

DEVELOPMENT OF COUNTERBALANCE ARM SLING  
EXERCISE FOR NEUROLOGICAL PATIENT WITH  
HEMIPARESIS OF MALAYSIAN POPULATION



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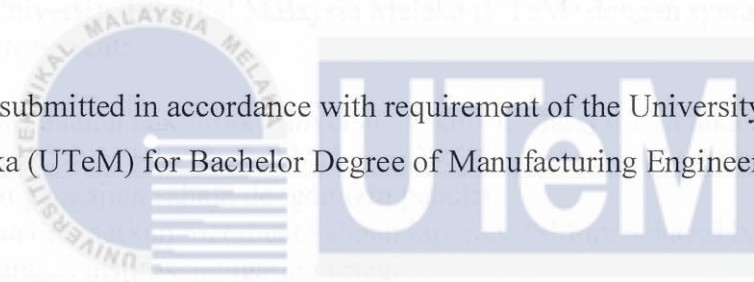
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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

TAJUK: DEVELOPMENT OF COUNTERBALANCE ARM SLING EXERCISE FOR NEUROLOGICAL PATIENT WITH HEMIPARESIS OF MALAYSIAN POPULATION

# DEVELOPMENT OF COUNTERBALANCE ARM SLING EXERCISE FOR NEUROLOGICAL PATIENT WITH HEMIPARESIS OF MALAYSIAN POPULATION

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



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Tajuk: **DEVELOPMENT OF COUNTERBALANCE ARM SLING EXERCISE FOR NEUROLOGICAL PATIENT WITH HEMIPARESIS OF MALAYSIAN POPULATION**

Sesi Pengajian: **2020/2021 Semester 2**

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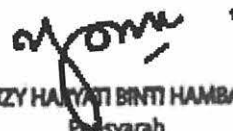
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Date

: 14 SEPTEMBER 2021



## 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:



## ABSTRAK

Strok telah menjadi salah satu penyakit terkemuka di dunia. Hemiplegia di satu sisi badan, digambarkan sebagai kelumpuhan akibat kecederaan otak, disebabkan semasa strok, biasanya bertentangan dengan lokasi di mana kemalangan otak (CVA) berlaku. Kerana kelemahan, pesakit neurologi menghadapi semua masalah ini dengan pakaian, tidur, menaip, dan bersenam. Walau bagaimanapun, CBAS-X yang ada mempunyai beberapa kekurangan di mana bahagian penyambungannya akan hancur apabila sering digunakan sebagai latihan sling lengan. Selain itu, ketika dipasang pada kerusi roda, posisi CBAS-X tidak terlalu stabil dan mudah bergoyang. Selanjutnya, CBAS-X yang ada mempunyai batasan tersendiri di mana peranti ini dibuat hanya untuk menyokong sling lengan dan tidak sesuai untuk latihan sling lengan. Oleh itu, projek ini bertujuan untuk membuat Latihan Counterbalance Arm Sling yang disesuaikan untuk rakyat Malaysia dengan kemampuan bergerak, boleh dilepas dan mesra pengguna. Selain itu, kajian ini lebih memfokuskan pada lengan manusia yang menyokong hemiparesis semasa melakukan aktiviti dan terapi tugas harian. Lengan kontra keseimbangan mensasarkan pesakit untuk berdikari. Tugas bermula dengan mengumpulkan data mentah pada skala dan spesifikasi konfigurasi kerusi roda dan ukuran setiap pengguna sasaran. Kemudian, pelaksanaan CBAS-X merangkumi pengeluaran komponen dan ujian lapangan. Pada masa yang sama, prosesnya lebih mudah bagi pesakit untuk kembali bekerja dan meningkatkan kualiti hidup mereka kerana kelemahan mereka. Selain itu, kajian dan penilaian projek untuk mengesahkan ulasan dan kebolegunaan produk menggunakan Analisis Elemen Terhingga. Pada akhir penyelidikan ini, data analisis keletihan menunjukkan bahawa reka bentuk yang diperbaiki mempunyai daya tahan kekuatan yang lebih tinggi dan jangka hayat yang panjang. Oleh itu, reka bentuk yang lebih baik dicadangkan untuk menjadi reka bentuk baru CBAS-X. Kajian ini diharapkan dapat meningkatkan reka bentuk terkini yang dapat membantu pesakit-pesakit ini dalam melakukan pemulihan melakukan aktiviti harian dan juga meningkatkan kualiti hidup mereka.

## ABSTRACT

Stroke has become one of the world's most prominent illnesses. Hemiplegia on one side of the body, described as paralysis due to brain injury, was induced during the strokes, typically opposite the location where a brain accident (CVA) occurred. Due to the weakness, neurological patients encountered all these problems with clothing, sleep, typing, and exercise. However, existing CBAS-X has some shortcomings where the joining part will be break when it is often used as arm sling exercises. Besides, when it is attached to the wheelchair, the position of the CBAS-X is not too stable and easy to sway. Furthermore, existing CBAS-X have its own limitation in which the device was created only for supporting arm sling and not suitable for arm sling exercise. Therefore, this project aims to create a customized Counterbalance Arm Sling Exercise for Malaysians with mobile, detachable and user-friendly capability. Besides, this study is more focusing on human arm supporting with hemiparesis during daily task activities and therapy. The counter-balance arm slings targeted patients to be independent. The task begins with compiling raw data on the scale and configuration specifications of wheelchairs and the size of each target user. Then, CBAS-X implementation include component production and field trials. At the same time, the process is easier for patients to go back to work and improve their quality of living due to their weakness. Furthermore, the design of this product might benefit the patient as an exercise aid, which is an added function to help the user with their upper limb strengthening. Besides, the project's review and evaluation to validate the product's reviews and usability using Finite Element Analysis. At the end of this research, fatigue analysis data show that the improved design has higher strength durability and long lifespan. Hence, improved design is proposed to be the new design of CBAS-X. This study is expected to improve the current design that can assist these patients in performing rehabilitation performing daily activities as well to improves their quality of life.



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## ACKNOWLEDGEMENT

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PERKASAD	-	Social Security Organization
PRC	-	PERKILSD Rehabilitation center
LVA	-	Cerightoversee of accident
EQI	-	Degree of freedom
NMT	-	Numerical Muscle Testing
CAD	-	Computer-aided design
CBAS	-	Counter Balance Arm slings
FEA	-	Finite Element Analysis
UTeM	-	Universiti Teknikal Malaysia Melaka





## LIST OF ABBREVIATIONS

PERKESO	-	Social Security Organization
PRC	-	PERKESO Rehabilitation center
CVA	-	Cerebrovascular accident
DOF	-	Degree of freedom
MMT	-	Manual Muscle Testing
CAD	-	Computer-aided design
CBAS	-	Counter Balance Arm slings
FEA	-	Finite Element Analysis
UTeM	-	Universiti Teknikal Malaysia Melaka
3D	-	3 Dimensional
2D	-	2 Dimensional
FDM	-	Fused Deposition Modeling
PETG	-	Polyethylene terephthalate
PLA	-	Polylactide



Figure 1.1: Type of Paralysis

Source: *Wikipedia*, <https://en.wikipedia.org/wiki/Paralysis#/media/File:Paralysis.jpg>

# CHAPTER 1

## INTRODUCTION

### 1.1 Research Background

According to (Weiss et al., 2017), Hemiparesis is a disease often caused by strokes or brain paralysis, but it can also be caused by multiple sclerosis, brain tumours and other diseases of the brain and the nervous system. Damage to the brain due to head injury, brain cancer or disease may also lead to development of muscle failure. The characteristic muscle weaknesses of hemiparesis can be caused by lesions in a spinal cord of the person, causing damage to the nerves and innervating the muscles. Damage to the brain of the individual can also cause muscle weakness. Hemiparesis can therefore be treated in order to solve the hemiparesis or to put the progress of the hemiparesis completely to a halt. A significant part is physical therapy in the treatment of the individual. Therapy helps people regain control of their muscles during muscle strength development.

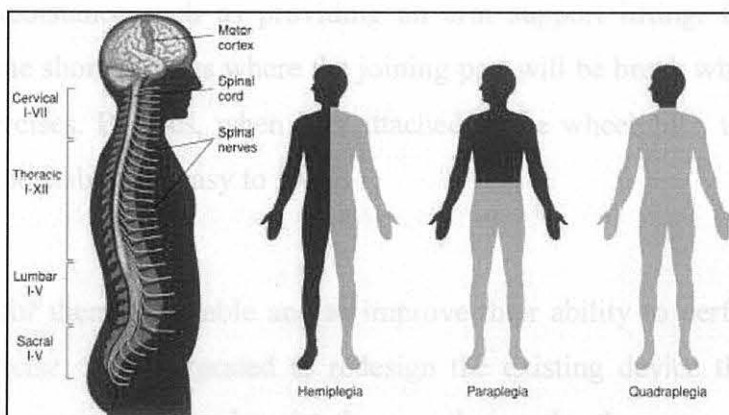


Figure 1.1-1: Type of Paralysis

Sources : (Hemiplegia - Psy3242, n.d.)

Currently available existing design in the market which is called counter balance arm sling. This is a device used to support patient with hemiplegia and hemiparesis condition in performing their daily routine. Thus, one of the main objectives of this project is to produce device that is mobile and detachable to client's wheelchair is the focus that has been concerned in order to help physical therapist and exercise in PERKESO Rehabilitation Centre (PRC) to meet he needs of neurological patients with hemiparesis. This device can also be used to support the patients with nerve injuries and brain injuries with certain categories of muscle strength.

This project intends to develop a device that support upper limb of neurological patient with hemiparesis people. The purpose this counter balance arm sling rest equipment for the patient as an exercise device in order to help the neurological patient with hemiparesis to support their arm for individual with weakness of one side body for their everyday living tasks which includes therapy exercise and daily activities.

## 1.2 Problem Statement

Assistive device is a product that have been designed and created to alleviate the burden faced by semi-paralyzed patients or better known as hemiparesis, according to (Hsu et al., 2012). As well known, hemiparesis patients have difficulty doing things like eating, dressing, using bathroom and others (Herder et al., 2006). Therefore, CBAS-X has provided some assistance such as providing an arm support lifting. However, existing CBAS-X has some shortcomings where the joining part will be break when it is often used as arm sling exercises. Besides, when it is attached to the wheelchair, the position of the CBAS-X is not too stable and easy to sway.

In order for them to be able and to improve their ability to perform daily routine and therapy exercise, it is suggested to redesign the existing device that is mobile and detachable which can support and assist the arm during the therapy exercise (Mohamad Khairon, 2017). Figure1.2-1 below show the current existing CBAS-X design.

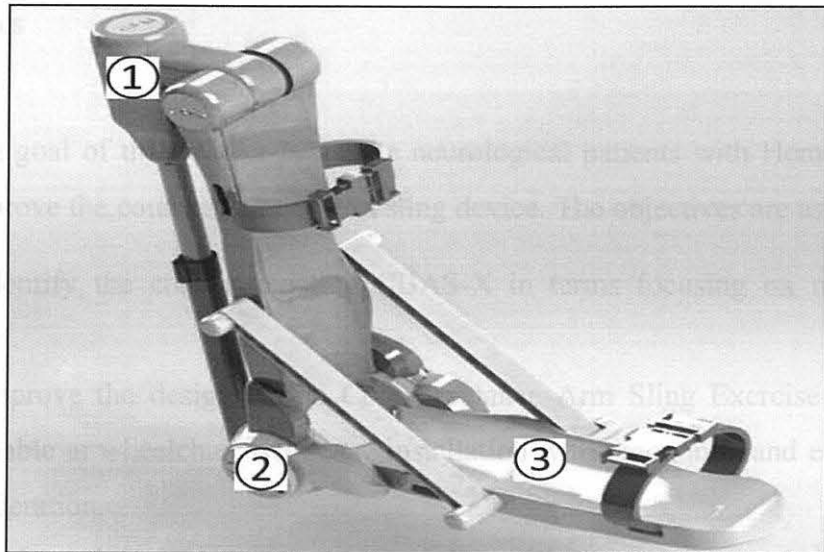


Figure 1.2-1 : 3D model of the current existing CBAS-X design

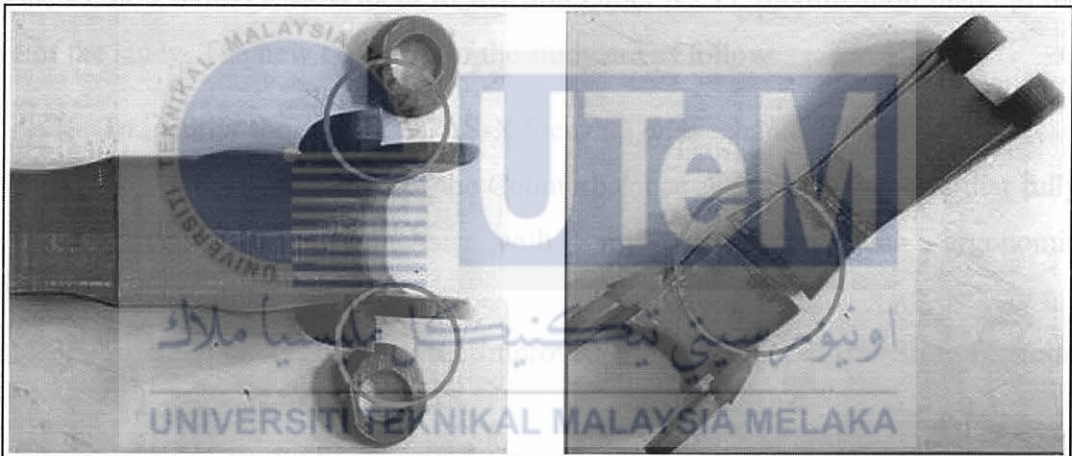


Figure 1.2-2 : Fracture part at current device

Sources : (Mohamad Khairon, 2017)

#### 1.4 Scope of Project

Current existing CBAS-X have its own limitation in which the device was created only for supporting arm sling and not suitable for arm sling exercise. Based on Figure 1.2-2 show the fracture at the current device. From the current devices, there is three critical part that have facing a problem during process of using the devices. First part is the connectors between the device and wheelchair. The second and third part is a joining part. Besides, the joining part was created only for support the arm sling and not for exercise uses. Then, this research focusses on redesign and improved an ergonomic counterbalance arm sling exercise that as well mobile and detachable that easier to be installed on the wheelchair.

### 1.3 Objectives

The main goal of this project is for the neurological patients with Hemiparesis to redesign and improve the counter balance arm sling device. The objectives are as follow:

1. To identify the current existing CBAS-X in terms focusing on mechanical design.
2. To improve the design of the Counterbalance Arm Sling Exercise that fully attachable at wheelchair with easy installation with ergonomic and economical consideration.
3. To analyze the effectiveness and usability of improved Counterbalance Arm Sling Exercise by using method of physical testing.

Due to the Covid-19 Movement Restriction Order MCO, modification made to the objective of the study. The new objective of the study are as follow:

1. To identify the current CBAS-X focusing on mechanical design.
2. To improve the design of the Counterbalance Arm Sling Exercise that fully attachable at wheelchair with easy installation with ergonomic consideration.
3. To simulate and analyze the improved Counterbalance Arm Sling Exercise by fatigue analysis.

### 1.4 Scope of Project

The purpose of this project is to redesign and improve counter balance arm sling rest for neurological patient with hemiparesis. The scopes of the project are:

1. Redesign counter balance arm sling by using Solidworks software.
2. Remain the same material Polylactide (PLA) for material selection.
3. Built a prototype of counter balance arm sling by using Ender 5 Plus 3D printing and manufacturing process.

4. Perform Finite Element analysis on the design to analyze the behavior of the critical part using Ansys software.
5. Simulate the design in order to know the functionality of the devices due to the improvement design

## 1.5 Rational of the Research

The rational of the study is to redesign and improve the current design of counter balance arm sling. Main factor of this study is to help the neurological patient with hemiparesis in PRC Melaka by developing an assistive device such as counter balance arm sling the counter balance arm sling to help the patient to assist them in daily routine and during therapy in PRC. Besides assist the patient, the counter balance arm slings also help to promote the patients to be independent and at the same time faster the process recovery of the patients due to their weakness. Furthermore, the other reasons why the counter balance is redesign because the current assistive device such as counter balance arm sling is not suitable for exercise and just more focus to assists the patient. Hence due to the problems, the idea to redesign an ergonomic counter balance that is suitable for support the arm, arm exercise, mobile and detachable will be redesign and improve to solve the problems.

## 1.6 Project Planning and Execution

In this project, Gantt chart is constructed to list all the related task and reallocate time to finish the respective task from the beginning until the end of the study including dated of report submission. This project Gantt chart schedule is presented in Appendix A and Appendix B.

## 1.7 Thesis Organization

This final year project is comprised of further four chapters as follows

- Chapter II Literature Review: This chapter discusses the general classification of strokes, the physical effects of strokes, and the hemiparesis condition in strokes, hemiparesis disabilities in terms of range of motion and which muscles are involved on the affected upper limb part, and technique recovery for hemiparesis patients. Aside from that, it also contains a method for evaluating muscle strength known as manual muscle testing, as well as information about available interventions such as arm slings and the use of assistive devices for patients with hemiparesis.
- Chapter III Experimental procedure: Describe the experimental work or technique that was performed during the product development process. This chapter covers data collecting methods, materials utilized, product mechanisms, manufacturing methods, experimental Finite Element analysis, types of software used to create a 3D model of the product, and final product simulation.
- Chapter IV. The product development process is described in detail, from the design phase through the final phase of development. In order to acquire the study findings, the results of static analysis, anthropometry data analysis, Finite Element Analysis, and final product fatigue simulation are discussed in this chapter.
- Chapter V. The segments that will represent the general findings and discussion of the project, as well as the suggestion and recommendation for upcoming projects, are offered in this research.

carpal tunnel and by other nerves or brain-related disorders. In addition, the hand often is paralyzed in the form of a claw. Pure motor stroke, also called motor hemiparesis is the most common form, where the patient has weakness of the arm, face, leg, and trunk of one part of the body but can also affect one part of the body more in some cases.

## CHAPTER 2

### LITERATURE REVIEW

In other cases, a stroke can affect the face, arm, and a part of the body that can't properly allow the leg to move or affect movement of the arm. Patients who have hemiparesis in neurology are having trouble moving their portions of the body such as their arm, leg, hand, face, trunk or leg where the coordination of the body is lost or physical failure to other causes has disabilities that prohibits them from performing routine.

This chapter presents a brief overview of hemiparesis in stroke and technique involves in recovery for hemiparesis. An overview of mechanical behaviour, mechanical system failures and Finite Element Analysis. Other important aspects included in this review are the assistive device as counter balance and its advantages for neurological patient with hemiparesis. All of this information has been extracted from various sources such articles, journals and related books.

#### 2.1 Overview of Hemiparesis

Stroke is the most prevalent source of adult injury in developed nations. As a result of better treatment, the mortality rate after stroke is expected to decline once the problem arises. The number of individuals with disabilities after a stroke will then be expected to grow. Muscle weakness is a typical consequence of a stroke which may cause physical activity to decline (Wist et al., 2016). Besides, strokes and hemiparesis patients are diagnosed with both reduced upper limb bone mass as well as decreased lower limb bone mass (Chang et al., 2020). However, for neurologic patients with hemiparesis, the counter balance arms sling is planned in this project. The term hemiparesis has its own definition where hemi terms stand for “one side of the body” and paresis mean “partial loss of movement” Roughly more than 80 percent of all cases suffering from stroke experienced weakening in one side of the body (Bartolo et al., 2014). Hemiparesis caused by stroke or