UNIVERSITI TEKNIKAL MALAYSIA MELAKA

THE DEVELOPMENT ON FOREARM CRUTCHES TO REDUCE UPPER LIMB PRESSURE DISTRIBUTION EVALUATED BY EMG (ELECTROMYOGRAPHY)

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

by

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BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **The Development On Forearm Crutches To Reduce Upper Limb Pressure Distribution Evaluated By EMG (Electromyography)**

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I hereby, declared this report entitled "The Development On Forearm Crutches To Reduce Upper Limb Pressure Distribution Evaluated By EMG (Electromyography)" is the results of my own research except as cited in references.

Signature	:	………………………………………….
Author's Name	:	Teo Xue Chee
Date	:	15^{th} December 2017

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 (Product Design) with Honours. The member of the supervisory is as follow:

……………………………….

Umi Hayati Binti Ahmad

(Project Supervisor)

ABSTRAK

Tongkat merupakan sesuatu peralatan yang terutamanya berfungsi untuk membantu pergerakan pesakit yang menghadapi kecederaan ataupun yang menjalani pembedahan di anggota badan rendah. Walaubagaimanapun, penggunaan tongkat selalunya membawa kesan kepada pesakit seperti ketidakselesaan tangan. Objektif utama projek ini adalah untuk menganalisis pengagihan tekanan di struktur anatomi di tempat tangan semasa bejalan dengan tongkat lengan piawai dan tongkat lengan dengan tambahan pemegang baru. Pemegang ergonomi telah direka bentuk dan dihasilkan dengan getah silikon. Dua ujikaji, satu dengan tongkat lengan piawai dan satu dengan tongkat lengan dengan tambahan pemegang baru telah dijalankan oleh enam orang dewasa yang sihat, dengan dua orang yang pernah menggunakan tongkat lengan disebabkan kecederaan di anggota badan bawah. Pengagihan tekanan anggota badan atas telah diukur menggunakan penderia tanpa wayar Trigno EMG System dan mendapatkan isyarat EMG dengan komputer riba yang mempunyai Delsys EMGworks® Software semasa sukarela menjalan lima gaya berjalan 3 titik. Keputusan ujian EMG menunjukkan tambahan pemegang ergonomik dapat mengurangkan pengagihan tekanan atau aktiviti otot di anggota badan atas. Pemegang yang ergonomik seperti alur jari, alur ibu jari, bonjol tapak tangan dan kawalan hujung meningkatkan permukaan sentuh antara tapak tangan dengan pemegang dan mengurangkan tenaga diperlukan untuk pemegangan yang kuat. Satu lagi dapatan menunjukkan diameter pemegang ergonomik yang dihasilkan bersesuaian dengan sukarela yang tangan panjang 18.5 hingga 20.5 cm.

ABSTRACT

Crutch is a walking aid that mainly functions to maintain mobility of patients who injured or having surgery at lower extremities and it normally bring side effects such as hand uncomfortable to the patient. The main objective of this project is to analyse the pressure distribution on anatomical structure of the hand during ambulation with standard forearm crutch and additional handgrip forearm crutch. The additional ergonomic handgrip was designed and manufactured using vacuum casting, with silicone rubber as the raw material. Two experiments in ambulation on crutch, one with standard forearm crutches and one with additional handgrip forearm crutches were conducted with participation of six healthy adults, where two of them ever used forearm crutch because of injury at lower limb. The pressure distribution on upper limb when volunteer performing five 3-point gait were measured using wireless sensors of Trigno EMG System and EMG signal was acquired by laptop with Delsys EMGworks® Software. The results of the EMG test showed that the additional ergonomic handgrip reduce the pressure distribution or muscle activity on upper limb significantly. The ergonomic design at the handgrip such as finger groove, thumb groove, palm bulge and end guard increase the contact surface of inner hand with the handgrip, results in the lower energy needed to perform power grasp action. Another finding shows that the diameter of the ergonomic handgrip manufactured is suitable to volunteer within range from 18.5 to 20.5 cm of hand length.

DEDICATION

To my beloved parents,

Teo Soo Chea and Lim Siok Huang,

Who always support me in my life;

To my beloved project supervisor,

Umi Hayati Binti Ahmad,

Who always give me valuable suggestion and guidance;

To my beloved friends,

Who always encouraging me;

To my beloved laboratory assistants,

Who always explain questions that I asked patiently.

ACKNOWLEDGEMENT

I would like to express my greatest gratitude to everyone who have helped me, supported me and guided me throughout my project, especially my project supervisor, Umi Hayati Binti Ahmad. She is always guide me, lead me to the correct path and give valuable suggestion if anything is wrongly done. She helps me to arrange the time in conducting experiment as the equipment is shared by few students. I will not able to complete my project in time and successfully without the guidance of my supervisor.

Then, I would like to thank to my beloved parents and friends who always support me and inspire to achieve more. They encourage me all the time so that I do not have thought of giving up even though when met some difficulties at the rush and heavy hours.

Last but not least, I would like to thank to laboratory assistants in Project Lab and Rapid Manufacturing Lab who always explain the concept and assist me in produce my prototype sincerely. They help me a lot in understanding more about the equipment and material used in my project. I will not able to complete this project on time without their warm help.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

ABS	-	Acrylonitrile-Butadiene-Styrene
EMG	-	Electromyography
MU	-	Motor units
MSDs	-	Musculoskeletal disorders
QTM	-	Qualisys Track Manager
RC	-	Rotator cuff

CHAPTER 1

INTRODUCTION

1.0 Introduction

Backgrounds of the project, problems of the project, objectives of the project as well as scopes of the project are being discussed in this chapter.

1.1 Background

In this day and age, the probability to get an injury is high. Regardless performing a simple morning exercise or completing a heavy task, these activities might end up with a sprained ankle or a broken leg (Ghalehkhani et al., 2016). Injuries at lower extremities not just bring the sense of pain, but also influence the routine work and activity. Thus, crutches have been created and used by humans for approximately 5000 years from the ancient time until now. It is a walking aid that mainly functions to maintain mobility of patients who injured or having surgery at lower extremities (Fischer et al., 2014). It minimizes the discomfort and pressure exerted on injured lower limbs by transferring the body weight from lower limbs to the upper limbs (Borrelli and Jr, 2013). By using a crutch, the injured body part can rest in a relaxing condition and avoids increasing seriousness of injury that can contribute to a longer healing time. Other than that, a crutch also plays a significant role on improving user's stability and balancing when ambulation by the enlargement of supporting base. There are several types of crutches that have different advantages and disadvantages to users, which are forearm crutches, underarm crutches, platform crutches, Strutters and leg support crutches as view in Livestrong website at <http://www.livestrong.com/article/192684-how-to-keep-fit-with-crutches/>. The crutch that used in this project is forearm crutch, also known as Lofstrand crutch or elbow crutch. It can be classified into two categories, which are open and closed cuff crutch. The handgrips can be adjusted until it levels with wrist bone to minimize the wrist bone impact when gait. Some of the elbow cuff can even be adjusted until forearm cradles just below the elbow joint.

A good physical product brings value to its customers, no matter increasing their life standard or solving problems met in their daily life. A good product with ergonomic design can even improve the comfort and safety level of users. Ergonomics is the investigation and study of interaction between human and physical environment, including a product. Its main purpose is to enhance human health and the system performance. It is also to reduce stress and eliminate an injury that comes with the overuse of muscle, bad posture and repeated task while using a particular product. Thus, implementation of ergonomic principle in a product can greatly decrease the probability of suffering musculoskeletal disorders (MSDs) as its design is optimum for our body and muscle structure (Dennerlein, 2014).

Title of this project is the development on forearm crutches to reduce upper limb pressure distribution evaluated by EMG (electromyography), this is mainly focus on reducing the pressure exerted between user's upper limb and crutch. According to Daud et al. (2016), different country having different causes of injury, however, people that getting injured on lower limbs always choose to reduce force exerted on lower limb by lean on crutches. When using a crutch to balance body stability, it arises some side-effect including palm pain. Electromyography will be the equipment to measure electrical activity of muscles when they at rest and moved. In order to reduce the pressure distribution on upper limb when walking with crutches, additional ergonomics handgrip will be added on the crutches.

1.2 Problem Statement

Nowadays, fall or accident that leads to lower extremities injured is very common especially when human chasing for fitness and health. Forearm or elbow crutches enable lower extremities injured patient to perform ambulation and stance in an easier way by enlarging the supporting area and increasing the stability of the body (Sherif et al., 2016).

It is not to be denied that crutches play a very important role in assisting the daily life of injured patient, nevertheless, there are some problems occur while using the Lofstrand crutch. According to Sherif et al. (2016), walking on crutches usually can cause hand uncomfortable and injury because joints of the hands are too weak to bear entire body mass. For instance, during crutch gait with the legs completely unloaded with forces, the radiocarpal joint between the radius and carpus may be loaded more than 100% of body weight (Westerhoff et al., 2012). In addition, user can also suffer traumas and localised fatigue when performing power grip associated with repetitive hand action (Shiri et al., 2006). The contact between hand and elbow with the handgrip and cuff of the elbow crutches can normally trigger tenosynovitis in biceps tendon and contributes to ulnar neurapraxia at the wrist (Ginanneschi et al., 2009). Last but not least, ulnar bone fracture and complication such as skin hematoma can be caused when walking on crutch for a certain period (Molteni, 2016).

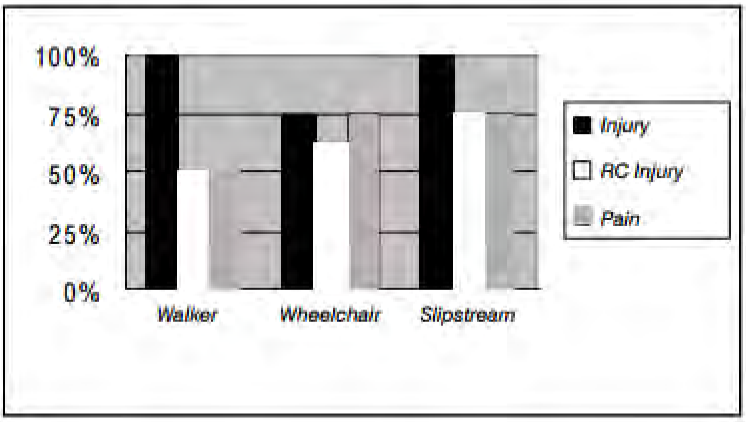

Figure 1.1: Graph of injury, RC injury and pain percentage for walker/crutch,wheelchair and slipstream (Source: <http://www.scielo.br/aob> 04/05/17)

1.3 Objective

Objective of a project is very essential as a guidance and direction throughout the project. Project will be suffered when conducting a plan without clarity and forethought. Defining of specific goals and objectives avoid the digression from the point. Thus, three objectives of this project have been listed below.

1) To develop an ergonomic handgrip that can assemble with the particular shape handle of forearm crutch
2) To analyse the pressure distribution on anatomical structure of the hand during ambulation with standard forearm crutches and additional handgrip forearm crutches
3) To determine the hand length that is suitable with the diameter of the handgrip

1.4 Scope

The scope of this project is only focus on walking on forearm or elbow crutches. Other types of crutches such as axillary or underarm crutches, platform crutches, Strutters and leg support crutches are not included in this project as the pressure distribution among these crutches are mostly different. Areas to be studied are focused on upper extremities, muscle involved are trapezius, deltoid, biceps brachii, brachioradialis and triceps brachii. The volunteer of this project study are adults that consist of male and female healthy volunteers with two of them ever used forearm crutches because of injury at lower limb. Three male and three female volunteers with about the same in heights and hand sizes will involve in this study. The equipment used in this project is electromyography (EMG), it is used to measure electrical activity of muscles when they at rest and moved. The data will be recorded when volunteers perform crutch gait. According to Timby (2009) and Heller (2016), crutch-walking gait can be categorized into four types, two-point gait, three-point gait (non-weight-bearing and partial weight-bearing), four-point gait and swing-through gait. Three-point gait with non-weight-bearing will be performed by volunteers and results of their