [4]

The figure 2.1 shows the average backpack load and bodyweight of the students. The researcher found no correlation between anthropometric characteristics and average load or maximum load; the limits usually proposed (10-15% of bodyweight) were exceeded. Mostly, the rates of low back pain occurs in adult but now the schoolchildren also have high risk to get low back pain because of exceeding backpack in their daily life.

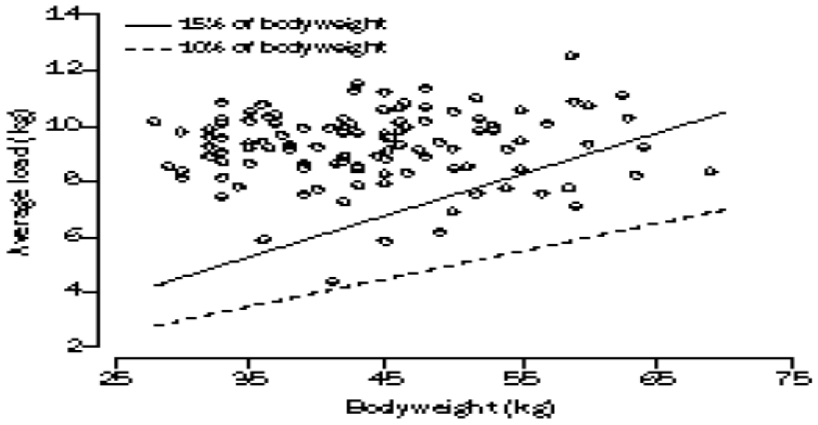

Figure 2.1: The average backpack load and bodyweight ratio [4]

This problem not only happen in Bresso, Milan. It also have same situation happen in Malaysia. In Malaysia, school bag weight carried by students in primary school has also become a major concern. A non- scientific survey conducted in a primary school was done by Nor Azli in kuala Lumpur. She found that most of the students regarded

carrying school bag as heavy job [20]. A recent study by Fazrolrozi and Rambely (2008) reported that more than 90% of the first year students (mean age 6.5 years) and more than 70% of the second year students (mean age 7.5 years) carried backpack loads of greater than 15% of their body weight to school nearly every day[21]. Hence, in this study three primary schools were randomly selected from a list Naional Sschool (NS), Chinese Medium School (CMS) and Tamil Medium School (TMS) schools in Kuala Lumpur in order to obtain a representative cross section of Kuala Lumpur primary school. Refer to the statistical analysis done by Nur Azli, the mean weight of school bags carried by the students was 6.40 (±2.51) kg. Based on the types of school, the mean weight of school bags was 4.55(±1.62) kg, 8.53((±1.94) kg and 6.06 (±2.09)kg for NS, CMS and TMS, respectively. The students who carried school bag which more than 10% of body weight is 80.1% [20]. Table 2.2 below show the school bag weight carried by Malaysians according to three different types of school:

Table 2.2: School bag weight according to types of school [20]

	NS	CMS	TMS	Total
Mean Schoolbag Weight (SD), Kg	4.55 (1.62)	8.54 (1.94)	6.06 (2.09)	6.40 (2.51)
Mean Weight of necessary learning materials (SD), Kg	3.91 (1.45)	8.54 (1.94	4.09 (1.81)	4.80 (1.97)
Mean weight of unnecessary materials (SD), kg	0.64 (0.91)	2.18 (1.49)	1.96 (1.56)	1.60 (1.57)
Mean % of schoolbag weight of body weight (SD)	11.72 (4.82)	22.02 (7.32)	16.04 (7.10)	16.64 (7.76)
Carried schoolbag>10% of body weight, n (%)	72 (60.5)	120 (98.4)	97 (82.9)	289 (80.1)

2.3 Low back pain (LBP) in schoolchildren

Low backpack is common in young people and has a marked impact on daily life although it is unlikely to lead them to seek doctor. In common with other studies of low back pain in children, prevalence increase across the teen age years (Fairbank et al., 1984; Nissinen et al.,1994; Grimmer and Williams, 2000) [6],[7],[8]. From the research done by Kath D. Watson et al. [5], the target a group of schoolchildren aged

between 11 and 14 years to determine the one month period prevalence of low back pain, symptom characteristics and related disability cause by low back pain. The researcher conducted a cross- sectional survey in secondary schools in Cheshire and North Derbyshire, North- West England. School children aged between 11 and 14 years participating schools in the area were compulsory take part in the study. Two related questions about low back pain is asked in the study: (1) 'Did you ever experience low back pain which lasted for one day or longer?' (2) 'Did you experienced pain in the shaded area (refer figure 2.2) which lasted for one day or longer?' Students are required to respond both question positively.

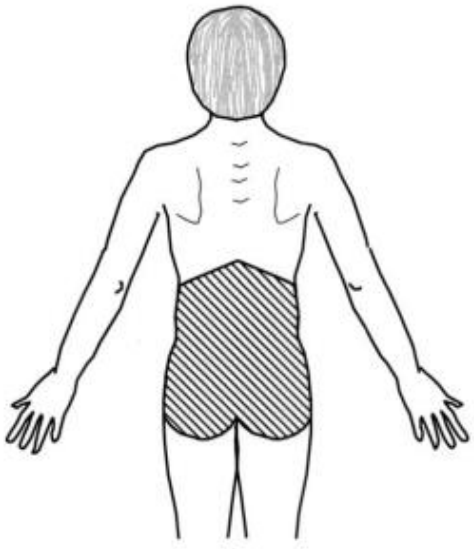

Figure 2.2: Defining of low back pain according to the shaded area [5]

The data is collected by using a visual analogue scale (VAS) ranging from 0 to 10. The low back pain questions were fully completed by 1376 schoolchildren. From the result, the researcher found that overall the one month period prevalence of low back pain was 23.9%. Girl reported a higher prevalence (28%) than boys (19%) and in both genders prevalence increased with age from 11-14. Among those with low back pain, 42% reported that symptoms normally lasted only 1-2 days (boys 39%, girls 44%) while 15% reported symptoms occurring for longer than 7 days. 31% of students reported radiating leg pain [5]. The disability activities reported with low back pain is carrying bag, sitting, sport, lying down, standing, bending, running, reaching up to get a book form a high shelf. Nevertheless, the most difficulty were carrying a school bag which having 65% students reported about this disability. The backpack load

contributes to low back pain [9], [10] and also becoming a disability of carrying backpack after their suffering the low back pain.

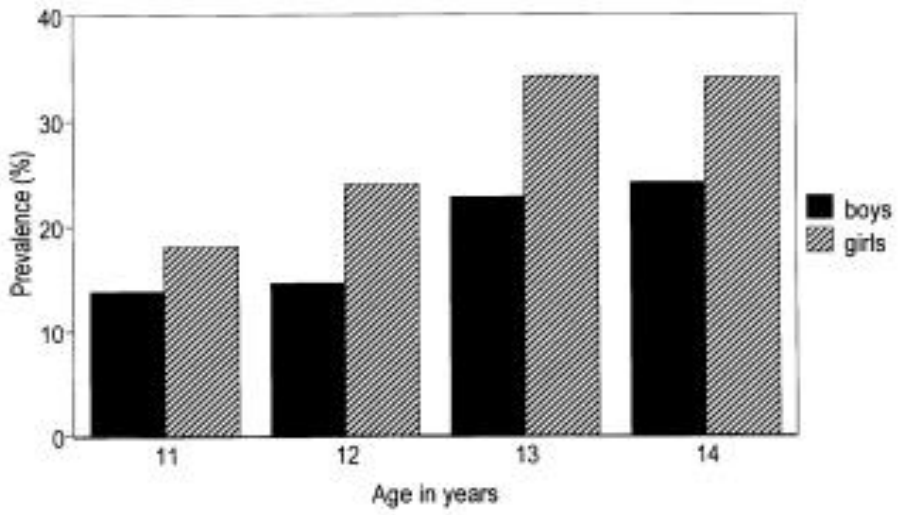

Figure 2.3: Period prevalence of low back pain by gender and age [5]

At the same research done by Nur Azli, the occurrence in three different types show high percentage which is 66.7% to 87.4%. The occurrence is highest in NS in which 104 of 119 students reported back pain (87.4%) [20].

Table 2.3: Perceived back pain and its association between the types of school [20]

Back pain	NS n(%)	CMS n(%)	TMS n(%)	Total n	X^2	p value
Yes	104 (87.4%)	83 (68.0%)	78 (67.0%)	265	16.64	0.00
No	15 (12.6%)	39 (32.0%)	39 (33.0%)	93		
Total	119	122	117	358		

2.4 Lower and Upper Extremity

In my study, I am going to analyse the performance of Electromyography (EMG) signal at Erector spinae (upper extremity) and biceps femoris (lower extremity).

2.4.1 Method of determine the orientation of erector spinae

Erector spinae muscle sites were determined at the level of the L4-L5 interspace, 2 cm lateral to the midline [12]. From the general sources, the erector spinae is a large muscle that originates near the sacrum and extends vertically up the length of the back. It lies on each side of vertebral column and extends alongside the lumbar, thoracic and cervical sections of the spine. The erector functions to straighten the back and provides for side- to- side rotation. An injury or strain to this muscle may cause back spasms and pain. Undoubted, if overloaded backpack carrying by human will influence or injury the erector spinae muscle. Hence, in this study, I am also going to investigate how the weight of a backpack could influence the activation of erector spinae muscle by using electromyography analysis.

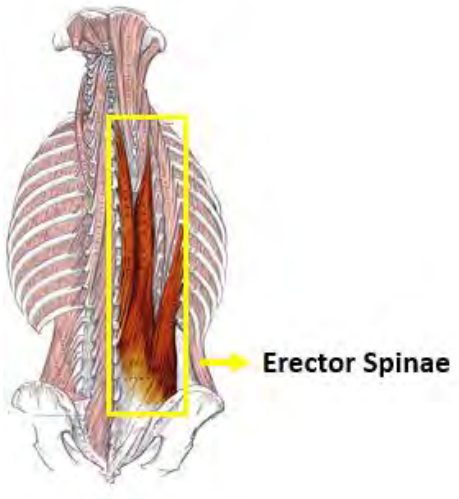

Figure 2.4: The Position of erector Spinae [25]

2.4.2 Method of determine the orientation of biceps femoris

Biceps femoris were sites at 50% on the line between the ischial tuberosity at the lateral condyle of the tibia [12]. From the others sources, the biceps femoris is a double- headed muscle located muscle located on the back of thigh. It consists of two parts: the long head, attached to the ischium (the lower and back part of the hip bone), and the short head, which is attached to the femur bone. The biceps femoris muscle is important for knee flexion, internal and external rotation, and hip extension. Pain in the biceps femoris can be caused by several reasons. The most common condition is a strained muscle caused by too muscle exercise, overloading, and improper lifting. So, in this study I also will investigate how the weight of a backpack could influence the activation of biceps femoris muscle by using electromyography analysis.

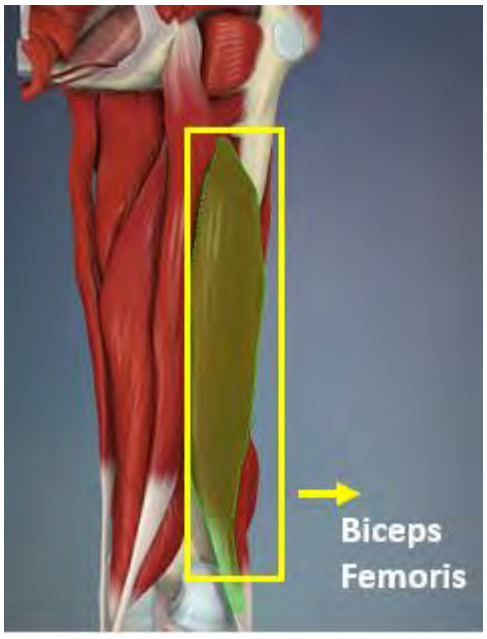

Figure 2.5: The Position of biceps femoris [25]