



A Biomechanical and Subjective Assessment and Comparison of Two Wheelbarrow Designs

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by

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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 requirements for the degree of Bachelor of Manufacturing Engineering (Hons.).

The members of the supervisory committee are as follow:

.....
(Dr Nadiah Binti Ahmad)

ABSTRAK

Tugas berulang seperti melakukan operasi mengangkat dan membongkar berat sering kali menyebabkan keletihan otot. Jangka panjang keletihan otot boleh menyebabkan kecederaan kronik seperti sakit tulang belakang yang memberi kesan kepada kesihatan seseorang. Kereta sorong adalah peranti biasa yang telah digunakan selama berabad-abad dalam penghantaran beban di sektor yang berbeza. Terdapat pelbagai modifikasi dalam reka bentuk yang telah dibuat sebelum ini untuk meningkatkan fungsi kereta sorong. Pengubahsuaian juga bertujuan untuk mengurangkan kadar kecederaan dalam kalangan pengguna kereta sorong. Kajian ini bertujuan untuk mengkaji perbandingan dua jenis kereta sorong yang berlainan dengan membandingkan aktiviti otot subjek apabila menggunakan kedua-dua jenis kereta sorong. Penilaian subjektif akan dianalisis dengan borang soal selidik. Kaedah elektromiografi permukaan digunakan untuk mengenal pasti aktiviti otot-otot umum yang terlibat ketika mengangkat dan memungkah beban. Otot biceps brachii, triceps brachii, otot trapezius, dan otot belakang rendah akan diperiksa. Data EMG permukaan akan dianalisis berdasarkan pemampatan pada persentil ke-90 dengan menggunakan analisis berulang varians (ANOVA). Hasil yang dijangkakan dalam kajian ini adalah bahawa kereta sorong yang diubah suai menggunakan tenaga yang kurang untuk beroperasi berbanding dengan kereta sorong konsep asal. Justifikasi ini adalah faktor penting yang membantu dalam mengurangkan kadar kecederaan otot antara pengguna alat kereta sorong.

ABSTRACT

Performing repetitive task such as lifting and unloading weights often causes muscle fatigue. Prolong of muscle fatigue may leads in chronic injuries such as low back pain that affects one's health. Wheelbarrow is a common device that had been used for centuries in transporting loads in different sectors. There are a lot of modifications in designs had been made previously to improve the function of wheelbarrow. The modification also aims to reduce the rate of injuries among the wheelbarrow users. This experiment is aimed to study the comparison of two different types of wheelbarrow based on comparing the muscle activity of subjects' when using these two devices. The subjective assessment will be analyze by questionnaires form. Surface electromyography method will be used to identify the muscle activity of the common muscles involved when lifting and unloading weights. In this research study, the muscles of biceps brachii, triceps brachii, trapezius muscle, and low back muscles will be examined. Surface EMG data will be analyze based on compression at 90th percentile by using the repeated measures analysis of variance (ANOVA). The expected result of this study is that the modified concept wheelbarrow uses less energy to operate than the original concept wheelbarrow. It is the most important factor that aids in reducing the rate of muscle injuries between wheelbarrow device users.

DEDICATION

Only

My beloved father and mother,

My appreciated siblings,

My beloved teammates, Yap Peei Yong and Ching Yung En

Thank you for giving me moral support, cooperation, encouragement and also understandings.

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LIST OF ABBREVIATION

KG	Kilograms
WMSDs	Work-related musculoskeletal dis-orders
EMG	Electromyography
NIOSH	National Institute for Occupational Safety and Health
LBD	Lower Back Disorder
KESG	Kinesiological Electromyography
SEMG	Surface Electromyography
ANOVA	Repeated measures analysis of variance
MVC	Maximum Voluntary Contraction

CHAPTER 1

INTRODUCTION

This chapter will explain regarding the research background of this title, problem statement, objectives, and the scope of this research. The significant of this study will be described and the organization of report will be portrayed in this chapter.

1.1 RESEARCH BACKGROUND

Extant literature reports that work-related musculoskeletal dis-orders (WMSDs) are among the most prevalent occupational health problems affecting manual workers. Construction workers (e.g., rebar workers, bricklayers and roofers) are by virtue of their occupation frequently exposed to elevated physical risk factors such as repetitive motions (lifting/lowering), awkward postures and lifting weights, which represent the major causes of WMSDs (Antwi-Afari et al., 2017). It is commonly known that construction workers are required to perform the lifting and lowering task repetitively in their working scope. In order to reduce the difficulty of manual workers carrying and transporting heavy loads, subsidy instrument was invented from time to time and the most widely seen instrument is the wheelbarrow.

A wheelbarrow acts like transporting vehicles that have storage for storing loads and weights. It is commonly been used in construction and farming industries globally. The basic design is imply based on a second-lever system. According to research made by Paul et al. (1979), the structure of a wheelbarrow consist of a small ramp member which is positioned between the rear wheels and pivoted at the front end of the A-frame. The study also states that the wheel is rolled up on the pivoted ramp and positions the wheelbarrow wheel in stable cradled relationship between the ramp and an adjustable transverse bar

ahead of it on the A-frame.

Improvements had been made from time to time among researchers in order to improve the usefulness and features of wheelbarrow. In these modern eras which full of technologies, it is quite a simple task to add in high-technology system to a wheelbarrow. For example, the concept presented by Bell (1950), which aimed to provide an improved machine for the purposes aforesaid, which is self-powered and arranged to be steered and otherwise controlled with improved facility. The improvements from time to time show that the present designs still have limitations that are necessary to be improved. The limitations includes that large forces need to be exerted while unloading the cart. Besides, the lifting action that is essential when performing the unloading task often created higher chances of getting injuries at hand muscles and lower back. The another design variants from Strobel (2013), claims to have a wheelbarrow with two wheels mounted on an axis which is allowed to swivel, thereby allowing the axle to tilt with the terrain and the tray and handles remain substantially level while the wheel assembly is coupled to stop-limits to prevent the excessive tilting of the wheels with respect to the tray and handles.

1.2 PROBLEM STATEMENT

Repetitive actions of lifting and lowering may cause injuries among manual handling workers. The usage of wheelbarrow that involves lifting and lowering when loading and unloading weights may cause musculoskeletal injuries among workers that commonly uses this instrument. The main purpose of this transporting vehicle is to help manual workers to reduce the burden of transporting heavy loads. The risk when handling this instrument has to be reduces to as minimum as possible to reduce the chances of injuries and awkward postures. The design of the wheelbarrow plays an important role in order to achieve the motive of this vehicle. Efforts had been made to redesign the features of wheelbarrow to increase the instrument usefulness and usability from time to time among different researchers to reduce WMSD. The constantly improvement that are made to the wheelbarrow design shows that there are needs to evaluate the design quality to prove the credibility of design improvements. It is important to understand the features that are needed to be modify in order to reduce the muscle usage among users and hence reducing the chances of injuries. The crucial additional feature that may enhance the

quality and reduce the risk factors of the wheelbarrow should be identified and evaluated. The benefits of new design should be proven experimentally to confidentially prove the design concept. The experiment results should be assessed to compare the design differences. The Electromyography (EMG) results will help in determining the muscle activity of operators when operating two different designs of wheelbarrow. The results can be analysed and studied.

1.3 OBJECTIVES

The objectives are as follows:

- a) To measure and assess the muscle activity of operators when performing the lifting and unloading task using two different designs of wheelbarrow.
- b) To analyse the Electromyography (EMG) data.
- c) To compare the effects of design differences on muscle activity based on the EMG results.
- d) To conduct subjective assessment on the effect of the design difference.

1.4 SCOPES

The scopes of research are as follows:

- a) Research on the muscle activity of male operators when performing the lifting and unloading task using the original concept of wheelbarrow and modified concept wheelbarrow.
- b) Research on the specific muscles that are commonly involves when lifting and unloading loads.
 - i. Biceps brachii
 - ii. Triceps brachii
 - iii. Lower back muscles (Erector spinae)
 - iv. Trapezius muscle

- c) The readings on Electromyography (EMG) device is only taken when the operators lift and unload the wheelbarrow.
- d) Only 2 designs of wheelbarrows are evaluated.

1.5 Significance of Study

This study research is significant to manual workers especially in construction sites. In this developing era, it is very common to find construction sites in cities or even rural area. Buildings and skyscrapers are being built from time to time to enhance the economy of country. Besides that, the wheelbarrow device is also can be commonly found in farming industries to transport soil or seedlings. Thousands of manual workers are working hard in these industries to promote the economy. Their health becomes the main concern not only for the performance of construction but also affects the age of retirement statistic of the country. The work-related musculoskeletal disorders are not a type of minor injuries that can be cure by treatments. It may affect the health of worker and the job of scope they can apply when they leave the industry. This study research is significant to show that the injuries can be reduced or prevented by integrating ergonomics consideration in the design of wheelbarrow.

1.6 Organizations of Report

1.6.1 Chapter 2 Literature Review

This chapter will mention about the previous studies from other researchers. The experiment that had been carried out by the researchers will be included in this chapter for the study references.

1.6.2 Chapter 3 Methodology

This chapter will explain the methodology that will be used in the experiment of this study. The procedure will be explained briefly in this part.

1.6.3 Chapter 4 Results and Discussion

This chapter will show the result of the experiment. Analysis of data will be explained in details. The discussion part will brief about the problems of the experiment.

1.6.4 Chapter 5 Conclusion and Recommendation

This chapter will conclude all the main points of the study and improvements that can be made.

CHAPTER 2

LITERATURE REVIEW

This chapter will describe regarding the previous study results from various researchers. Related information will be extracted as references and discussion for this study. The system for this title will be the wheelbarrow transporting device. The main problem studied in this title will be the muscle fatigue based on the lifting and unloading operations of wheelbarrow. The method that is used to investigate this title will be the Electromyography (EMG) test on the muscle activity of operators.

2.1 Wheelbarrow

The wheelbarrow is the main system that will be analyze in this study. Based on the studies of Chassis (1941), the objective of the invention of a wheelbarrow was to provide a novel wheelbarrow that can be operated with the minimum effort. Besides, he also stated in his study that the invention was meant to provide the wheelbarrow with a novel body and constructed in a way that enables easy dumping. The wheelbarrow is commonly used as a transporting device in construction sites, factories and farming industries. It is often used to transport bricks, sand, soil and heavy metal pieces. The basic components that can be found in a wheelbarrow include a wheel that is mounted on an axle where the axle is operatively associated with a pair of handles and a load bearing receptacle (John, 2015). Loads and weights are placed in the receptacle and the operator will lift the wheelbarrow by the handles. The wheel aids in the transportation of loads and weights. In such scenario, the wheel also becomes the main support of the whole system where all the weight is supported at the wheel point after the wheelbarrow is lifted and it is then moved to the desired destination to unload the loads

2.1.1 Different Types of Wheelbarrow Designs

A variety of wheelbarrow types can be found in today's market. All of them can be differentiated based on these three categories:

- i. Number of wheels;
- ii. Tire types;
- iii. Material types.

All these three categories will be discussed further in the subtopics below.

2.1.1.1 Category Type 1: Number of Wheels

The first category type of wheelbarrow is determined by the number of wheels. The most common types are one wheel wheelbarrow and two wheel wheelbarrow.

2.1.1.1.1 One Wheel

Figure 2.1 shows the schematic diagram of one wheel wheelbarrow (Indiamart, 2012).



Figure 2.1 Schematic Diagram of One Wheel Wheelbarrow

This is the most classic version of wheelbarrow. It is the most maneuverable and the easiest to dump type of wheelbarrow. This type of wheelbarrow requires more upper body strength since there is only a wheel acts as the support system of the whole device (Jordan, 2011).

2.1.1.1.1 Two Wheels

Figure 2.2 shows the schematic diagram of two wheels wheelbarrow (The Home Depot)



Figure 2.2 Schematic Diagram of Two Wheels Wheelbarrow

This type of wheelbarrow provides more stability than a single wheel cart. It is able to manage heavier or unbalanced loads. If compare to a single wheel type of wheelbarrow, the maneuverable capability is much more lower. It is not compatible to be moved on inclined surfaces (Jordan, 2011).

2.1.1.2 Category Type 2: Tire Types

This category of wheelbarrow includes wheelbarrows with different types of tires. With the improvement of technologies, inventions of tires had been improving from time to time. This improvement had led to the implementation of different type of tires to the wheelbarrow cart to suit the system for a variety of working scenarios.

2.1.1.2.1 Pneumatic

Figure 2.3 shows the schematic diagram of pneumatic tire type of wheelbarrow (Walter J. Farrell,2017).



Figure 2.3 Schematic Diagram of Pneumatic Tire Type of Wheelbarrow

The pneumatic tires contain an internal air-filled tube which is inflatable. The air in the tire tube acts as a shock-absorber which aids in the movement on uneven surfaces such as on rocks or stairs. The only disadvantage is that the air pressure needs to be checked and maintained on an occasional basis (Jordan,2011).

2.1.1.2.2 Semi-Pneumatic

Figure 2.4 shows the schematic diagram of semi-pneumatic tire type of wheelbarrow (Plantedwell, 2018).



Figure 2.4 Schematic Diagram of Semi-Pneumatic Tire Type of Wheelbarrow

Semi-pneumatic tire type wheels are built-in with air pockets. The air pockets provide some shock absorption of pneumatic tires without having to concern about the pumping air problem (Jordan, 2011). The semi-pneumatic tire also can be called as flat-free tires. It means that the tire will not goes flat so maintenance can be avoided.