



**DEVELOPMENT OF ASSISTIVE DEVICE FOR HIP ABDUCTOR
ADDUCTOR FOR NEUROLOGICAL AND SPINAL CORD INJURY
PEOPLE**

This report is submitted in accordance with requirement of the University Teknikal Malaysia Melaka (UTeM) for bachelor's degree of Manufacturing Engineering (Hons.)

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2022

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

Tajuk: **DEVELOPMENT OF ASSISTIVE DEVICE FOR HIP ABDUCTOR ADDUCTOR FOR NEUROLOGICAL AND SPINAL CORD INJURY PEOPLE**

Sesi Pengajian: **2021/2022 Semester 2**

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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:



ABSTRAK

Paraplegia adalah sejenis lumpuh yang menjejaskan separuh bahagian bawah keupayaan badan untuk bergerak. Ia berlaku apabila penyakit atau kemalangan menjejaskan bahagian sistem saraf yang mengawal bahagian bawah badan pesakit. Keadaan ini disebabkan oleh kecederaan otak dan saraf tunjang yang disebabkan oleh kemalangan, jatuh dari ketinggian, sukan dan faktor lain. Tahap kecacatan atau lumpuh bergantung pada peringkat kecederaan saraf tunjang, dengan kajian ini memfokuskan kepada pesakit yang mengalami kecederaan pada tahap L1 hingga L5, yang menjejaskan kawasan pinggul dan pangkal paha, serta otot perut bawah dan fleksi paha. Majoriti pesakit ini memerlukan bantuan daripada penjaga untuk melakukan aktiviti asas. Terdapat juga keperluan untuk peranti bantuan (AD) yang boleh membantu pesakit menjadi lebih berdikari. Walau bagaimanapun, produk AD semasa di pasaran dan di pusat pemulihan tidak mencapai kebebasan pengguna kerana pesakit masih memerlukan bantuan untuk memindahkan dari kerusi roda ke peranti atau sebaliknya. Hasilnya, tujuan projek ini adalah untuk menambah baik peranti bantuan sedia ada dan membangunkan alat bantuan yang akan membantu pesakit dalam memindahkan dari kerusi roda ke peranti sedia ada atau sebaliknya tanpa bantuan orang lain. Ia bertujuan untuk lebih menjimatkan dan ergonomik mengikut keperluan dan keperluan, selain boleh alih dan boleh ditanggalkan. Pengukuran antropometri, soal selidik, temu bual, dan keperluan reka bentuk semuanya digunakan dalam pembangunan peranti bantuan ini sebagai sebahagian daripada metodologi yang digunakan dalam kajian ini. Usaha itu juga termasuk ahli terapi dan pesakit yang menguji dan mengesahkan keputusan. Ujian otot manual (MMT), dan ujian Electromyography (EMG) telah digunakan untuk menentukan kebolehpercayaan dan kegunaan peralatan bantuan ini. Alat bantuan yang baru dibangunkan ini bertujuan untuk digunakan oleh pesakit SCI Malaysia. Kajian ini terbukti membantu pesakit ini dengan pemulihan dan tugas harian, serta meningkatkan kualiti hidup mereka secara keseluruhan.

ABSTRACT

Paraplegia is a paralysis that impairs the bottom half of the body's ability to move. It is when a disease or accident affects the section of the nerves system that regulates the patient's lower body. This condition is caused by brain and spinal cord injuries by accidents, falls from great heights, sports, and other factors. The level of disability or paralysis depends on the stage of spinal cord injury, with this study focusing on patients who had injuries at levels L1 to L5, which affects the hips and groin area, as well as the lower abdominal muscles and thigh flexion. Most of these patients require assistance from carers to perform basic activities. Reported as well that the assistive device (AD) able to improve and assist patients in activity daily life (ADL). However, current AD products on the local market and in rehabilitation centres do not reach user's independency. The patients still necessitate assistance either from physiotherapist or carers to transfer from wheelchair to device or vice versa, as well to abduct and adduct their bodies. Hence, the aim of the project is to improve the existing assistive device and develop an assistive device mechanism that will aid patients in transferring from a wheelchair to an existing device or vice versa and abduct and adduct with minimal help to no help from others. This includes more economical and ergonomically suit the needs and necessity of patients, movable and detachable ability of device. Anthropometry measurements, questionnaires, interviews, and design requirements were all employed in the development of this assistive device as part of the methodology used in this study. The effort also includes therapists and patients testing and validating the results. Manual muscle testing (MMT), and Electromyography (EMG) were utilised to establish the reliability and usefulness of this assistive equipment. This newly developed assistive device is intended for use by Malaysian SCI patients. This study proved to help the patients with rehabilitation and everyday tasks, as well as enhance their overall quality of life.

DEDICATION

A gratitude to:

My Lovely Parents

Hj. Mohd Sufi bin Ibrahim

Hjh. Rafeah bt Abd Kadir

for the perfect living and endless love



My Lovely Supportive Siblings

Nurul Syafiqah binti Mohd Sufi

Nurul Syaquirah binti Mohd Sufi

Nurul Syafiyah binti Mohd Sufi

as my stress relievers

My High Spirits and Energetic Supervisor

Puan Ruzy Haryati binti Hambali

for the ideas, encouragements, motivations and keeping trust on me

the pure hearts

Aina Dalila binti Ahmad Rozelan

During the highest and lowest points of this journey.

ACKNOWLEDGEMENT

In the name of Allah, the Most Merciful, I thank Him for allowing me to complete my final year project effectively and without difficulty.

My valued supervisor, Puan Ruzy Haryati binti Hambali, for the outstanding guidance I received during the assignment. She has contributed valuable ideas and suggestions that have aided in the accomplishment of our research project. I'd also like to express my gratitude to PERKESO Rehabilitation Centre (PRC) Melaka, the psychotherapist, and the patients for their great supervision, advice, insights, and guidance, as well as for giving me with invaluable experiences during my studies.

Finally, I'd like to thank my one and only best friend, my partner in crime, Aina Dalila binti Ahmad Rozelan who is the only one who has helped me to complete this report and is always by my side throughout this journey, especially for her invaluable insights, supportive and encouraging advice, and unwavering support. She has been there for me throughout my last year, listening to my anger and frustration and helping me to feel better so that I can finish this report. Thank you for being the best friend a person could ever ask for.

In summary, I'd like to express my gratitude to everyone who helped with my Final Year Project report, and I apologise for not being able to thank you all individually.

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LIST OF ABBREVIATIONS

PRC	- PERKESO Rehabilitation Centre
PERKESO	- Pertubuhan Keselamatan Pekerja
SCI	- Spinal Cord Injury
CIMT	- Carotid Intima-Media Thickness Test
FYP	- Final Year Project
GH	- Government Hospital
MMT	- Manual Muscle Testing
ROM	- Range of Motion
ASIA	- American Spinal Injuries Association Impairment Scale
WHO	- World Health Organization
ADL	- Activities Daily Life
MRC	- Medical Research Council
PT	- Physical Therapy
OT	- Occupational Therapy
AT	- Assistive Technology
AD	- Assistive Device
FES	- Functional Electrical Stimulation
FNMS	- Functional Neuromuscular Stimulation
HZ	- Hertz
ISCI	- Incomplete Spinal Cord Injury
MCO	- Movement Control Order
QFD	- Quality Function Deployment
HOQ	- House of Quality
CR	- Customer Requirement
FR	- Function Requirement
CAD	- Computer-Aided Design
FEA	- Finite Element Analysis
FDM	- Fused Deposition Modeling

3D	- Three-dimensional
EMG	- Electromyography
FKP	- Fakulti Kejuruteraan Pembuatan
NM	- Neuromuscular
MIG	- Metal Inert Gas
GTL	- Gluteal
PEC	- Pectineus
TFL	- Tensor Fasciae Latae
RMS	- Root-mean-square



CHAPTER 1

INTRODUCTION

In this chapter, the background of the study covers the information of neurological and spinal cord injury, SCI. The issues are identified using a variety of methods, including interviews, surveys, observations, and video recording. Following that, objectives are defined, with scope of study focuses on developing an assistive device for hip abductor equipment to help people with neurological SCI. Significance of the study and organisation of the report also included this chapter.

1.1 Background of Study

There are several activities of daily living (ADL) that humans might engage in daily in this age of globalization. ADLs are vital chores that involve independent living, such as dressing, bathing, eating, toileting, and utilizing ambulances. There are various disorders across the world that cause persons with these limits to have reduced function.

This study focuses on the person with spinal cord injury (SCI) that associated with long-term and ultimately severe neurologic dysfunction and disability. SCI can cause from damage to the vertebrae, ligaments, or discs of the spinal column, as well as the spinal cord itself. Symptoms include loss of muscular function, sensation, or autonomic function in areas of the body supplied by the spinal cord that are not severely damaged. The spinal cord can be injured at any level and can be severely damaged, resulting in total loss of sensation and muscle function in the lumbar segments, or partial, allowing some nerve signals to flow through the injured section of the cord up to the Lumbar L1-L5 spinal cord segments as shown in Figure 1.1.

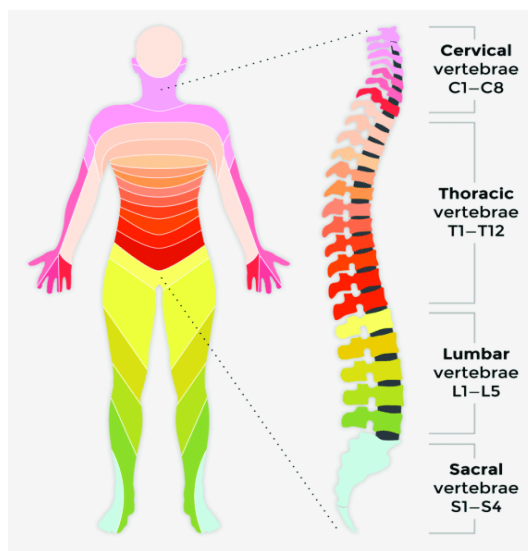


Figure 1.1: Level of Injuries in Spinal Cord

Source: https://www.researchgate.net/figure/Spinal-cord-injury-levels_fig3_338854892

Neurological disorders affect the brain, as well as the nerves that travel throughout the body and the spinal cord, according to medical definitions. Structural, metabolic, or electrical abnormalities in the brain, spinal cord, or other nerves can cause a range of symptoms. The brain and spinal cord make up the central nervous system. Soft tissue surrounds the spinal cord, which is encircled by bones (vertebrae). It stretches from the base of your brain and contains nerve cells as well as tracts of nerves that lead to other places of your body. Despite being surrounded by strong membranes, encased in the bones of the skull and spinal vertebrae, and chemically segregated by the blood–brain barrier, the brain and spinal cord are extremely vulnerable if they are damaged. Nerves are usually found deep beneath the skin, yet they can still be damaged.

Due to these weaknesses, neurological patient with SCI facing issues in performing ADL and depending on physiotherapist and carer to perform these activities. There are variety of treatment that is used to regain strength includes rehabilitation treatment for example CIMT, electrical simulation, mirror therapy and etc, exercises at home and assistive device (Physical, 2016). The treatment that is recommended by the physical therapy and most preferable by the patient is using the assistive device (Resnik et al., 2009). With the assistive aids, this method helps to increase control and flexibility which accommodate limitation yet promote self-management to the patients (Jutai et al., 2007). As suggestion, the process of rehabilitation using hip showed that the rehabilitation process after an injury

or surgery is an exercise conditioning program to help the clients or patients return to daily work activities.

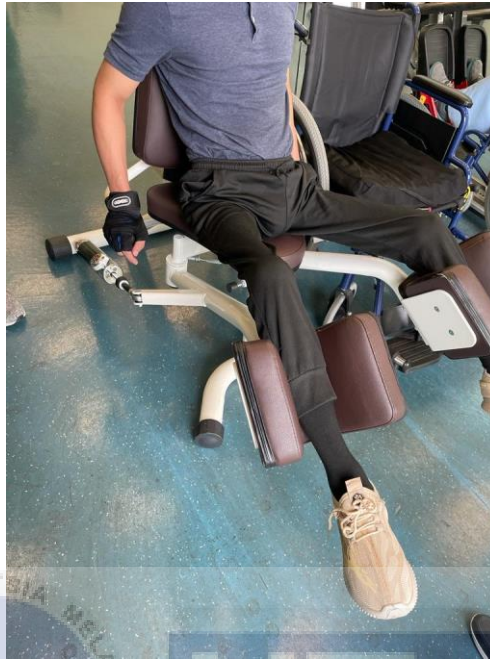


Figure 1.2: A Patient Uses the Hip Abductor Equipment in PERKESO Rehabilitation Centre Melaka

Figure 1.2 above shows the hip abductor equipment in PERKESO Rehabilitation Centre Melaka. In general, hip abductor equipment is an assistive device to help people with neurological and spinal cord injury to strengthen the muscles in your hips that regulate posture. Muscles that are weak in some individuals, putting runners more vulnerable to injury. The hip abductor muscles appear to be crucial for managing weight shifting during actions that demand it (Francis et al., 2018; Inacio et al., 2018; Lanza et al., 2020a). These muscular groups have also been correlated to the control of weight-bearing resistance workouts (e.g., squats and lunges; McCurdy and Conner, 2003; Stastny et al., 2015). Given that physical function varies over time, the hip abductor muscles may vary with human growth. Preventing disability-related problems is the most critical part of therapeutic treatment for SCI patients. Supportive assistance has been demonstrated to reduce mobility-related problems.

For this limitation or weakness of neurological and spinal cord injury people, hip abductor equipment or device have been recommended to strengthen the target muscles, as the hip abductor muscles function as to stabilize the hip within the frontal plane during the

single-limb support phase of walking. Nonetheless, the weight, torque, expense, and size of the current device are only a few of the issues that have been raised.

The main issue for this equipment was the mechanism of the equipment. The patient entirely dependent to the carer or physiotherapist to any flexion activities. The project aims to develop assistive device to improve and increase the ability of the SCI patient in using the device. Furthermore, as our understanding of the brain-computer interface grows, we may be able to minimize some of the difficulties associated with SCI in the future.

1.2 Problems Statement

Paraplegia is a type of paralysis that mostly impairs lower-body movement. Paraplegics are unable to move their legs, feet, and even their abdomen on their own. Incomplete paraplegia affects some persons. When only one leg is paralysed, this is the case. The mobility of the lower part of the body is significantly hampered by paraplegia. It can be caused by a long-term illness or an accident that damages the brain or spinal cord. People with paraplegia may develop issues such as spasticity over time. Paraplegics will experience mobility issues and may necessitate the use of a wheelchair. Long-term therapeutic options do exist, however, to help persons with paraplegia lessen symptoms and problems. Damage to the brain or spinal cord prevents signals from reaching the lower body, resulting in paraplegia. The lack of signalling induces lower-body paralysis. According to the National Spinal Cord Injury Statistical Centre, car accidents accounted for 38.3 percent of spinal injuries in 2015, while falls accounted for 31.6 percent. Violent crimes and sporting accidents are two more common causes. Paraplegic patients frequently necessitate long-term treatment and everyday care. There is no cure for paraplegia currently. Physical therapy, medicines, and surgery are among the long-term therapeutic options available. These may aid in regaining some control over the damaged areas.

Individuals who undergo changes in their physical ability might benefit greatly from rehabilitation since it tackles many of the concerns and challenges that they face. Cramping, weakness, and movement issues; balance, dizziness, and difficulty coordination are some of the specific symptoms that can be treated. Traditionally, rehabilitation activities have been

limited to rehabilitation centres or rehabilitation units within government hospitals, such as Pertubuhan Keselamatan Pekerja (PERKESO) (GH). This is owing to the equipment and facilities available in the PERKESO Rehabilitation Units (PRC) and the General Hospital (GH).

The problem here was that there was no spinal cord injury (SCI) centre for this condition. As a result, most of these cases are referred to a general hospital. The ward staff typically lacks the necessary experience, expertise, and support to handle patients with SCI (Engkasan et al., 2017). In other circumstances, most patients are discharged and then immediately returned home from the hospital. Untrained family members are usually the ones who help them handle their everyday duties at home. According to reports, the assistive device is a successful technique to support patients with rehabilitation and routine everyday activities (Hambali et al., 2019). However, the device's design placed too much reliance on the psychotherapist or guardian. The hip abductor's design also needs to be improved. This demonstrated that there is still opportunity for improvement, and the new assistive device has the potential to be the best version for paraplegic people.

1.3 Objectives

The main aim of this project is to design and develop an assistive device for hip abductor of neurological and spinal cord injury patients which ensures to help stabilize the hip within the frontal plane and increase dependency. The objectives of the project are as follow:

1. To determine issues of neurological and SCI in performing activities using hip abductor
2. To develop an assistive device for hip abductor that suitable for the neurological and spinal cord injury people and promote independency of the users.
3. To test and analyse the usability of the product.

1.4 Scope of the Study

This project analysis focuses the person that has neurological disorders cause by spinal cord injuries and focuses to analyse the muscle activity and force analysis with assistive device (HiAD2021) of paraplegic patient in PERKESO Rehabilitation Centre, Melaka. The patient needs the hip abductor as it functions as an assistive device to help and protect the patient from injury, improve comfort and function and improve the independency of the users. The scopes of this project are:

- I. In terms of identifying and deciding the patient, the research is restricted. The total number of patients or respondents, as well as their age, size, and gender, are the work's limitations. It is entirely based on case studies (patients) that are selected based on certain criteria.
- II. Analysing the assistive device that has been designed using finite element analysis (FEA) to ensure that it is safe to use for the user.
- III. Explanations of the process or fabrication of the part utilizing various manufacturing procedures, as well as a product analysis on a chosen product.
- IV. Product analysis is looking at features, pricing, availability, quality, appearance, and other factors of a product, as part of the product design process which incorporates all aspects of the product, including its purpose, function, and attributes, as well as to translate a high-level product description into project deliverables and requirements.

1.5 Significant/Important of Study

The assistive device has shown to be an effective means of assisting patients with their rehabilitation and everyday tasks. As a result, this project expanded to improve the ability of disabled people and increase dependency and confidence level.

1.6 Organization of the Report

To have a clearer vision and a concise summary of the entire project, the project organization was designed based on the Final Year Project (FYP). The structure of this study's report is as follows:

Chapter 1: Introduction

The introduction chapter discusses the study's background as well as the background of the company, PERKESO Melaka rehabilitation centre. Current issues are identified through a variety of ways, including surveys, observations, video recording, and questionnaires. The goals to be achieved and the study's scopes are then discussed to narrow down the field of expertise. It is also recognized the significance of studying.

Chapter 2: Literature Review

This chapter presents a literature review on the study's history or fundamental information, which was compiled from many sources such as the internet, books, papers, and journals. These sections provide an overview of the approach used to overcome issues and provide alternatives. This chapter also explains a basic categorization of paraplegia based on research into the severity of paraplegia, the causes of paraplegia, the effects of the injury, and the abilities of paraplegic individuals. It also includes disease diagnosis based on a hypothesis of the patient's everyday activities, as well as techniques of evaluating muscular strength using manual muscle testing (MMT) and perform muscle testing activity using electromyography (EMG). This chapter also contains information on therapy treatments or rehabilitation approaches, as well as assistive devices.

Chapter 3: Methodology

The approach and method for developing the assistive device are described in this chapter. There are several options for gathering data, including visiting the PERKESO Melaka rehabilitation centre. From that, there will be material selection using CES EDUPACK, product mechanism, a manufacturing method divided into 3D printing and manufacturing process, tools for selecting the final design, product analysis using Finite Element Analysis to determine the maximum stress, software for developing the 3D model design, and final product testing.