Sheet Metal Lift Trolleys: Effects of Design Differences on Muscle Activity and Subjective Perceptions of Operators

Submitted in accordance with requirement of the University Teknikal Malaysia Melaka (UTeM) for Bachelor Degree of Manufacturing Engineering (Hons.)

By

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I hereby, declared this report entitled “Sheet Metal Lift Trolleys: Effects of design differences on muscle activity and subjective perceptions of operators” is the result of my own research except as cited in references.

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for Degree of Manufacturing Engineering (Hons). The member of the supervisory committee is as follow:

…….....

(Dr. Nadiah Binti Ahmad)

ABSTRAK

Keletihan otot disebabkan apabila manusia melakukan tugas-tugas yang berulang dan dalam postur yang janggal dalam tempoh yang panjang. Penggunaan jack gerobak meja angkat memerlukan pengguna membungkuk untuk memegang logam lembaran yang boleh menyebabkan keletihan otot. Pengangkat troli direka cipta untuk mengurangkan postur subjek yang tertekan ketika menjalankan tugas pemuatan dan pemunggahan.

Eksperimen dilakukan untuk mengkaji kesan perbezaan dalam kedua-dua peranti pengendalian logam lembaran yang mengangkat keranjang meja dan alat pengangkat troli. Objektif kajian ini adalah untuk membandingkan aktiviti otot dan persepsi subjektif subjek menggunakan alat pengendalian lembaran logam untuk melaksanakan tugas. Elektromiografi permukaan telah digunakan untuk mengukur dan menganalisis aktiviti otot untuk membandingkan perbezaan kesan antara dua peranti pengendalian logam lembaran. Data elektromilografik permukaan dikumpulkan pada bisep brachii, triceps brachii, otot belakang bawah dan trapezius dengan menggunakan peranti EMG Noraxon. Data sEMG meramalkan mampatan pada persentil ke 90 dengan menggunakan analisis berulang variasi (ANOVA) dan T-ujian. Persepsi subjektif dibuat antara dua alat pengendalian logam lembaran berdasarkan kegunaan, kebolehgunaan dan keinginan. Kajian ini menunjukkan bahawa aktiviti otot untuk alat pengangkat troli adalah lebih rendah daripada jack gerobak meja angkat dari segi pemuatan dan pemunggahan tugas. Selain itu, subjek lebih suka menggunakan alat pengangkat troli berbanding dengan gerobak meja.

ABSTRACT

Muscle fatigue are caused when human is performing the manual tasks repetitively and in awkward posture for prolonged period. The using of lift table cart jack required subject to bend down to hold the sheet metal may causing the muscle fatigue. Trolley lifter was designed to reduce the awkward posture of the subject during performing the loading and unloading tasks.

An experiment was conducted in order to examine the effect of differences in the two sheet metal handling devices which is lift table cart and trolley lifter. The objective of this study is to compare the muscle activity and subjective perceptions of the subjects using the sheet metal handling devices to performing tasks. Surface electromyography has been used to measure and analysed the muscle activity in order to compare the effect differences between two sheet metal handling devices. The surface electromyography data were collected at biceps brachii, triceps brachii, lower back muscle and trapezius by using Noraxon EMG device. sEMG data predicted compression at 90^{th} percentile by using the repeated measures analysis of variance (ANOVA) and the T-test. The subjective perceptions were made between two sheet metal handling devices based on the usefulness, usability and the desirability. This study showed that the muscle activity for the trolley lifter is lower than the lift table cart jack in term of loading and unloading task. Besides that, the subjects were more prefer to use the trolley lifter for transportation compare to the lift table cart jack.

DEDICATION

Dedicated to

My beloved mother, Ung Saw Ean

My beloved father, Yap Eng Lee

My beloved sister, Yap Peei San

My beloved teammates, Ching Yung En, Tan Yu Qi for giving me moral support, encouragement, cooperation and also understanding.

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sEMG	-	surface Electromyography
WMSD	-	Work-related musculoskeletal disorders
%	-	Percentage
MVC	-	Maximum Voluntary Contraction
SENIAM	-	surface EMG non-invasive assessments of muscles
MSDs	-	musculoskeletal disorders
MHH	-	manual material handling
uV	-	microvolt

CHAPTER 1
INTRODUCTION

This chapter explains the information regarding to research background, problem statement, objectives, and scope of the research. The organization of study is also presented in this chapter.

1.1 Research Background

Skeletal muscle can be regarded as the largest organ within the human body. It is essential for all activities involving spontaneous movement. Skeletal muscle is the muscle attached to the bone. These muscles are subjected to contracting and relaxing when the person is moving. Continuous or repetitive actions, exerted force and speedy movements may be stimulated pain receptors in muscles (Bridger, 2003). The repeated or sustained activities may cause muscle fatigue and back injury to the low back muscle.

Work-related musculoskeletal disorders (WMSDs) are a group of painful disorders of muscles, tendons and nerves. The subject occupation frequently exposed to elevated physical risk factors such as repetitive task, awkward posture and lifting task, which represent the major causes of WMSDs. The symptoms of WMSDs may include lower back pain, neck/shoulder pain (Li *et al*, 2017).

McFarlane et al. (1997) found an increased risk of a new episode of low back pain was found in those whose tasks required lifting/pulling/pushing objects of at least 25 Ibs(11.36kg), or whose jobs required prolonged periods of standing or walking. The finding helps explain why chronic low back pain sufferers are at risk in task that required carrying of weight and repetitive lifting in front of the body, leaning forward or with trunk extended;

all these activities require continuous movement of the back extensors (Bridger, 2003). The extensors are the muscles work to straighten/extend or contract the body part.

Material handling processes are one of the most significant aspects of demanding environments such as loading and unloading of the materials from one place another place. Lift table cart jack is a device that commonly used in manufacturing industrial to raise and lower large, heavy loads. Some common activity of the lift table cart jack is used to transfer and lift the sheet metal or other material from work cell to work cell. Lift table cart jack that are manually pushed and elevated through the use of a foot pedal.

By using the lift table cart jack, during transporting the sheet metal from one work cell to another work cell, the worker need to support the other end of the sheet metal manually while another worker pushing the lift table cart jack. Furthermore, during the elevation period, the worker also need to support the other end of the sheet metal while another worker pumping the foot pedal. The subject may expose to injuries during the repetitive lifting tasks and awkward posture.

To prevent injuries to the muscles from operating the lift table cart jack, a trolley lifter has been designed as an alternative sheet metal handling device. The trolley lifter consists of which does not require two workers to carry the material during transport period. Besides that, the trolley lifter also does not require the worker to bend down for support the end of the sheet metal during transportation period and elevation period. The design of the trolley lifter could help to eliminate and reduce the awkward posture.

The objective of the study is to analyse the muscle activity of the lift table cart jack and trolley lifter. The muscle activity is measured using EMG machine that can detect the electrical signal produced by the muscle when it expands or contracts.

1.2 Problem Statement

Muscle pain due to the accumulation of waste products in the muscles is called cramp and can be accompanied by muscle weakness or spasm (the muscle may temporarily lose up to 50% of its normal strength when fatigue) (Bridger, 2003). Muscle fatigue are caused when human regularly carried out repetitive task for prolonged period. When using the lift table cart jack, it required the subject bending down or in awkward postures to hold the sheet metal for transportation. This working method will lead the subject to muscle fatigue and awkward posture when the subject carried out the task repetitively. By using trolley lifter, it will not require the subject to bend down to place the sheet metal on the lift table cart jack. The trolley lifter transfers the sheet metal by the subject pull and slide the sheet metal from storage rack and lean on the trolley lifter. In this study, it will analyse the electrical signal that produced by the muscle and compare the muscle activity for two design of lift trolleys for handling sheet metals. The effects of the design differences on operators will be evaluated. Experimental study will be organized to measure muscle activity and operator subjective perceptions on using the lift table cart jack and trolley lifter. EMG device is used to during the experimental study for measuring the muscle activity.

1.3 Objectives

The objectives are as follows:

(a) To measure and analyse the muscle activity of the operators when using sheet metal handling device.

(b) To analyse the subjective perceptions on using sheet metal handling device.

(c) To compare the differences between lift table cart jack and trolley lifter in term of muscle activity and operator subjective perception.

1.4 Scope of the Research

In order to achieve the objectives of the study, there are a few scopes as listed. Research on the of design differences on muscle activity and subjective perceptions of operators. In this research the gender for the subject only focus on male and 25 subjects will be recruited for the experiment.

In this study, the measurement of the muscle activity is concentrated on the sheet metal loading and unloading process as it is potentially contributing to muscle fatigue. The muscles analysed in this study are biceps trachii, triceps trachii, and lower back muscle and shoulder muscle as well trapezius. For the lift table cart jack, the electrical signal is only measure for the subject who is doing similar tasks with the trolley lifter which is loading and unloading the sheet metal and pushing the lift table cart jack from the storage rack to the laser cutting machine.

The surface EMG has been used to detect the electrical signal produce by the muscle during carry out the experiment. The equipment used to detect the electrical signal is Noraxon EMG.

To study the electrical signal produced by the muscles, subjects will go through a repetitive activity which is loading and unloading the sheet metal using the lift table cart jack and trolley lifter with different type of metal. The selection of the participant is randomly chosen among the student of Faculty of Manufacturing Engineering.

1.5 Rational of the research

The finding of this research will help to eliminate and reduce the awkward posture and low back pain of the subject when using the lift table cart jack for material handling process. Therefore, creating and designing a safe and comfortable new material handling device could be beneficial to the workers who works in the iron and steel company. The small and medium sized company may not afford to buy an automation machine for material handling process and they still depend on the manual handling process by using the lift table cart jack. The trolley lifter could be beneficial to those workers that works in the small and medium sized company and reduce the muscle fatigue and awkward posture when performing the material handling process.

The implementation of ergonomics in the trolley lifter design have to make the trolley lifter work better by eliminating factors of the trolley lifter functioning that are undesirable, uncontrolled or unaccounted for, such as muscle fatigue and awkward posture. (Bridger, 2003). Besides that, trolley lifter only required one worker during the material handling process. The design of the trolley lifter is more ergonomics compare to the lift table cart jack. The workers do not need to bend down for a long period during transfer the material and this will reduce the risk factor for muscle fatigue and awkward posture. The outcome is beneficial in a few aspects in term of ergonomics in the material handling device.

1.6 Thesis Organization

This report will mainly comprise of 5 chapter, which included introduction, literature review, methodology, result and discussion and lastly conclusion.
Chapter 2 literature review will consider about the previous study or researches such as journals and books study the effect on muscle activity by using EMG device, muscle fatigue, human muscle types, lift table cart jack and trolley lifter. It is essential to contribute the overview on the research title.

Chapter 3 methodology will discuss about the process flow of the developing the experiment and conducting the survey. Furthermore, it also explains about the methods to prepare and conduct the experiment for collecting the EMG activity.

Chapter 4 result and discussion will discuss about EMG activity result after conduct the experiment by using different type of trolley lifter. Besides that, it will also about the subjective perception after using both of the trolley lifter.

Chapter 5 conclusion will be discussed about the result that collect from chapter 4 and the objective of the project. The summary of this study and recommendations for future work will also be described in Chapter 5.

CHAPTER 2
LITERATURE REVIEW

This chapter proceeds with the detailed literature review. It includes the various type of human body muscles, muscle fatigue, surface electromyography signal, the placement of the electrode and the work-related musculoskeletal disorders (WMSDs). The information is obtained through online manual handbook, journal article, and references text.

2.1 Human muscles

Human muscle system is performing the posture and movement of the human body. The muscle performance essential roles in human body, which is produce movement, maintain postures, stabilizes the joints and generates beats (Marieb, 2006). Human muscle is classified into three different types of muscle, which is cardiac muscle, skeletal muscle and smooth muscle. Each type of muscle plays specific and different role in the human body.

2.1.1 Skeletal Muscle

A whole skeletal muscle is considered as an organ of human body (SEER Training Modules, 2017). Skeletal muscle comprises about 45% total mass of the human body, it is essential to generating forces for supporting and moving the skeleton (Kwee & Mooney, 2017). Skeletal muscle is a voluntary muscle, which means that we are able to consciously control its movements. Skeletal muscle is the muscles that attached and connected to the human body's skeleton by tendon structures and allows movement performance and maintain the posture.

The role of the skeletal muscle utilize tension between the bone points to which they are attached. Skeletal muscles develop the active force for the static and dynamic motor actions within the human body when acting upon the bone and the joint system (Disselhorst-Klug *et al.*, 2009). Tension is applying when a muscle is changing from resting to active state in responses to impulses to central nervous system (Bridger, 2003). Figure 2.1 shows the structure of skeletal muscle (SEER Training Modules, 2017).

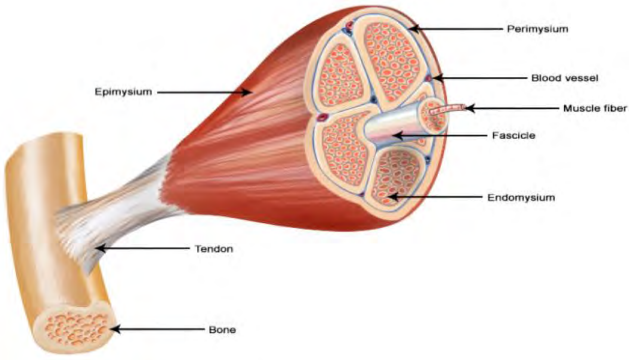

Figure 2.1: Structure of a Skeletal Muscle (SEER Training Modules, 2017)

The skeletal muscle generally occurs in pairs, which means one of the muscle is act as dominant mover and the other acts as an antagonist. Such as, during the subject bends the arm, the biceps trachii will contract and the triceps brachii is relaxed. When the arm returns to the extended position and the triceps brachii is contracts while biceps is relaxing. The repetitive movements or awkward posture may cause the subject exposed to muscle fatigue and muscle injuries on the muscle. Figure 2.2 shows the flexion and extension of the arm (Newcastle University, 2017).

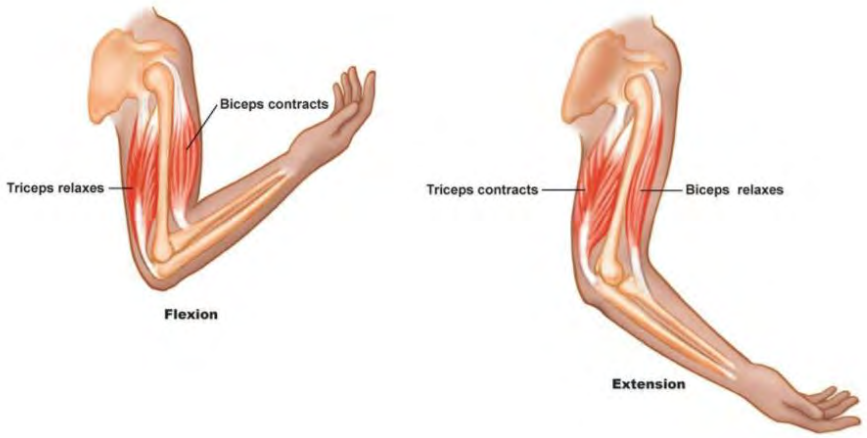

Figure 2.2: Schematic diagram of Flexion and extension of the arm (Newcastle University, 2017)