

**THE EFFECTIVENESS OF ROBOTIC
REHABILITATION THERAPY ON ACTIVITIES
OF DAILY LIVING AMONG WORKERS WITH
ACQUIRED BRAIN INJURY**

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By

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In the name of Allah, the most compassionate and merciful.

So verily, with every difficulty, there is a relief. [94:5]

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DECLARATION

I, Mohd Khairul Anwar Bin Kamdi, declare that the work presented in this thesis is originally mine. The information that has been derived from other sources is clearly indicated in the thesis.

Mohd Khairul Anwar Bin Kamdi

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Signed on 28th December 2022

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LIST OF DRAFT PAPERS

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- USM

LIST OF ABBREVIATIONS

ADL Activities of Daily Living

AIC Akaike Information Criterion

BI Barthel Index

BMI Body Mass Index

CDs Compact Discs

CI Confidence interval

CVA Cerebrovascular Accident

CVDs Cardiovascular diseases

DALYs Disability adjusted life years

GLMM Generalized Linear Mixed Model

HADS Hospital Anxiety and Depression Scale

HAL Hybrid Assistive Limb

HUSM Hospital Universiti Sains Malaysia

ICC Intra-level Correlation Coefficient

ID Identifier

JEPeM Human Research Ethics Committee of USM

MMC Malaysian Medical Council

MBI Modified Barthel Index

MOH Ministry of Health, Malaysia

MREC Medical Research and Ethics Committee's

mRS Modified Rankin Scale

NCDs Non-communicable diseases

NHS National Health Service

PSD Post Stroke Depression

QOL Quality of Life

RCT Randomized Controlled Trial

RM ANOVA Repeated measures analysis of variance

RM Malaysian ringgit

RTW Return To Work

SD Standard deviation

SOCSSO Social Security Organisation

TBI Traumatic Brain Injury

USM Universiti Sains Malaysia

WHO World Health Organization

LIST OF SYMBOLS

$>$ More than

$<$ Less than

$=$ Equal to

$\geq$ More than and equal to

$\leq$ Less than and equal to

α Alpha

β Beta

Θ Theta

% Percentage

p p -value

ABSTRAK

KEBERKESANAN TERAPI PEMULIHAN ROBOTIK TERHADAP AKTIVITI KEHIDUPAN HARIAN DALAM KALANGAN PEKERJA YANG MENDAPAT KECEDERAAN OTAK.

Latar belakang: Strok adalah salah satu punca utama hilang upaya yang diperoleh di kalangan orang dewasa dan punca utama kematian keenam di seluruh dunia. Di Malaysia, terdapat 50,000 kes strok setiap tahun, dan 40,000 daripada kes tersebut berlaku dalam kalangan mereka yang sudah bekerja. Populasi yang semakin tua telah meningkatkan keperluan global untuk perkhidmatan terapi fizikal. Ramai yang menggunakan penilaian penjagaan diri *Barthel Index* untuk menentukan sama ada pesakit strok, neuromuskular atau kanser boleh memenuhi keperluan asas mereka atau tidak. Kajian ini bertujuan untuk menentukan keberkesanan terapi pemulihan robotik berbanding terapi pemulihan konvensional terhadap skor *Modified Barthel Index* (MBI) dan kesan peramal dalam kalangan pekerja yang strok di pantai timur Semenanjung Malaysia.

Objektif: Objektif pertama untuk kajian ini adalah untuk membandingkan perubahan markah MBI dalam kalangan pekerja yang mendapat kecederaan otak yang menjalani terapi pemulihan robotik berbanding terapi pemulihan konvensional, semasa memulakan terapi (garis dasar), semasa terapi (minggu ke-2), dan pada penghujung terapi (minggu ke-4). Objektif kedua, untuk mengukur kesan *Hospital Anxiety and Depression Scale* (HADS) pada perubahan skor *Modified Barthel Index* (MBI) semasa 4 minggu terhadap intervensi dalam terapi pemulihan robotik. Objektif ketiga adalah untuk menentukan pengantaraan HADS terhadap mRS dan MBI di kalangan pekerja yang mendapat kecederaan otak yang menjalani terapi pemulihan robotik.

Metodologi: Kajian kohort prospektif telah dilaksanakan di negeri Kelantan yang menerima pesakit strok di seluruh pantai timur Semenanjung Malaysia. Setiap kumpulan terapi pemulihan robotik dan konvensional terdiri daripada 50 sampel. Terapi pemulihan robotik terdiri daripada tiga sesi setiap hari selama empat minggu. Sementara itu, kumpulan terapi pemulihan konvensional melakukan latihan berjalan selama dua minggu, lima hari seminggu, dengan hari rehat pada hujung minggu. Data dikumpul pada peringkat awal (semasa kemasukan), minggu ke-dua, dan minggu ke-empat (semasa discaj) untuk kedua-dua terapi. Kemerosotan pesakit dinilai menggunakan *Modified Barthel Index* (MBI) oleh ahli terapi bertauliah. *Modified Rankin Scale* (mRS) adalah peramal untuk melihat kesan hasil pemulihan. Kebimbangan dan kemurungan yang dinilai oleh *Hospital Anxiety and Depression Scale* (HADS) dianggap sebagai pengantara yang menjelaskan mekanisme asas hubungan antara mRS dan MBI. Bagi objektif pertama, *Repeated Measures Analysis of Variance* (RM-ANOVA) telah dilakukan untuk menilai arah aliran hasil dan membandingkan trend dengan kedua-dua kumpulan rawatan. Keberkesanan keseluruhan kajian dianalisis menggunakan *Generalized Linear Mixed Model* (GLMM) untuk kedua-dua pemulihan bagi objektif kedua dan ketiga.

Keputusan: Kami hanya berjaya mengumpul 54 pesakit strok yang mengambil bahagian dalam kajian ini. Tiga puluh (55.6%) daripada pesakit ini menerima terapi pemulihan robotik. Apabila kami membandingkan untuk semua ciri, mereka yang menerima terapi pemulihan konvensional adalah jauh lebih tua daripada mereka yang menerima terapi pemulihan robotik, manakala skor MBI mempunyai peningkatan yang ketara dalam tempoh 4 minggu untuk kedua-dua terapi. Skor MBI juga meningkat dengan ketara jika dibandingkan dengan kumpulan rawatan. Bagi HADS-A, terdapat perbezaan yang signifikan antara kumpulan rawatan, di mana dalam

kumpulan pemulihan robotik mempunyai HADS-A yang lebih tinggi. Apabila HADS diselaraskan kepada kumpulan rawatan, terdapat penurunan dalam HADS dengan HADS-A berkurangan kepada 0.22 unit dan HADS-D berkurangan kepada 0.28 unit walaupun ia tidak ketara. Selepas kami menambah mRS dalam model 5, ia menunjukkan bahawa skor MBI meningkat dan mereka yang mempunyai poor mRS mempunyai MBI yang lebih rendah sebanyak 11.15 unit. HADS juga tidak mempengaruhi mRS apabila diselaraskan dengan kumpulan rawatan apabila skor MBI masih menunjukkan peningkatan yang ketara dengan purata 3.74 unit pada minggu ke-2 dari minggu pertama dan 5.41 unit pada minggu ke-4 dari minggu pertama.

Kesimpulan: Pemulihan fungsional berlaku pada pesakit strok akut apabila min skor *Barthel Index* meningkat dari garis dasar (minggu 0) ke minggu 2 dan kemudian ke masa discaj (minggu 4) dalam kedua-dua terapi. Ia menunjukkan bahawa aktiviti kehidupan seharian bertambah baik setiap minggu dan status psikologi pekerja yang mengalami kecederaan otak tidak menjejaskan tahap kecacatan selepas menjalani terapi pemulihan robotik. Tidak ada kemudaratan atau keburukan dalam memperkenalkan pemulihan robotik dalam pesakit selepas strok. Walau bagaimanapun, penilaian dalam percubaan klinikal yang lebih besar diperlukan untuk menilai keberkesanan terapi tambahan yang berguna ini dalam populasi strok.

KATA KUNCI

Strok, Robotik, Konvensional, Pekerja, Pemulihan, MBI, HADS, mRS.

ABSTRACT

THE EFFECTIVENESS OF ROBOTIC REHABILITATION THERAPY ON ACTIVITIES OF DAILY LIVING AMONG WORKERS WITH ACQUIRED BRAIN INJURY

Background: Stroke is one of the leading causes of acquired disability in adults and the sixth leading cause of death worldwide. In Malaysia, there are 50,000 cases of stroke per year, and 40,000 of those cases occur in working-age people. Ageing populations have increased the global need for physical therapy services. Many use the Barthel index self-care evaluation to determine whether a stroke, neuromuscular, or cancer patient can meet their basic needs. This study aims to determine the effectiveness of robotic rehabilitation therapy compared to conventional rehabilitation therapy on Modified Barthel Index (MBI) score and the predictor effect among workers with stroke in East Coast Peninsular Malaysia.

Objectives: The first objective of the study was to measure the changes of MBI scores among workers with acquired brain injury who underwent robotic rehabilitation therapy compared to conventional rehabilitation therapy, upon starting therapy (baseline), during therapy (week 2), and at the discharge of therapy (week 4). Secondly, to measure the effect of HADS on the changes of MBI during a 4-week follow-up on intervention in robotic rehabilitation therapy. Thirdly, we would like to determine the mediating effect of HADS between the mRS and MBI score among workers with stroke who underwent robotic rehabilitation therapy.

Methodology: A prospective cohort study was implemented in Kelantan, which receives stroke patients throughout east coast Peninsular Malaysia. Each group of robotic and conventional rehabilitation therapy consisted of 50 samples. Robotic

rehabilitation therapy comprises of three sessions every day for four weeks. Meanwhile, the conventional rehabilitation therapy group did gait training for two weeks, five days a week, with a weekend rest day. Data was collected at baseline (at admission), week two, and week four (at discharge) for both therapies. The patient's impairment was assessed using the Modified Barthel Index (MBI) by a certified therapist. Modified Rankin Scale (mRS) was the predictor to observe the effect of the rehabilitation outcome. Anxiety and depression that were assessed by Hospital Anxiety and Depression Scale (HADS) was considered the mediator that explained the underlying mechanism of the relationship between mRS and MBI. As for the first objective, Repeated Measures Analysis of Variance (RM-ANOVA) was performed to evaluate the outcome's changes and compare the changes with both treatment groups. The overall effectiveness was analysed using Generalized Linear Mixed Model (GLMM) for both rehabilitation for second and third objectives.

Results: We only managed to recruit 54 acquired brain injury patients to participate in this study. Thirty (55.6%) of these patients received robotic rehabilitation therapy. When we compared for all the characteristics, those who received conventional rehabilitation therapy were significantly older than those who received robotic rehabilitation therapy, while the MBI scores has a significant increased over 4 weeks duration for both therapies. The MBI scores also significantly increased when compared with the treatment group. As for HADS-A, there was a significant difference between the treatment group, in which those in the robotic rehabilitation group had higher HADS-A. When adjusted HADS to the treatment group, there is a decrease in HADS with HADS-Anxiety reduced to 0.22 units and HADS-Depression reduced to 0.28 units although it was not significant. After we add mRS in model 5, it showed that the MBI score improve overtime and those with Poor mRS had lower MBI by

11.15 units. HADS also did not influence the mRS when adjusted with the treatment group when the MBI scores still showed significant improvement with an average of 3.74 units at week 2 from baseline and 5.41 units at week 4 from baseline.

Conclusion: Functional recovery occurs in acute stroke patients when the mean Barthel Index score increases from baseline (week 0) to week 2 and then to the time of discharge (week 4) in both therapies. It shows that the activities of daily living improved over time and the psychological status of the workers with acquired brain injury did not affect the level of disability after undergoing robotic rehabilitation therapy. There is no harm or disadvantage in introducing robotic rehab in post-stroke patients. However, evaluation in a larger clinical trial is required to evaluate the effectiveness of this useful adjunct therapy in the stroke population.

KEYWORDS

Stroke, Robotic, Conventional, Worker, Rehabilitation, MBI, HADS, mRS.

CHAPTER 1

1.1 INTRODUCTION

1.1.1 Stroke Burden

A brain injury can cause a stroke in some cases. A traumatic brain injury (TBI) can cause damage to the blood vessels and disrupt blood flow to the brain, leading to a stroke. Additionally, a brain injury can cause changes in behaviour and physical function that increase the risk of stroke. However, it's important to note that not all brain injuries lead to strokes, and strokes can also be caused by other factors, such as high blood pressure, smoking, and atrial fibrillation. In this study, we only focus on workers with an acquired brain injury that causes stroke/hemiparesis (Cerebrovascular Accident (CVA) and TBI).

Stroke is often considered a disease related to the elderly. Most studies have found that a successful outcome of rehabilitation is the return to an appropriate level of independence in day-to-day activities. World Health Organization (WHO) in 2018 reported very high mortality caused by non-communicable diseases (NCDs). In 2019, an estimated 17,9 million individuals died from CVDs, accounting for 32% of all fatalities worldwide. 85% of these deaths resulted from heart attacks and strokes (WHO, 2021). Stroke or cerebrovascular accident is considered a global public health problem.

In addition, it primarily imposed a considerable burden on nations with low and moderate incomes because more than 85% of stroke deaths that occurred worldwide occurred in these countries (O'Donnell et al., 2010). Apart from that, stroke also causes very significant high morbidity and disability. Disability-adjusted life years (DALYs)

from stroke cases in 1990 was 38 million, and the projection of the cases in 2020 will be increased to 61 million (Akhavan Hejazi et al., 2015).

In Malaysia, stroke is considered the third leading cause of mortality and the most common cause of adult disability (Sin et al., 2014; Wan-Arfah et al., 2018). A population-based study done in Penang in 2010-2011 showed the overall age-standardised stroke incidence in Malaysia was 67 cases per 100,000 populations, with more than half (53.1%) being males and nearly a quarter (23.7%) recurrent stroke (Kooi Cheah et al., 2016).

Complications following a stroke can considerably influence sufferer's physical health, mental well-being, social relationships, and economic standing, often rendering them handicapped before their most productive years. (Yamamoto, 2012). In addition, young stroke patients had a higher chance of long-term unemployment, cognitive impairment over the long term, depression, and anxiety than older patients (Maaijwee et al., 2016).

1.1.2 Burden of workers with stroke

The percentage of stroke patients who are adults in the working age range (between 18 and 50 years old) accounts for 10%–15% of the total number of stroke patients and is increasing (Lutski et al., 2017; Noortje Maaijwee et al., 2014). In Malaysia, with about 50,000 new stroke cases every year, it's also worrying that 40% of those affected are working-aged. As a result of the rising incidence of stroke over the past many years, Malaysia needs to be prepared. According to the results of the National Health and Morbidity Surveys conducted by the Malaysian Ministry of Health over the past few years, the prevalence rate among Malaysians increased from 0.3% in 2006 to 0.7% in 2011.

There was a correlation between going back to work and increased autonomy levels in daily living activities (ADL) (Ghoshchi et al., 2020). When someone has had a stroke, their quality of life is significantly impacted by whether they can return to work under the same circumstances as they were before the acute incident.

It is well-acknowledged that stroke is the leading cause of disability among adults. It creates physical and mental problems, which can be considered a physical impairment. It may significantly impact the patient's functionality or capability to carry out activities that are important for daily living. Patients who suffer from motor impairments due to conditions such as stroke have a significantly reduced capacity to carry out ADL. Having trouble with activities of daily living (ADL) might contribute to post-stroke depression (PSD) and lower one's quality of life (QOL). ADL demonstrated a substantial link with both the degree of depression experienced by stroke patients and their overall quality of life (Haghgoo et al., 2013).

1.1.3 Robotic Rehabilitation Therapy

In recent years, demand has grown for physical therapy services across the globe partly because of ageing populations. The increased survival rate from various medical conditions, such as stroke, has brought attention to technology's role in the healthcare industry. The use of robotic rehabilitation and assistive technologies holds the potential to reduce the strain placed on physiotherapy personnel, bring costs under control, and improve the overall quality of life for patients (Seinfeld et al., 2020).

Robotic rehabilitation is a type of physical therapy that uses robots to assist in the rehabilitation of patients with physical impairments. The effect of robotic rehabilitation on the activities of daily living (ADL) has been studied in several clinical trials and has shown promising results.

Studies have shown that robotic rehabilitation can improve a person's ability to perform ADLs, including tasks such as walking, reaching, and grasping. This is due to the precise and repetitive movements provided by the robots, which can help to re-train the brain and improve motor function.

Additionally, robotic rehabilitation can be adjusted to the individual needs and abilities of the patient, providing a personalized and targeted approach to rehabilitation. This can lead to improved outcomes and faster recovery times compared to traditional rehabilitation methods.

Robotic rehabilitation has been shown to have a positive effect on the activities of daily living in individuals with physical impairments. It can improve motor function and help individuals to perform ADLs more independently, leading to improved quality of life. However, more research is needed to fully understand the long-term effects of robotic rehabilitation on ADL. Robots are utilised in this environment primarily as therapeutic instruments rather than as helpful gadgets (Chang and Kim, 2013).

1.1.4 Rehabilitation Unit of Hospital USM

Hospital Universiti Sains Malaysia in Kubang Kerian is the first university hospital in Malaysia to provide patients who have been paralysed with access to Robotics Rehabilitation Services in order to aid in their recovery. They collaborated with the Social Security Organisation (SOCSO) to provide the best rehabilitation treatment services to the community.

HAL, which stands for "Hybrid Assistive Limb," is the world's first cyborg-type robot. Its purpose is to develop, support, and increase the bodily capacities of the person who wears it. When putting on the robotic suit, "man," "machine," and "information" are

ultimately merged into a single entity. A person who is physically disabled can move with the assistance of a robot, which enables them to exert a tremendous amount of motor energy beyond what is ordinarily possible. In addition, the robotic suit is thought to be the system that quickens the process of motor learning in the cerebral nerves.

SOCSSO has supplied six units of Robot Suit Hybrid Assistive Limb (HAL) exoskeleton developed by the Centre for Cybernetics Research, University of Tsukuba, Japan. Rehabilitation Services at Hospital USM will benefit recipients in Kelantan and other East Coast states who suffered injuries, accidents, or physical disabilities to return to work and be independent in their daily lives (Gorgey, 2018).

1.1.5 Modified Barthel Index (MBI) in Stroke Assessment

The Modified Barthel Index (MBI) is commonly used to measure the activities of daily living (ADL) in stroke assessment (Sainsbury et al., 2005; Trevissón-Redondo et al., 2021). Strokes can cause physical and cognitive impairments that affect a person's ability to perform daily tasks and live independently. The MBI provides a quantitative measure of a person's functional abilities in performing activities related to personal care and mobility, such as bathing, dressing, toileting, and transferring.

Many people use the Barthel index self-care assessment because it is an accurate and trustworthy instrument that can determine whether a patient can take care of their basic requirements. Patients suffering from stroke and other neuromuscular or musculoskeletal problems, and oncology patients, were the target medical condition for these devices (Trevissón-Redondo et al., 2021). The results of the measurements indicate whether the patient can be released from the hospital so they can continue their recovery at home.

After the Modified Rankin Scale (mRS), the Barthel Index is currently the functional outcome measure employed in modern stroke research studies, the second most frequently used (Imran et al., 2018). The Barthel Index (BI) and the modified Rankin Scale (mRS) are the evaluation tools that see the most activity in clinical and research settings. Although various measures are available, the BI and the mRS are the tools that see the most action. Both scales were developed to measure disability and dependency in stroke survivors (Lee et al., 2020).

In general, the modified index is used to determine which aspects of patient's daily living activities they can perform on their own and which elements they require assistance with. The interpretation of a patient's score on the Barthel index can help identify the level of assistance that a patient requires. The MBI is a valuable tool in stroke assessment as it provides a quantifiable measure of a person's functional abilities in performing specific ADLs and can be used to track changes and compare functional status over time.

1.1.6 Effect of Anxiety and Depression on ADL

Anxiety and depression can have a significant impact on a person's ability to perform activities of daily living (ADL). Anxiety can cause physical symptoms such as muscle tension, fatigue, and difficulty sleeping, which can make it harder for a person to perform tasks such as bathing, dressing, and cooking. Anxiety can also cause avoidance behaviours, leading a person to avoid certain activities or places, which can further limit their ability to perform ADLs. Depression can also affect a person's ability to perform ADLs. Symptoms of depression such as low energy, lack of motivation, and difficulty concentrating can make it difficult for a person to complete everyday tasks. Additionally, depression can lead to feelings of hopelessness and worthlessness,

which can further impact a person's ability to perform ADLs. A study also mentioned that a strong and inverse correlation was found between ADL and the symptoms of depression and anxiety (Wang et al., 2019).

Depression following a stroke has been shown in several studies to exacerbate neurological and psychological damage, which in turn has a negative impact on an individual's ability to perform activities of daily life (Jae Jeong et al., 2014). Physical and language recovery from stroke were adversely affected by depressive disorder (Robinson, 1998).

In some cases, the impact of anxiety and depression on ADLs can be so severe that it interferes with a person's ability to live independently. This can lead to increased reliance on others for support and a decline in overall quality of life. It can have a significant impact on a person's ability to perform ADLs. They can cause physical symptoms and emotional difficulties that can limit a person's independence and overall quality of life.

1.1.7 Modified Rankin Scale (mRS) in Stroke Assessment

The mRS is a commonly used tool to assess the level of disability in patients with stroke, spinal cord injury, and other conditions. The mRS measures the level of dependence a person has in performing activities of daily living (ADL), and ranges from 0 (no symptoms) to 6 (death). The first version of the Rankin Scale was developed in Scotland in 1957 to evaluate the level of disability in individuals who had just had an acute stroke (Rankin, 1957).

In the context of assessing ADL after undergoing robotic rehabilitation, the mRS can be used to determine the extent to which the rehabilitation has improved a person's

functional abilities. A lower mRS score indicates a higher level of independence in performing ADLs, while a higher score indicates a greater degree of dependence.

By tracking changes in mRS scores over time, it is possible to determine the effectiveness of robotic rehabilitation in improving a person's functional abilities. Additionally, the mRS can be used to compare the functional status of different individuals and to track progress over time.

The mRS is a useful tool in assessing ADL after undergoing robotic rehabilitation. By providing a standardized measure of functional abilities, the mRS can be used to track progress, compare functional status, and determine the effectiveness of rehabilitation interventions.

1.2 Problem Statements

Recent publications report the incidence of stroke is increasing, and the impact leads to a severe sequel of events in their lives and the lives of family, community members and the countries (Ekker et al., 2018; Noortje Maaijwee et al., 2014; Wu et al., 2012). Stroke is a common, serious, and disabling healthcare problem worldwide. It has a marked impact on the ability to return to work. Emotionally, a stroke can cause depression and personality changes. Still, we don't know if anxiety and depression could affect the improvement of activities daily living in workers with acquired brain injury that underwent robotic rehabilitation.

Introducing robotic rehabilitation therapy for workers with brain injury that causes stroke are important in view of improving the ADLs and psychological status like anxiety and depression. Robotic rehabilitation has been shown to improve a person's ability to perform activities of daily living (ADL), such as bathing, dressing, and eating. By improving ADL, workers with brain injury may be able to live more independently and participate in more daily activities, which can have a positive impact on their overall quality of life.

Brain injury also can lead to anxiety and depression, which can further affect a person's ability to perform ADL. Robotic rehabilitation has been shown to improve mood and reduce anxiety and depression, which can help to improve overall psychological well-being. By helping workers with brain injury to perform ADL and regain some independence, robotic rehabilitation can also improve self-esteem and confidence. This can have a positive impact on a person's overall mental and emotional well-being. Robotic rehabilitation equipment can be programmed to provide personalized treatment for each patient, based on their specific needs and abilities. This allows for

a more tailored and effective rehabilitation experience, which can help to reduce anxiety and depression and improve overall well-being.

Although significant advances have been made in acute stroke management, most post-stroke care to reduce patient dependency relies on rehabilitation treatments. No study has been done on the effect of robotic rehabilitation on the ADL of workers with acquired brain injury compared to conventional stroke rehabilitation. Aside from this, most stroke patients undergo conventional or standard physiotherapy, which may improve the patient's function, but the improvement is highly variable (Suputtitada et al., 2003).

1.3 Study Rationales

In response to the gaps of knowledge, this study was able to provide a baseline score of MBI after robotic rehabilitation therapy among workers with acquired brain injury. With the actual data and figures, further management can be initiated to improve stroke rehabilitation so that the workers can safely return to work.

There is a minimal or inconclusive study that explored the success of robotic rehabilitation therapy in workers with acquired brain injury compared to conventional rehabilitation. This study can provide evidence that how much ADL will increase to determine how quickly workers will return to work and how anxiety and depression will affect their ADL.

Brain injury that causes stroke is a common and debilitating condition that affects millions of people worldwide. It can lead to a range of physical and cognitive impairments, including difficulties with ADL. Currently, there are limited options for rehabilitation for workers with brain injury. Traditional rehabilitation approaches, such as physical therapy and occupational therapy, can be time-consuming and limited in their effectiveness. Robotic rehabilitation therapy offers the potential for improvement in ADL for workers with brain injury. Robotic equipment is designed to help patients perform repetitive movements that can improve motor function, balance, and coordination.

There is some evidence from previous studies that suggests that robotic rehabilitation therapy can be effective in improving ADL for patients with brain injury. However, more research is needed to determine the extent of these improvements and how they can be optimized. This study also can provide information to respective agencies regarding the effectiveness of robotic rehabilitation therapy and then be introduced to

other healthcare facilities to use robotic rehabilitation as part of their stroke rehabilitation.

In summary, studying the effectiveness of robotic rehabilitation therapy for workers with acquired brain injury in improving ADL is important because it has the potential to provide a more effective and efficient rehabilitation option for this population, which can lead to improved independence and quality of life.

1.4 Research Questions

1. Does robotic rehabilitation therapy improve the Activities of Daily Living (ADL) (measured by Modified Barthel Index (MBI)) scores among workers with acquired brain injury compared to conventional rehabilitation?
2. Does Anxiety and Depression (measured by Hospital Anxiety & Depression Scale (HADS)) affect the change of the ADL among workers with acquired brain injury who underwent robotic rehabilitation?
3. Do mRS and HADS affect the change of the ADL among workers with acquired brain injury who underwent robotic rehabilitation?

1.5 Objectives

1.5.1 General Objective:

To study the effectiveness of robotic rehabilitation therapy compared to conventional rehabilitation therapy on activities of daily living measured by Modified Barthel Index (MBI) score and the mediator effect among workers with acquired brain injury in East coast Peninsular Malaysia.

1.5.2 Specific Objectives:

1. To compare the MBI scores among workers with acquired brain injury who underwent robotic rehabilitation therapy compared to conventional rehabilitation therapy, upon starting therapy (baseline), during therapy (week 2) and at the discharge of therapy (week 4).
2. To measure the effect of HADS on the changes of MBI during the 4-week follow-up in robotic rehabilitation therapy.

3. To determine mediating effect of HADS between the mRS and MBI score among workers with acquired brain injury who underwent robotic rehabilitation therapy.

1.6 Outcome Measures

To estimate the changes of ADL using MBI score for workers with acquired brain injury who underwent robotic and conventional rehabilitation therapy from baseline to week 2 and week 4.

1.7 Research Hypotheses

1. Robotic rehabilitation therapy improved the MBI score over time from baseline to week 2 and week 4 for workers with acquired brain injury compared to conventional rehabilitation therapy.
2. There is a significant effect of HADS during the 4-week follow-up period of robotic rehabilitation therapy on the changes of the MBI scores.
3. There is a significant effect of mRS on the changes of the MBI scores among workers with acquired brain injury who underwent robotic rehabilitation therapy, with the effect of HADS mediating the relationship between mRS and MBI scores.

CHAPTER 2

2.0 LITERATURE REVIEW

Mainly all the literature search about robotic rehabilitation therapy on stroke patients, MBI in stroke rehabilitation, anxiety, and depression in stroke rehabilitation, mRS in stroke rehabilitation and the effect of anxiety and depression on MBI was widely done by using search engines such as PubMed, Science Direct, EBSCOhost and SpringerLink. Various searching strategies were applied, such as combining terms with connectors (AND, OR, NOT). The entire literature searches published from 2000-2020 were included.

2.1 Modified Barthel Index (MBI) In Stroke Rehabilitation

The Barthel Index is one of the most well-known indicators of functional status following a brain injury. It is the measure of disability in stroke rehabilitation studies that have received the most citations in the literature (Sangha et al., 2005). It was initially created as a clear gauge of independence following a stroke and a helpful grading tool for rehabilitation (Terence J. Quinn et al., 2011). The 10-item Barthel Index ranges in scores from 0 to 100 in 5-point increments, is the most widely used form of the Barthel Index and has an outstanding reliability rating (Duffy et al., 2013; Tibaek and Dehlendorff, 2012). According to Tibaek and Dehlendorff, (2012) and Uyttenboogaart et al., (2007), the highest score is 100 (complete independence), and the lowest score is 0 (wholly dependent bedridden state).

The results of the rehabilitation process are evaluated using activities of daily living (ADL) as a gauge of functional independence. The Barthel Index (BI) are the most often utilised evaluation tool in the clinic and research (T. J. Quinn et al., 2009), despite the fact that there are several measures available for measuring reliance and disability

in stroke survivors. The MBI were mostly used functional outcome measure in stroke studies (T. J. Quinn et al., 2009; Terence J. Quinn et al., 2011). Many studies concluded regarding using MBI to measure stroke patients' daily living activities. A study by Kelley et al., (2013) showed that the participant's baseline Barthel Index mean was 57.50, with respective post-intervention and 3-month follow-up scores being 65.00 and 61.75. Such improvements could indicate less burden of care.

Although the MBI offers a wide variety of ADL function scores, the results interpretation is only possible using changes in the overall score as a numeric measure. How much of the difference in the total score is clinically significant is currently unknown. It is crucial to define clinically distinct grades of ADL in stroke patients for analysing the results of individual patients and outcomes at the community level. There is disagreement over the number of ADL levels that could be effectively classified in the MBI or the threshold scores for those levels in each category (Lee et al., 2020).

The question of whether employees should be allowed to return to work after experiencing a severe health event, such as a stroke, has been deemed an essential one from the perspectives of both policy and welfare (Vestling et al., 2003). As a result, taking steps to facilitate a quicker return to work ought to help boost the patient's social involvement and quality of life, in addition to lowering the social cost that the sickness ultimately imposes. It is crucial to establish what factors are essential in assisting stroke survivors in having a greater probability of returning to work and what factors can be modified through rehabilitation services (Tanaka et al., 2011).

As for return to work (RTW), factors like job type, age, and Barthel Index at initial rehabilitation significantly influenced RTW (Tanaka and Toyonaga, 2014). According to Cho et al., (2018), significant improvement was observed in upper limb function, activities of daily living, and kinematic performance after six weeks of rehabilitation.

Patients who were entirely dependent when admitted to the hospital were less likely to recover and return to work (Tanaka et al., 2011). According to Saeki et al., (2010)'s research, an individual's ability to do ADLs at admission was not a significant predictor for returning to work. On the other hand, their most recent research discovered that ADLs measured by the Barthel Index at admission were a significant predictor for RTW (Saeki et al., 2010).

Barthel Index increased significantly within three years among stroke patients compared with that at discharge ($p < 0.01$) (Wang et al., 2019). It is also known that RTW was associated with higher independence in the activities of daily living (assessed by the Modified Barthel Index) (Ghoshchi et al., 2020). Barthel Index was praised for its advantages of completeness, sensitivity, adaptability for statistical manipulation, and familiarity in a prior study of ADL tools (Terence J. Quinn et al., 2011). According to the literature cited, the popularity and simplicity of the Barthel Index are its strong points.

2.2 Anxiety And Depression in Stroke Rehabilitation

Despite significant advances in early diagnosis and medical management, which have led to a reduction in the incidence of stroke as well as the mortality rate associated with the condition, approximately 25%-74% of stroke patients still suffer from a life-long disability as well as a severe psychological illness, which may include cognitive impairment, anxiety, and depression (Bennett et al., 2014). As a result of motor and sensory impairments, which lead to life-long disability and limitation of activities of daily living (ADL), many stroke patients find it challenging to accept these sequelae and find it easy to lose confidence, or even have inferiority complexes, which leads to an increase in anxiety and depression. This is because these sequelae lead to life-long disability. Therefore, research into stroke rehabilitation strategies is vital if one wants

to improve the mental health of stroke patients and raise the quality of life they enjoy after a stroke (Cheng et al., 2018). There is a high prevalence of post-stroke depression, according to a recent comprehensive review, even though there is less information addressing post-stroke anxiety. The literature implies that survivors may endure psychological damage after a stroke (Sen et al., 2019).

Numerous psychologic issues, including anxiety and depression, have been proven to impact patient's willingness to participate in rehabilitation sessions and, consequently, the results (Paolucci et al., 2012). Post Stroke Depression (PSD) is thought to be the primary risk factor for a patient's inability to return to work after a stroke, and the intensity of depression has been identified as an independent predictor of post-stroke death (Rabi Žikić et al., 2014). However, PSD is infrequently recognised, mood disorders are commonly disregarded, and its importance in relation to the prognosis of strokes is disregarded and undervalued. Uncertainty exists regarding the relationship between depression and the cognitive, neurological, and functional status of stroke patients and the importance of depressive disorder for stroke outcomes (Hadidi et al., 2009).

The most helpful technique to analyse the connection between physical impairment and PSD is to express the impairment as a functional handicap for activities of daily living (ADL) rather than assessing the degree of neurological abnormalities. Functional disability, which is most usually linked to PSD as a psychological response to physical impairment, has been found to be a contributing factor in prior studies. However, it is far from the sole (Rabi Žikić et al., 2014).

A prospective study in a Turkish population found that the quality of life six months after a stroke was significantly lower than it was for healthy controls ($p < 0.0001$) and was significantly correlated with depression, functional status, and educational attainment (Ones et al., 2005).

A study by Calabrò et al., (2015) showed that about one-fifth of stroke survivors might experience mood and anxiety disorders leading to worse functional outcomes. As for stroke rehabilitation using robotic rehab, it is proven that rehabilitation therapy delivered by robotic-based telemedicine devices improves limb rehabilitation and increases mobility, independence and mind-body connection while decreasing anxiety and stress (Cherry et al., 2017). Psychologic features, mainly recovery focus of control and anxiety, affected the rehabilitative outcomes of the patients involved in robotic treatment more than those in conventional rehabilitation (Bragoni et al., 2013).

Even a short, 2-week training programme with new technology resulted in a considerable recovery of post-stroke functional level in self-care, upper limb motor capacity, and anxiety reduction (Adomavičienė et al., 2019). Patients generally treated for post-stroke depression (PSD) tend to have better motor and cognitive rehabilitation outcomes than non-treated patients (Mane et al., 2020). Therefore, some psychological characteristics, such as the patient's fear and feeling of control, may influence patients' active engagement in robotic walking training and the results of rehabilitative intervention.

2.3 Modified Rankin Scale (mRS) In Stroke Rehabilitation

The mRS score is a clinically based assessment of overall impairment that uses a 7-point scale ranging from 0 (no symptoms) to 6 (dead). The original Rankin scale has been changed to create the mRS (Rankin, 1957). The mRS was initially intended to be a handicap scale, but it is now seen as more of a disability scale (De Haan et al., 1995). Scores of 0–2 on the Modified Rankin Scale (mRS) have been used to describe “good outcome” for stroke patients, while mRS scores of 3 and 4–6 indicate “poor outcome” (Powers et al., 2015). In a perfect world, a scale would measure and be able to identify changes throughout the full spectrum of conceivable functional outcomes. A study in Italy demonstrates that the mRS can comprehensively describe the patient's functional condition, provided that it is performed at least 3 months after the patient has suffered a stroke (Cioncoloni et al., 2012).

The metrics mRS and MBI are frequently compared since mRS has been used extensively to assess stroke recovery and as a primary endpoint in treatment trials (Sulter et al., 1999). The two metrics, though, differ significantly from one another. The most significant distinction is that the MBI is a quantitative assessment of fundamental ADL, whereas the mRS is a worldwide disability scale. It has been stated that because mRS uses subjective categories, it is challenging to accurately depict the severity of disability (Lee et al., 2020). In actuality, differences between disability as measured by the mRS and ADL as measured by the MBI were frequently found while attempting to explain the functional result of stroke survivors (Uyttenboogaart et al., 2007). Thus, knowing how the mRS and MBI relate to one another may aid clinicians in assessing treatment outcomes and planning clinical trials that use both measures.

The validity and reliability of the mRS have been attested to by a variety of different sources of evidence. It shows that the mRS is a valuable instrument for assessing the impact of new stroke treatments (Banks and Marotta, 2007). According to Balu (2009), there was no apparent relation between the time to initiation of stroke therapy and outcomes measured by the BI and the mRS. As long as the mRS is performed at least three months following a stroke, it can comprehensively describe the patient's functional condition. Six months after a stroke, it appears that mRS has reached its maximum discriminating capacity. Prior to this, the mRS did not effectively distinguish between patients who are functionally independent and those who are dependent. Another study showed that when the frequency distribution and statistical comparison of the data were collected at various points in time further corroborated this, indicating that the longer the time since the stroke, the more significant the mRS's description of the patient's functional condition will be (Cioncoloni et al., 2012). mRS grade seemed to differentiate mild residual disability of stroke survivors sensitively. On the other hand, the MBI provided more detailed information on the functional state of stroke survivors with moderate to severe residual disability (Y. H. Kim et al., 2018).

One drawback of utilising the mRS as the primary indicator of success in acute-stroke rehab is that additional recovery improvements that might have therapeutic significance are not taken into account. According to Sulter et al., (1999), the majority of medications are used to treat neurological impairments and associated disabilities rather than to treat stroke itself. If so, even if their three-month health status has not fully recovered, patients whose neurological deficits and disability have improved since their stroke should be regarded to have benefited from the therapies. People whose recovery demonstrated Rankin state transitions (e.g., from Rankin 5 to 3 or 4 to

3) have improved clinically meaningfully in ADL, greater levels of physical and social functioning, and a higher level of health (Lai and Duncan, 2001).

2.4 Anxiety And Depression effect ADL In Stroke Rehabilitation

Stroke is a fatal health issue that affects 700,000 individuals yearly (Hadidi et al., 2009). Patients with anxiety and depression recover from functional impairments far more slowly than patients without these disorders. They also have a 3.4 times higher mortality rate in the first decade following stroke (Morris et al., 1993). Stroke patients with mood issues can be challenging to diagnose. Fatigue, changes in eating, sleep patterns, or interest patterns are common post-stroke symptoms. Aphasia, anosognosia, and the cognitive effects of the stroke confound the diagnosis. As much as one-third of stroke patients have anosognosia, a term used to characterise a person's lack of knowledge, awareness, or acknowledgement of physical disease (Hadidi et al., 2009). The majority of investigations have demonstrated that functional impairment is markedly more severe in depressed patients when compared to non-depress patients. Women also have higher rates of depression and lower quality of life than men. They are more likely to require assistance after a stroke, even when control for factors such as age and premorbid function (Persky et al., 2010).

Other studies found that the association between depression and impaired ADL was independent of the severity of cognitive impairment, social functioning, age, and education. Moderate to severe disability increased the risk of PSD by about 20% (Morris et al., 1990). Additionally, some studies showed the importance of disability as a predictor of PSD, while others found that the association between depression and impaired ADL was independent of these factors (Dennis et al., 2000; Paolucci et al., 2005). Data are contradictory; nevertheless, other research revealed no link between ADL impairment and the degree of depression (Cassidy et al., 2004).

Cognitive impairment and mood disorder are related to poor functional recovery after a poor quality of life (Cumming et al., 2013). The activities of daily living (ADL) strongly correlates with depression and QOL in patients with stroke (Haghgoo et al., 2013). Despite that, post-stroke depression (PSD) aggravates neurological and psychological damage, adversely affecting performance in activities of daily living (Jae Jeong et al., 2014). According to Eum and Yim (2015), PSD makes patients have more severe deficits in activities of daily living, a worse functional outcome, more severe cognitive deficits and increased mortality compared to stroke patients without depression. This shows that ADL is significantly and inversely correlated with depressive and anxiety symptoms (Wang et al., 2019). According to the differences in brain activations seen between passive and active performances during robotic gait training, robotic therapy may be especially responsive to patient's active participation during training sessions.

There has been researched on the association between PSD and functional results at a specific time. Still, no study has looked at how depression and function evolve following a stroke (Hadidi et al., 2009). With a highly significant difference in ambulation, functional impairment was much more severe in depressed patients than in non-depressed individuals. Although depressed patients showed low functional capacities at the end of rehabilitation treatment than non-depressed patients, their potential for functional recovery was no less strong (Rabi Žikić et al., 2014).

It can be assumed that the degree of ADL impairment while in the hospital may be a good indicator of depression later in the course of the disease if functional disability results in depression via a psychological mechanism. Similarly, it can be hypothesised that in-hospital depression will predict later ADL impairment if the intensity of depression impacts functional recovery. Both hypotheses have been supported by prior

research (R. Robinson, 2006). Still, there is also contradictory evidence that, despite functional disability and other potential risk factors, depression risk remains elevated for many years following a stroke (Lenze et al., 2001).