



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**MUSCLE ACTIVITY ANALYSIS USING SURFACE
ELECTROMYOGRAPHY (sEMG) FOR PASSENGER WHILE
RIDING MOVING TRAIN IN PROLONGED STAND**

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Manufacturing Engineering Technology (Process and Technology) with Honours.

by

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering Technology (Process and Technology) with Honours. The member of the supervisory is as follow:

.....

(PM Dr Wan Hasrulnizam bin Wan Mahmood)

ABSTRAK

Tujuan projek ini adalah untuk mewujudkan maklumat mengenai faktor risiko yang berkait dengan ketidakselesaan dan keletihan otot semasa berdiri dalam kereta api; menganalisis aktiviti otot penumpang semasa menaiki kereta api yang bergerak dalam keadaan berdiri dalam jangka masa yang panjang. Untuk metodologi penyelidikan, soal selidik yang berkaitan dengan berdiri dalam jangka masa yang panjang diedarkan kepada KTM Berhad penumpang untuk mendapatkan maklumat yang berkaitan dengan faktor risiko yang menyebabkan ketidakselesaan dan keletihan otot. Surface Electromyography (sEMG) digunakan untuk mengukur dan menganalisis aktiviti otot di *erector spinae*, *gastrocnemius* dan *tibialis anterior*. Kajian soal selidik dan sEMG telah dijalankan di KTM Komuter Berhad. Seramai 20 orang pelajar menjadi subjek untuk analisis sEMG. Aktiviti otot subjek diukur selama 1 jam dan 30 minit berdiri berterusan daripada awal perjalanan, tengah perjalanan, dan akhir perjalanan di KTM Komuter Berhad yang mengembara sepanjang 18 stesen dari stesen Pulau Sebang / Tampin ke stesen KL Sentral. Hasil daripada analisis soal selidik, semua responden mengalami keletihan psikologi akibat berdiri yang berpanjangan semasa menaiki kereta api yang bergerak. Begitu juga, keletihan otot telah dikenal pasti melalui pengukuran sEMG iaitu hanya satu otot iaitu *gastrocnemius* tidak mengalami kelesuan otot semasa subjek menaiki kereta api yang bergerak dalam keadaan yang berdiri berpanjangan. Hasil ujian statistik bukan parametrik menggunakan korelasi urutan peringkat Spearman, mendapati bahawa terdapat hubungan positif antara keletihan subjektif dan keletihan otot. Kajian ini menyimpulkan bahawa berdiri dalam jangka masa yang panjang menyumbang kepada keletihan otot di kalangan penumpang apabila menaiki kereta api bergerak. Keputusan daripada hasil kajian ini dapat memberi kesedaran kepada para penumpang untuk meminimumkan ketidakselesaan dan keletihan otot apabila menggunakan KTM Komuter Berhad.

ABSTRACT

The purposes of this project is to establish information on risk factors pertaining to discomfort and muscle fatigue associated with prolonged standing; analyse muscle activity of passengers while riding moving train in prolonged standing. The questionnaire was distributed to KTM Komuter Berhad passengers to establish information on risk factors relating discomfort and muscle fatigue. A Surface Electromyography (sEMG) was used to measure and analyze muscle activity in the erector spinae, gastrocnemius, and tibialis anterior inside the train. A total of 20 students participated as subjects for sEMG measurement. The muscle activity of the subjects was measured for 1 hours and 30 minutes of continuous standing during the beginning of travel, middle of travel, and end of travel in KTM Komuter Berhad which travel along 18 stations from Pulau Sebang/Tampin station to KL Sentral station. The results of the questionnaire surveys revealed that all respondents experienced psychological fatigue due to prolonged standing in a moving train. Similarly, muscle fatigue has been identified through sEMG measurement and according to the results of the myoelectric level, only one muscle which is right gastrocnemius muscle did not experience fatigue during all travel sessions. The non-parametric statistical test using the Spearman's rank order correlation found that there is a positive correlation between subjective fatigue and muscle fatigue. The study concluded that standing in a long period of time is a cause of muscle fatigue experienced by the passengers while riding moving train in prolonged standing. Results of this study can provide awareness to the passengers in order to minimize discomfort and muscle fatigue when traveling using KTM Komuter Berhad.

DEDICATION

This thesis is dedicated to my husband, who had taught me the best kind of knowledge. It is also dedicated to my family who always support me during my studies. Special thanks to my supervisor, associate professor Dr Wan Hasrulnizam bin Wan Mahmood for supervision. And also to my beloved friends who keep giving me encouragements of completion of this thesis.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

Abbreviations

BMI	-	Body Mass Index
EMG	-	Electromyography
ERA	-	Ergonomic Risk Assessment
KTMB	-	Keretapi Tanah Melayu Berhad
LBP	-	Low Back Pain
MDF	-	Median Frequency
MPF	-	Mean Power Frequency
MS	-	Mean Square
MSD	-	Musculoskeletal Disorders
MUAP	-	Motor Units Action Potential
OSHA	-	Occupational Safety and Health
RPE	-	Rating Perceived Exertion
sEMG	-	Surface Electromyography
SENIAM	-	Surface Electromyography Non-Invasive Assessment Of Muscles
SPSS	-	Statistical Package for the Social Sciences
VAS	-	Visual Analogue Scale
WRMSD	-	Work-Related Musculoskeletal Disorders

Nomenclature

Hz	-	Hertz
$\sqrt{\text{MSE}}$	-	Square Root of Mean Squared Error
μV	-	Micro Volt

CHAPTER 1

INTRODUCTION

1.1 Project Background

Musculoskeletal disorders (MSD) is frequently prescribed with ergonomics. In other words, MSD is the issue and ergonomics is a solution. Soft tissues such as tendons or muscles of the human body's movement or musculoskeletal system affected by MSD. Furthermore, musculoskeletal disorders are currently among the most widespread occupational pathologies. It has previously been observed that by Plamondon et al., (2017), MSDs are essentially more common in women (1.3%) than in men (7.6%). When the MSD is related to the work, it known as a work-related musculoskeletal disorder (WRMSD). MSD account for large cases of job-related injury and illness. Muscle fatigue is one of the factors lead to MSD. In order to prevent the MSD, many methods were developed to assess MSD risk factor exposure (Chiasson et al., 2012). The effort to examine the reasons of MSD in recent years expanding to make a move to prevent them.

There are two categories that exposure to risk factors; ergonomic risk factors and individual-related risk factors. In ergonomic risk factors, there are many factors but this research is focused on awkward postures. Refer to Figure 1.1 due to the risk factor that exposure to MSD. This project proposed assessment method associated with prolonged standing while riding moving train. About 57 percent being female riders, were invented of 60 percent commuters mostly to educational centers and workplaces are using Keretapi Tanah Melayu Berhad (KTMB) Komuter as a public transportation (Bachok et al., 2014). According to Halim et al., (2012) all muscles decreased their performance after two hours of standing lead to discomfort and muscle fatigue based on Surface Electromyography (sEMG) due to prolonged standing in a long period of

time. Research changes postural position more or less frequent, usually by shifting body weight from one leg to the other during periods of prolonged standing to minimize discomfort and pain (Ringheim et al., 2015).

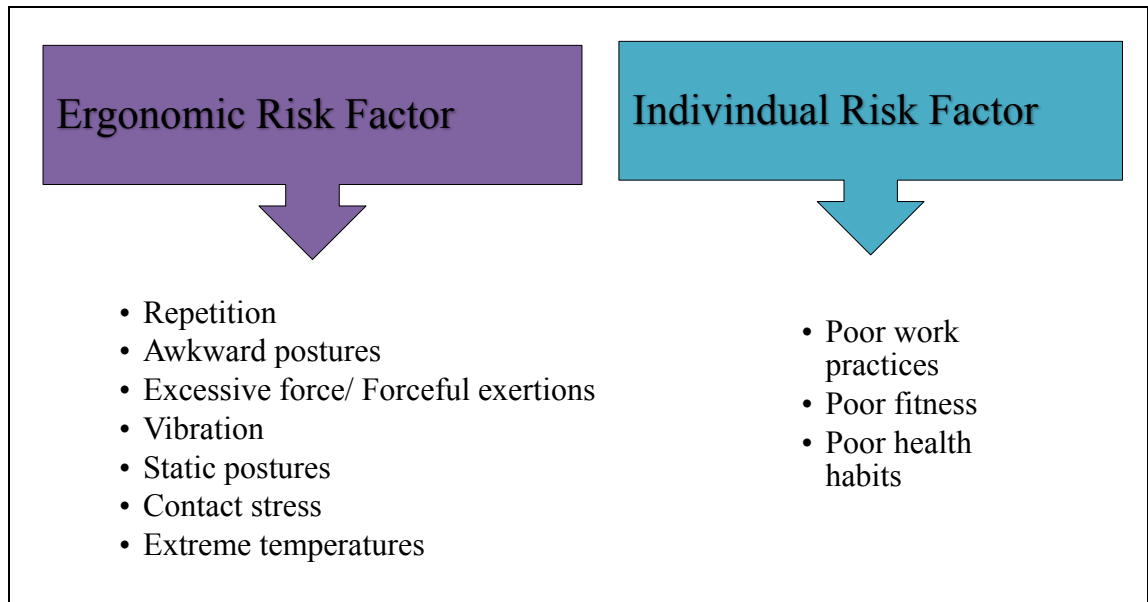


Figure 1.1: Risk factor leads to MSD (R.S. Bridger, 2003).

A pre-survey conducted before the research consists of 23 respondents who are a regular user of KTM Berhad Komuter. According to previous research, Zein et al., (2015) also used the questionnaire for investigated working postures, workers background, physical and mental fatigue among Malaysian industrial workers. In the questionnaire, the passenger is required to answer all the parts of the questionnaire based on the passenger awareness and experience during train in prolonged standing. Moreover, the questionnaire surveys were performed to examine the level of psychological fatigue experienced by the passenger while riding moving train in prolonged standing.

The tools that are going to be used in this project is sEMG which is collecting the electromyography (EMG) signal from the skin surfaces of the muscles. EMG is a technique for evaluating the health of muscles and nerves. Therefore, EMG can be established as an assessment instrument in many areas, such as sports science, medical research, rehabilitation, and ergonomics. There are two types of EMG sensors, which is surface (non-invasive) and intramuscular (invasive) EMG. sEMG is the most

common technique used to assess muscle activity and this technique is considered as a good method to quantify the muscle activity either in force, motion, and fatigue. All muscles suffered from fatigue that identified from the sEMG measurement (Halim et al., 2012). Meanwhile, Rashid et al., (2015) used sEMG to estimated muscle fatigue for a healthy male motorcyclist during a real on-road motorcycle riding testing. Hence, an assessment of ergonomic risk factor is important to reduce the level of fatigue among passenger in prolonged standing while riding in the moving train.

1.2 Problem Statement

Due to the economic growth, private vehicle ownership has significantly increased in Malaysia (Mohd, 2012). Thus, it can create a traffic jam for transport infrastructures. The highest population density in Kuala Lumpur leads to traffic jam and to overcome this issue public transportation is one of the best solutions. Public transportation such as KTM Berhad Komuter system is an on-going challenge in many developing countries including a middle-income country such as Malaysia. Therefore, this service, which began in 1995 as one of the main public transport services provider in Malaysia (Khalid et al., 2014).

Most of the people traveling using this KTM Berhad Komuter as one of the primary public transportation. Based on KTMB Traffic Statistics (2006-2015) in Figure 1.2, approximately 110,000 passengers traveled by KTM Berhad Komuter train. Hence, KTM Berhad Komuter, operated by Malaysian Railway is alternative ways and more sustainable public transportation for the user to go their workplaces, school or for those who do not have private transportation. This transportation system also became an option for the community that in middle-class society. KTM Berhad Komuter service makes it very easy to accommodate passengers for ease of transportation crossroads from various transportation modes.

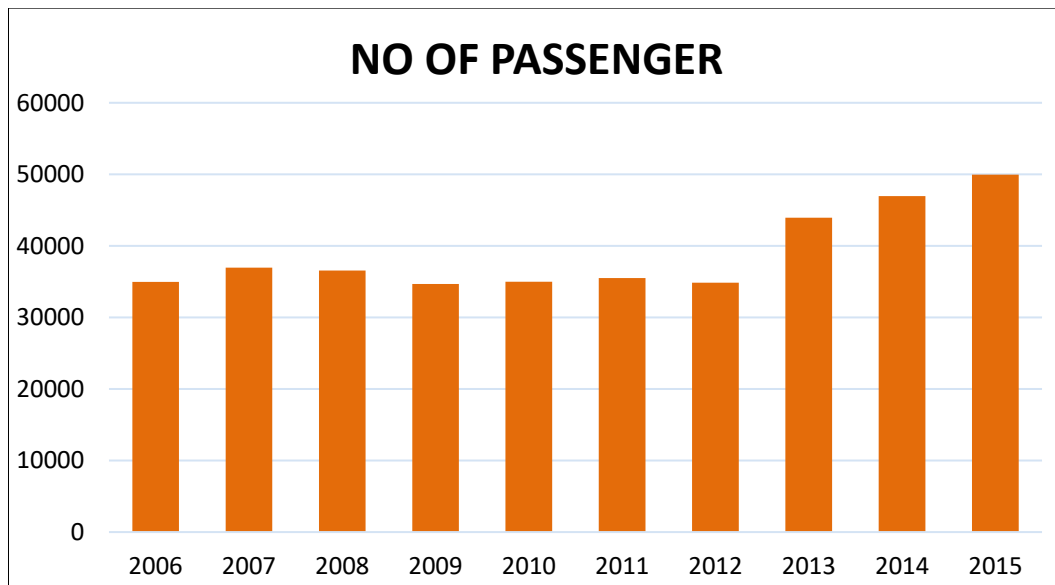


Figure 1.2: Number of passenger travelling using KTM Berhad Komuter (KTMB Traffic Statistics, 2006-2015).

When passengers riding moving train during peak hours, possibility to face with congestion inside the train where the passenger crowded and have to stand for a long period time. The effect of standing for long periods of time while riding moving train can cause discomfort and muscle fatigue. It also, can contribute the number of occupational injuries in the workplace, provide an ergonomic environment that is not conducive and give negative effect to the passenger. Dabholkar et al., (2015) in their research, showed that the most common musculoskeletal problems were low back pain, shoulder pain, knee pain and pain in the feet while standing for a long period of time with an incorrect posture among the bus conductors.

Meanwhile, prior to the research study by Lin et al., (2012) discomfort and pain in lower back, lower extremity, and varicose veins occurred when standing for prolonged periods of time. In addition, Halim et al., (2014) emphasized that the ability of a human to perform a job involving flexion or extension postures and their productivity can be affected due to prolonged standing which can cause lower back pain. Another study also contributed that prolonged standing posture has been recognized as an occupational risk factor especially for women and the middle-aged workers (Capodaglio, 2016). In all the studies reviewed on the above-mentioned

issues, it is obviously indicated that discomfort and muscle fatigue related to prolonged standing can possibly influence the health of human.

1.3 Project Questions

In order to develop the objectives of the project, several questions have been constructed. The questions as follow:

- i. What are the ergonomic risk factors that needs to be considers as contributors to the women passenger in Malaysian while riding moving train in a prolonged stand?
- ii. How to determine the human factor using direct measurement method for the passenger while standing for prolonged time periods in moving train?
- iii. What are the significant relationships of human factor among psychophysical approach (pain and discomfort) and biomechanical approach (muscle fatigue)?

1.4 Project Objectives

The objectives of this project can be outlined as the following:

- i. To establish information on risk factors that contribute to discomfort and muscle fatigue of passengers in prolonged standing condition while travelling using train by using subjective method (Questionnaire surveys).
- ii. To analyze muscle activity of passenger with direct measurement method (using sEMG, video recording) inside train in prolonged standing condition.
- iii. To propose recommendation of alternative solution to minimize discomfort and muscle activity for prolonged standing in moving train.

1.5 Project Scope

There are few scopes are listed in order to achieve the project objectives. First, this project focuses on Malaysian women passenger who regularly used the KTMB commuter as a primary transportation. Previously published studies are testified that the prevalence of low back pain (LBP) commonly occurred in middle-aged women (Singh et al., 2012; Varte et al., 2012) hence this project has assign women passenger as experimental subjects. This project has select KTMB commuter as a case study due to the services duration time, distances and route coverage which were more comparable to various suburban heavy rail systems around the Malaysia. Besides, KTMB commuter requires more passenger to prolonged standing while riding train due to packed of ridership during peak hours.

Apart from this, the selection of KTMB commuter has also been based on the specialized services it offered for the increased in comfort and safety levels of female users, not typical of the other rails system in the city region of Kuala Lumpur. Selection of passenger which are 20 respondent users has been particularly limited to age between 19-37 years old and people with has classified normal and obesity. This group of women was significantly higher muscle fatigue in prolonged standing task compared to men. Previous research has observed that the regularity of discomfort and muscle fatigue often reported in middle-aged women (Varte et al., 2012).

In this project, the passenger has to stand for a long period of time during their traveling from Tampin / Pulau Sebang station to KL Sentral station and the journey will approximately take two hours. In addition, the respondent required to carry weight along the journey. Plamondon et al., (2017) showed that female potentially leading to higher risk of injury while lifting 15 kg load compared to men. So in this thesis, the subjects also have to carry bag pack which is around 5 kg behind them so that preventive interventions of the train user's postures can be proposed.

1.6 Significance of Project

The finding of this project has been identified to offer some potential benefits towards:

- i. The information on prolonged standing associated to minimize discomfort, reduce the level of fatigue associated with prolonged standing will be documented as knowledge for future research during travel with train.
- ii. The public transport user can know the limit of muscle activity due to prolonged standing posture condition inside train during peak hours. This will promote awareness among the passenger about the importance of providing good ergonomic environmental in everyday life.
- iii. This project can suggest new references and techniques for the future project to make more contribution research by using sEMG related to prolonged standing.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter aims to explain about the ergonomic risk factor for the passenger while standing for a long period of time inside a moving train. Besides, this section briefly describes the case studies related to this project regarding each main topics of the title given. There are several types of source such as journals, books and newspaper will be utilized as a manual for decide the purpose and direction of this project. This literature review is important because it serves as a guide for the new study and a researcher can avoid repeating the same mistakes by past researchers. In addition, the literature review can help to produce a better study. The author provides an outlines and contrast between the previous research works toward the finish of this section at the end of this chapter in minimizing discomfort and muscle activity related with prolonged standing in a moving train.

2.2 Muscle Activity

Muscles in charge of creating the force needed any movement either simple or aggressive one; supported by the respective contracts it. Furthermore, a muscle can gradually move into the condition of fatigue in a continuous contracting process (Chiu et al., 2015). In the muscular system consists of all the muscles of the body and there are three distinct types of muscles inside a human body. Figure 2.1 shows the types of muscle in a human body which consists of smooth muscle, cardiac muscle, and skeletal muscle. There are three categories of muscle in the human muscular system as the followings:

- i. Smooth muscle = found in the walls of organs and structures such as the stomach, bronchi abdomen, uterus, blood vessel, bronchi abdomen esophagus, arrector pili etc.
- ii. Cardiac muscle = located in the heart walls and formed of three layers acts similar to smooth muscle. The structure is thickened and shorter and known as myocardium.
- iii. Skeletal muscle = the muscles most attached to bones at each end via tendons and cooperate together in order to move the skeletal muscles and control the movements of the body.

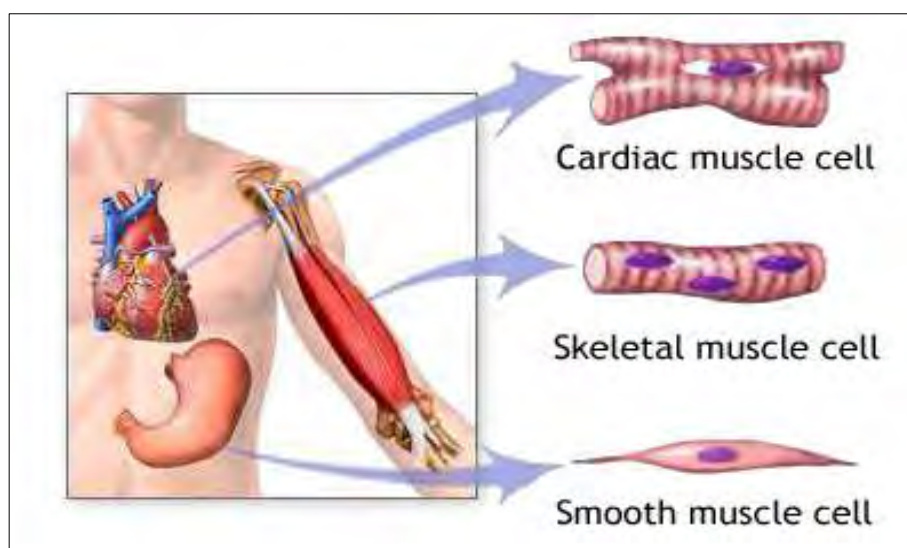


Figure 2.1: Type of muscle inside a human body (ADAM, 2015)

Nath et al., (2017) found that fatigue occurred caused by the repetitive work or lack of energy that can be alluded as a sentiment tiredness or exhaustion or a need to rest. Therefore, muscle fatigue is characterized as a diminishment in the force producing the limit of a muscle because of the past movement. The rationale to incorporate the muscle activity of passenger inside moving train is that passenger need to perform in standing position when faced with congestion inside the train. A nonstop exposure to standing position may prompt to muscle fatigue and discomfort. Muscle fatigue indicates to a reduction in muscle force crated over a sustained period of activity or because of pathological and problem arises when lactic acid accumulates in the muscle.